Reputation Building and Vertical Integration: An Experiment on Commitment and Monopolization in the Presence of Behavioral Types

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Abstract:

In an experiment, I analyze the impact of reputation building on collusive outcomes in a market with one integrated and one non-integrated manufacturer. Manufacturers have heterogeneous incentives to publish their price history and thereby to establish a reputation for a commitment to set high prices. The integrated firm has an incentive to signal via reputation building future withdrawal from the upstream market in order to raise the input cost for downstream rivals. Building on the seminal paper on one-sided reputation building of Fudenberg and Levine (1989) I test their predictions in the lab. When getting the opportunity, integrated firms opt significantly more often to build a reputation than their non-integrated upstream opponents. Reputation building of the integrated firm increases the minimum price for the input good significantly while reputation building of the non-integrated firm has no such effect. Due to reputation building of the integrated firm, one fourth of all markets are monopolized which is ten times more than without reputation building. I find evidence that monopolization is achieved by adapting Fudenberg and Levine's (1989) predicted strategy.

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1 Introduction

Vertically integrated firms are prevalent in many industries and numerous vertical mergers are proposed every year. For decades there has been a debate about the effect of vertical integration on market competition. When making a decision about a proposed vertical merger, the most common concern of US agencies is input foreclosure (Salop and Culley, 2015)[1]. The integrated wholesaler has an incentive to hamper effective upstream competition which raises prices for the input good and therefore cost for downstream rivals (Coase, 1937). This argument has been formalized by Ordover, Saloner and Salop (1990, in the following OSS), however, Hart and Tirole (1990) and Reiffen (1992) challenged their approach. The criticism concerns mainly the source of commitment for the integrated wholesaler: High upstream prices would imply an incentive for the integrated wholesaler to undercut the price of the opponent.

Bolton and Whinston (1991) summarize their concern: "There are two crucial steps in the OSS argument. The first is to show that as a result of a vertical merger, competition on the input market can be reduced. OSS establish this by assuming that the vertically integrated firm can commit to compete less fiercely on the input market. Exactly how this commitment is achieved is not explained. The second step is to show that by committing to compete less fiercely the integrated firm induces the other upstream firm to raise its input price and thus to raise the marginal cost of the unintegrated downstream sector."(p. 208).

In this paper, I study reputation building as commitment device in the laboratory. One-sided reputation building of the integrated firm tackles both points of Bolton and Whinston (1991)'s criticism: First, by establishing a reputation, the integrated firm can commit to withdraw from the input market. Second, after some periods of withdrawal, the non-integrated firm is convinced that the integrated firm withdraws in the current period as well and best responds with the monopoly price. In theory, I show that Fudenberg and Levine (1989)'s model predicts a monopolization of the market after at most two periods. Subsequently, I test their predictions in an experiment and show their empirical relevance.

Formally, one-sided reputation building in a simultaneous move game has been analyzed in the seminal paper by Fudenberg and Levine (1989). A long-lived player

[1] https://scholarship.law.georgetown.edu/cgi/viewcontent.cgi?article=2541&context=facpub

(the integrated wholesaler) meets successively infinitely many short-lived players (the non-integrated wholesaler) who can observe previous choices of their opponent. Because short-lived players are uncertain about the type of long-lived player they are facing, reputation building can be employed to reach an outcome that could otherwise not be achieved but is preferable for the long-lived player. A crucial assumption is the presence of "Stackelberg types" who are committed to the corresponding "Stackelberg strategy". The Stackelberg strategy is the profit-maximizing choice of the long-lived player in the subset of outcomes that are rationalizable for the short-lived player (Fudenberg and Levine (1989) restrict attention to pure strategies). Stackelberg types always choose the Stackelberg strategy irrespectively of the past choices of their opponents. A small fraction of Stackelberg types is sufficient because rational long-lived players imitate the behavior of Stackelberg types in order to obtain higher payoffs. In every period, short-lived players observe previous play and update their belief about their opponent's choice. After a critical number of withdrawals, the short-lived player will best respond to the Stackelberg strategy. For sufficiently patient long-lived players, Fudenberg and Levine (1989) obtain explicit boundaries on the minimum payoff of the long-lived player and on the periods that the players do **not** play the Stackelberg outcome.

A market with a long-lived integrated and a short-lived non-integrated wholesaler seems to be unrealistic. Monte (2016) shows that Fudenberg and Levine's (1989) result also obtains when both players are long-lived while one player (the non-integrated firm) can perfectly observe the price history of the opponent and the other player (the integrated firm) has no access to such information. Prices of manufacturers are often unobservable, thus, we can interpret one-sided reputation building as a setting in which the integrated upstream firm makes its previous price choices visible and the non-integrated firm does not. Or, put it differently, the non-integrated firm commits to play the myopic best response in every period by making it impossible to monitor its price choices.[2]

[2]Note that this behavior can be interpreted as mimicking a maverick firm. According to the Non-Horizontal Merger Guidelines of the European Commission a maverick firm is defined as "a supplier that for its own reasons is unwilling to accept the co-ordinated outcome and thus maintains aggressive competition." (see *Guidelines on the assessment of non-horizontal mergers under the Council Regulation on the control of concentrations between undertakings*, European Commission (85), 18 October 2008, available at `http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008XC1018(03)&from=EN`). Recent research has highlighted the role of maverick firms in antitrust cases such as horizontal mergers and collusion (see for example Gayle et al., 2009 and Marshall et al., 2016).

In OSS's (1992) reply to the criticism of Hart and Tirole (1990) and Reiffen (1992), they argue that "The notion that vertically integrated firms behave differently from unintegrated ones in supplying inputs to downstream rivals would strike a businessperson, if not an economist, as common sense" (OSS, 1992, p. 698).

In addition to the intuition that integrated firms behave differently, there is empirical evidence that Stackelberg types exist. Normann (2011) tested the predictions of OSS (1990) in the laboratory. Normann's (2011) results suggest that Stackelberg types exist: I interpret firms as Stackelberg types whenever they withdrew from the input market over the whole course of the experiment irrespectively of the opponent's price choices. Overall Stackelberg types represent 5% of all integrated firms.[3] The fraction of Stackelberg types seems to be low, however, by employing reputation building I show that it is large enough to monopolize the upstream market after two periods (based on Fudenberg and Levine, 1989).

This is the first experiment to test reputation building with endogenous behavioral types. In experimental papers on reputation building (see the section on related literature), the payoff function is manipulated or robot players are introduced in order to induce different (behavioral) types. The obvious advantage is the control over and the common knowledge of the fraction of behavioral types. However, it comes at a cost: It is unclear whether the induced types are empirically relevant. And even if they would exist, indeed there is no common knowledge of their frequency of occurrence. This paper tests reputation effects in a more realistic setup. Although Fudenberg and Levine (1989) also require common knowledge of the fraction of Stackelberg types, it is less restrictive than it seems to relax this assumption. Watson (1993) shows that the result in Fudenberg and Levine (1989) also obtains with dispersed beliefs about the frequency of Stackelberg types. Watson (1993) does not study equilibrium behavior, he only requires that the non-integrated firm best responds to its belief about the opponent. Because he does not consider equilibria, beliefs can be dispersed and do not have to be "correct". However, he finds that as long as the beliefs are not "too dispersed", the same bound as in Fudenberg and Levine (1989) on the payoffs of the integrated firm can be established.

[3]Note that in a similar treatment, I obtain almost the same fraction of Stackelberg types. In the treatment without reputation building, I observe 6.25% Stackelberg types.

I implemented three different treatments in the laboratory.[4] The treatment *Choose_Rep* is structured in two stages. In the first stage, both upstream firms decide whether they want to reveal their price history to the competitor, hence, build a reputation. In the second stage, firms compete in the market for the input good in one-shot interactions. In treatments U_1*_Rep* and *No_Rep* the first stage is predetermined. In U_1*_Rep* one-sided revelation of the price history is imposed, i.e. the integrated firm reveals the price history to the competitor whereas the non-integrated firm does not. In *No_Rep* reputation building is impossible. Thus, no upstream firm learns the previous price choices of the actual competitor.

The results support predictions: The integrated firm opts for reputation building significantly more often than the non-integrated opponent. I find that foreclosure of the integrated firm occurs almost three times as often when the integrated firm builds a reputation in U_1*_Rep*. In *Choose_Rep* the integrated firm forecloses the market even 10 times more often when it opts for reputation building. Overall, more than one fourth of all markets are monopolized in the outcomes with reputation building of the integrated firm in *Choose_Rep* and in U_1*_Rep*. Reputation building of the integrated firm leads to a significant increase of the upstream posted prices and the minimum price in the input market. Analyzing the decisions of the non-integrated firm, I find evidence for the predicted reputation effect: Only after observing a price history with several periods of market foreclosure, the non-integrated firm responds with the monopoly price. These observations cannot be explained by the well-known Grim trigger[5] strategy or by naive best responses[6].

2 Related literature

In this section, I summarize the literature on vertical integration and reputation, both, theoretical papers and related experiments.

Several papers contribute to the discussion of commitment and input foreclosure raised in OSS (1990). In Choi and Yi's (2000) framework upstream firms can either produce a generalized or a specified product. The generalized input good

[4] The experimental design is built on Normann (2011) who analyzed the potential anticompetitive effects of vertical integration as compared to no integration.

[5] Grim trigger starts with cooperation and cooperates whenever the opponent cooperated in every previous period, otherwise the player defects.

[6] I consider players as being naive if they best respond to the opponent's price in the last period and call this behavior "naive best response".

is similarly useful for both downstream firms while each of them would prefer an individually specialized intermediate product. Commitment in vertical integrated markets is realized via specialization of the input. Church and Gandal (2000) analyze a system product consisting of a software and hardware component. They show that integration and foreclosure can be an equilibrium outcome if the value depends on the software component. By making the software incompatible with the rival's hardware, commitment can be achieved. Allain, Chambolle and Rey (2011) show that the necessity of downstream firms to share sensitive information once they trade with an upstream firm might lead to input foreclosure. In a market with two upstream firms and vertical integration the non-integrated downstream firm might be reluctant to exchange information which cannot be protected by property rights. Deals between an integrated upstream supplier and non-integrated downstream firms might not occur due to the concern that information will be leached the downstream division. Allain, Chambolle and Rey (2016) show that vertical integration can create hold-up problems for competitors. If the integrated supplier can commit to be "greedy" or alternatively commits to offer a degraded input to the downstream competitor, hold-up problems occur. On the other hand they show that even without commitment, foreclosure emerges if the quality of the upstream product is non-verifiable.

Theoretical papers extend OSS's (1990) idea. Chen (2001) considered not only the change in incentives upstream but also in the downstream market in case of a vertical merger. He finds collusive effects but also efficiency gains and an ambiguous result for competitive effects in general. Nocke and White (2007) analyze vertical integration in a market with two-part tariffs upstream and repeated interaction. They show that a vertical merger facilitates upstream collusion. In a similar setting but with linear prices Normann (2009) shows that collusion is easier to sustain in a vertically integrated market. Related to reputation of being a "Stackelberg" type, Mouraviev and Rey (2011) show that price leadership can facilitate collusion. In a theoretical model they show that the choice of deciding simultaneously or sequentially about prices can sustain perfect collusion.

Normann (2011) was the first to analyze experimentally the effect of vertical integration on selling prices and market foreclosure. Although he finds a significant increase in the minimum price paid by the independent downstream firm, there is little evidence for total foreclosure. The integrated firm does not withdraw completely from the input market. However, partial foreclosure, i.e. the integrated firm sets a higher price than the non-integrated firm, indeed takes place. In an experiment, Allain et al. (2015) find support for the predictions in Allain, Chambolle and Rey (2016). Vertical integration creates hold-up problems, in particular, if commitment is possible. A related experimental study (Martin, Normann and Snyder, 2001) analyzed the commitment problem of an upstream monopolist to restrict the total quantity for downstream firms to the monopoly level. Public contracts between downstream firms and the upstream monopolist and, alternatively, vertical integration result regularly in monopolization of the input market. In contrast, if firms are independent and contracts are secret, beliefs of downstream firm about the contract offer to the rival determine the outcome. In this case, monopoly power cannot be sustained and market quantity is significantly above the monopoly level. Moellers, Normann and Snyder (2016) extend this study and analyze the impact of communication on the commitment problem. They find that open communication leads to monopolization whereas bilateral communication between the producer and retailers do not lead to the monopoly quantity downstream. Mason and Phillips (2000) analyze the double marginalization problem in a market with two upstream and two downstream firms. They find larger outputs and a higher consumer surplus with both firms vertically integrated as compared to no integration. Durham (2000) finds support for the double marginalization problem it upstream and downstream markets are monopolized, whereas competition downstream eliminates this problem.

By introducing the concept of sequential equilibria, reputation has been analyzed by Kreps and Wilson (1982), Milgrom and Roberts (1982). The sequential equilibrium supports the deterrence of entry in Selten's Chain Store Paradox by building a reputation of being "tough" even in a finitely repeated game. Fudenberg and Levine (1989) show that a long-run player who faces sequentially infinitely many (different) short-run opponents, can commit to the Stackelberg strategy in a simultaneous move game.

Camerer and Weigelt (1988) were the first to test whether the prediction of sequential equilibria holds in an experiment. In a lending game the player in the second stage can either pay back or renege. They implement uncertainty about the type by varying the preference of the borrower. In the majority of cases the player prefers to renege but there is a small exogenous probability that he will prefer to pay back. They find evidence in support of the reputation effects predicted by Kreps and

Wilson (1982) and Milgrom and Roberts (1982). Neral and Ochs (1992) replicate the results of Camerer and Weigelt (1988) in an experiment but find deviations from theoretical predictions with different parameters. More recently and adding a further stage which decides if reputation is potentially harmful or beneficial, Grosskopf and Sarin (2010) find that reputation is rarely harmful but it can be beneficial. While they find a positive effect, building a reputation was not as beneficial as predicted by theory.

Experimental studies have analyzed reputation building in a trust game, i.e. the effect of providing feedback on trustees' previous decisions. Several studies (Keser, 2002, Bohnet and Huck, 2004, Bolton, Katok and Ockenfels, 2004 as well as Bohnet, Huck, Harmgart and Tyran, 2005) show that one-sided feedback on previous decisions of trustees increases efficiency substantially. In addition, if trustors can observe histories of other trustors, Bohnet, Huck, Harmgart and Tyran (2005) document an additional positive impact on efficiency. If, on the other hand, trustors get information about all trustees' histories, this has no effect on efficiency as was shown by Huck, Lünser and Tyran (2012). However, when trustors can choose with whom they want to play, efficiency is above 80%. Also related to my work is Kartal, Müller and Tremewan's (2015) study on gradualism. In a setting with repeated interaction and hidden information they analyze the impact of reputation building on trust. Whereas the trustee knows his own type, either a low or a high discount factor, the trustor cannot observe the type of his trading partner. They find strong support for their gradualism theory, i.e. trustors start with a low level of trust and gradually raise the level of trust as long as the trustee returned.

3 Experimental market

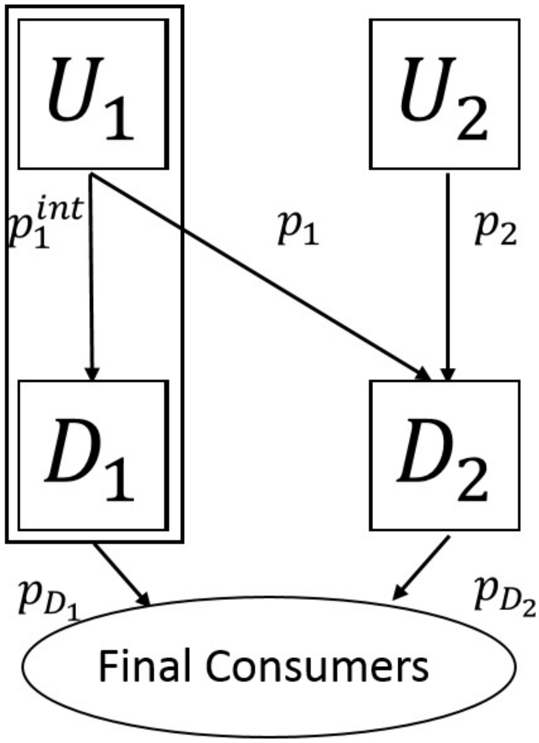

Figure 1: Market Structure

I build on the experimental design of Normann (2011) and use the theoretical model developed by OSS (1990). Figure 1 shows the underlying market structure of the experiment. Two competing upstream firms, a vertically integrated manufacturer U_1 and a non-integrated manufacturer U_2, produce a homogeneous input good with constant marginal costs normalized to zero. Both simultaneously set a price p_i, $i \in \{1, 2\}$ subsequently downstream firm D_2 makes its purchase decision. Because of vertical integration downstream firm D_1 is assumed to purchase the input good internally from U_1 at a price equal to marginal costs ($p_1^{int} = 0$). Retailers produce with a constant returns to scale technology and transformation costs are assumed to be zero. Firms D_i offer the final good for a price of p_{D_i}, $i \in \{1, 2\}$. The demand of final consumers for heterogeneous retailer products is assumed to be $q_i(p_{D_1}, p_{D_2}) = a - bp_{D_i} + dp_{D_j}$ for $i \neq j$ and $i, j \in \{1, 2\}$.[7]

[7]Further specifications of the model as well as the derivation of profits can be found in Normann (2011).

Table 1: Payoff

p_2	1	2	3	4	5	6	7	8	9
p_1									
1	85.5, 19.5	105, 0	105, 0	105, 0	105, 0	105, 0	105, 0	105, 0	105, 0
2	66, 39	101, 27	128, 0	128, 0	128, 0	128, 0	128, 0	128, 0	128, 0
3	66, 39	74, 54	118.5, 34.5	153, 0	153, 0	153, 0	153, 0	153, 0	153, 0
4	66, 39	74, 54	84, 69	136.5, 40.5	177, 0	177, 0	177, 0	177, 0	177, 0
5	66, 39	74, 54	84, 69	96, 81	150, 45	195, 0	195, 0	195, 0	195, 0
6	66, 39	74, 54	84, 69	96, 81	105, 90	181.5, 49.5	231, 0	231, 0	231, 0
7	66, 39	74, 54	84, 69	96, 81	105, 90	132, 99	204, 45	249, 0	249, 0
8	66, 39	74, 54	84, 69	96, 81	105, 90	132, 99	159, 90	216, 36	252, 0
9	66, 39	74, 54	84, 69	96, 81	105, 90	132, 99	159, 90	180, 72	223.5, 25.5

Note: Payoffs (Π_1, Π_2) for each combination of prices (p_1, p_2).

The crucial stage for the commitment problem is the price choice of the upstream firms. To keep the setting as simple as possible, downstream firms as well as final consumers are assumed to decide according to the Nash prediction. Hence, every market is represented by two participants in the laboratory. Both upstream firms simultaneously choose an integer price $p_i \in \{1, 2, ..., 9\}$.

The Nash prediction of the following stages, including the raising-rivals'-costs effect downstream, lead to payoffs in table 1. The upstream firm, which sets the lower price, obtains a positive profit in the market for the input good. If both upstream firms set the same price, i.e. $p_1 = p_2$, they will share the Bertrand profit equally. In addition, the integrated firm U_1 benefits from the cost advantage downstream. Depending on the input price $p_{min} := min\,(p_1, p_2)$ of the downstream rival D_2 there is a raising-rivals'-costs effect. The additional profit is positive and increasing in p_{min}.

In every period a participant is randomly matched with another participant in the lab. In addition, a random continuation rule of 90% was implemented (which can be interpreted as a discount factor of $\delta = 0.9$ as was done for example in Dal Bó (2005) before). In total, four supergames were run.

I study three different treatments using the same market structure while varying the available information about competitors. In the first baseline treatment, *No_Rep*, none of the firms is able to recognize the opponent, thus, this setting represents a static game.[8] In the second baseline, in treatment U_1*_Rep*, firm U_2 observes previous price decisions of the current opponent (although they may not have met before). However, the integrated firm U_1 does not learn the price history of his competitor. In *Choose_Rep*, participants choose themselves whether they build a reputation. In this treatment I add an additional stage in which both upstream firms, i.e. U_1 and U_2, get the opportunity to choose whether they want to disclose their price history to their competitor. They make this decision separately for each supergame, i.e. four times in total.

[8]Note that this treatment is similar to *INTEG_RAN* in Normann (2011). However, in his experiment there was a fixed number of periods, namely 15.

4 Predictions

Considering the three treatments, four different situations are possible. The matched pair of upstream firms both build a reputation, either U_1 or U_2 reveals previous prices one-sided or nobody does. Throughout the paper I will refer to a player with reputation building as "long-lived" and a player without reputation building as "short-lived" as was done for example by Fudenberg and Levine (1989).

4.1 No reputation building

Starting with the static game prediction, I analyze the best-response function of firm U_2 in a first step. Because of homogeneous products and Bertrand competition upstream, the non-integrated firm would like to undercut its rival. With discrete prices $p_i \in \{1, 2, \ldots, 9\}$ of firm U_i and production costs of zero, the best-response function reads (see table 1):

$$p_2^{BR}(p_1) = \min\left(\max(1, p_1 - 1), p^M\right)$$

whereas p^M is defined as the monopoly price in the upstream market. In my setting the monopoly price is equal to $p^M = 6$ (see table 1).

In a second step, consider the integrated firm U_1 with payoffs displayed in table 1. Despite the benefits from high input costs of D_2, the integrated firm has the incentive to undercut its rival on the input market. The gain from undercutting upstream outweigh the decrease of the raising-rivals'-costs effect as was shown by Hart and Tirole (1990) and Reiffen (1992).

$$p_1^{BR}(p_2) = \max(1, p_2 - 1)$$

Both reaction functions lead to the static Nash prediction of $\left(p_1^N, p_2^N\right)$ in equilibrium with $p_1^N := 1$ and $p_2^N := 1$.

4.2 Two-sided reputation building

The introduction of reputation building entails a dynamic component. In *Choose_Rep* both firms in the market potentially build a reputation and therefore play an infinitely repeated game. According to the folk theorem (Friedman, 1971) many outcomes can be supported in equilibrium with a grim trigger strategy. It implies cooperation in the first period and in every following period as long as the opponent always cooperated in the past. Once the opponent deviated, the static Nash prediction will be played forever.

Define Π_i^C as the coordination payoff of player i, Π_i^D as the deviation payoff and the payoff in the static game as $\Pi_i^N := \Pi_i(p_1^N, p_2^N)$. Deviation is assumed to occur in the first period because future periods are discounted, hence, the critical discount factor δ_i^{min} can be obtained:

$$\delta_i^{min} = \frac{\Pi_i^D - \Pi_i^C}{\Pi_i^D - \Pi_i^N}$$

The critical discount factor is increasing in the deviation profit, decreasing in coordination profit and increasing in the static game payoff.

In my setup and with a discount factor of $\delta = 0.9$, the set of equilibrium outcomes equals $(p_1, p_2) \in \ddot{S}^2$ with

$$\begin{aligned} \ddot{S}^2 := & \{(p_1, p_2) \,| p_1 = p_2, p_1 < 9\} \cup \left\{(p_1, p_2) \,| p_2 = p_2^{BR}(p_1), p_1 > 4\right\} \\ & \cup \{(8,7), (9,7), (9,8)\}. \end{aligned}$$

In equilibrium, the minimum price p_{min} is in the set $p_{min} \in \{1, 2, 3, 4, 5, 6, 7, 8\}$.

4.3 One-sided reputation building

Throughout this section, I assume that the long-lived player can only choose from a finite set of pure strategies. The second assumption I make is that the short-lived player $j \in \{1, 2\}$ always chooses her best reply, i.e. only outcomes for firm j and opponent $i \neq j$ in $p_j^{BR}(p_i)$ are possible. Fudenberg, Maskin and Kreps (1990) show that with these assumptions in games with one long-lived and one short-lived player a variant of the Folk theorem holds. The restriction to the best-response function of the short-lived player reduces the set of equilibrium outcomes compared to settings with two long-lived players.

One-sided reputation building of the non-integrated firm uniquely results in the static game prediction $\left(p_1^N, p_2^N\right)$. The reason is that best responses of firm U_1 always lead to zero profit for U_2 except if both choose a price of $p_1 = p_2 = 1$, i.e. $\Pi_2\left(p_1^{BR}(p_2), p_2\right) \neq 0 \Leftrightarrow p_1^{BR}(p_2) = p_2 = 1$.

In contrast, one-sided reputation building of U_1 leaves us with several equilibria. The set of equilibrium outcomes $\dot{S}^2$ equals

$$\dot{S}^2 := \{(1,1)\} \cup \left\{(p_1, p_2) \,|p_2 = p_2^{BR}(p_1), p_1 > 4\right\}$$

with $\dot{S}^2 \subset \ddot{S}^2$. Hence, the set of possible equilibria lies within the set of equilibria with two long-lived players but is strictly smaller in my setting. Market prices $p_{min} \in \{1, 4, 5, 6\}$ are supported in equilibrium.

Intuitively one would expect the long-lived player U_1 to coordinate on the equilibrium he likes the most, i.e. maximize its profit Π_1 restricted to the best response function of U_2:

$$\max_{p_1} \Pi_1(p_1, p_2^{BR}(p_1)).$$

In line with the intuition of OSS (1990) this optimization program leads to complete withdrawal (Stackelberg outcome). For the sake of convenience I denote the solution to the optimization program above with $\tilde{p}_1 \in \left\{p_1 | p_1 > p^M\right\} =: \tilde{S}_1$ and let $\tilde{p}_2 := p_2^{BR}(\tilde{p}_1) = p^M$.

Introducing uncertainty about the type of the long-lived player leads to the required restriction on the set of equilibria as was shown by Fudenberg and Levine (1989).[9] Following their line of reasoning I assume that there is a certain fraction of long-lived players whose preferences are such that the choice of $\tilde{p}_1 \in \tilde{S}_1$ is strictly favored in the repeated game. I define these long-lived players as (Stackelberg) type ω^*. Let type ω_0 be a long-lived player who prefers to undercut his rival. In addition to these two types there might be other types, for example type ω_l who strictly prefers to choose price $l \in \{1, \ldots, 6\}$ in the repeated game. Whereas the long-lived player knows his own type, the short-lived players have identical beliefs $\mu(\omega)$ about each type $\omega \in \Omega$. I assume that the short-lived players believe the probabilities of types ω^* and ω_0 are strictly positive, i.e. $\mu(\omega^*) > 0$ and $\mu(\omega_0) > 0$.

The idea of Fudenberg and Levine (1989) is the following: Suppose the short-lived players believe that some of the long-lived players, say a fraction of $\mu^* := \mu(\omega^*) > 0$,

[9] In my setting the type is not reflected in the actual payoffs, i.e. the payoff function Π_i only depends on i. I focus in my paper on heterogeneity of preferences for an equilibrium.

is initially committed to play the Stackelberg strategy $\tilde{p}_1 \in \tilde{S}_1$. For a sufficiently large discount factor, long-lived players will imitate the Stackelberg types in order to obtain profits close to $\Pi_1(\tilde{p}_1, \tilde{p}_2)$. If the long-lived player chose $\tilde{p}_1 \in \tilde{S}_1$ in every previous period, the short-lived player would become convinced after some time that he will set $\tilde{p}_1 \in \tilde{S}_1$ in the current period as well. After k periods the short-lived player will choose $\tilde{p}_2 = p_2^{BR}(\tilde{p}_1) = p^M$ because the probability she attaches to the price $\tilde{p}_1 \in \tilde{S}_1$ exceeds the required threshold. However, this does not necessarily mean that the non-integrated firm will change her belief about the type $\omega \in \Omega$ of her opponent.

Let me start with calculating the required number of periods k which are needed to convince the short-lived player to set $\tilde{p}_2$. First, it depends on the initial belief μ^*; the smaller μ^* the larger k. As I do not know anything about initial beliefs I take results from previous experiments. Normann (2011) found that 1 out of 20 participants seemed to be committed to $\tilde{p}_1 \in \tilde{S}_1$ in a treatment similar to *No_Rep*.[10] Hence, I will define $\mu^* := 0.05$ in my setting. Second, k depends on the critical fraction $\bar{f}$ of long-lived players choosing $\tilde{p}_1 \in \tilde{S}_1$. If the short-lived player chooses $\tilde{p}_2$, she either gets the monopoly profit or, in case of deviation, she gets nothing. On the other hand, U_2 can at least secure the profit from the static game prediction. With a price choice of p_2^N, she sets the lower price with a probability of at least μ^*, i.e. 39 ECU, and has to share upstream profits with a probability of at most $1 - \mu^*$. A lower bound on the fraction $\bar{f}$ can be obtained:[11]

$$99\bar{f} + 0\left(1 - \bar{f}\right) = 19.5\left(1 - \mu^*\right) + 39\mu^*$$
$$\Rightarrow \quad \bar{f} \approx 0.21$$

[10]In contrast to my setting Normann did not implement a random stopping rule but rather has a fixed number of 15 periods in his treatment. However, in *No_Rep* I find a similar fraction of Stackelberg types, 1 out of 16 participants chose without any exception a price of $\tilde{p}_1$.

[11]Because prices are not as competitive as predicted (Normann, 2011), I recalculated with actual obtained payoffs of U_2 in *No_Rep*. With an average payoff of $\Pi_2 = 37.92$, results are $\bar{f} \approx 0.38$ and $k \approx 3.12$. Hence, 3 or 4 periods might be a more realistic bound for the time needed to convince non-integrated firms. The normalized present value for integrated firms equals $(1-\delta)\,\Pi_1^{min} = 109.3$ with $k = 4$ which is still larger than the profit obtained with any other pure strategy and restriction on p_2^{BR} (compare table 1).

Obviously, there is a positive number $k > 0$ since the initial belief μ^* is strictly smaller than the required fraction $\bar{f}$ of long-lived players choosing $\tilde{p}_1$, i.e. $\mu^* < 0.21$. Fudenberg and Levine's (1989) model implies that:

$$\begin{aligned} k &= \frac{\log(\mu(\omega^*))}{\log(\bar{f})} \\ &= \frac{\log(0.05)}{\log(0.21)} \\ &\approx 1.90. \end{aligned}$$

Rounding up leads to the conjecture that the number of periods equals $k = 2$. After 2 periods of choosing $\tilde{p}_1$ the short-run player will play her best response $\tilde{p}_2$. Therefore, the long-run player can assure himself at least a payoff of:

$$\begin{aligned} \Pi_1^{min} &= 66 + 66\delta + 132\frac{\delta^2}{1-\delta} \\ &= 1194.6. \end{aligned}$$

The normalized present value is $(1-\delta)\,\Pi_1^{min}$ which equals 119.46. This threshold for the payoff of the integrated firm cannot be reached by committing to any other pure strategy.[12] Therefore, commitment to the Stackelberg outcome $(\tilde{p}_1, \tilde{p}_2)$ is the unique prediction in my experimental market.

4.4 Reputation building in *Choose_Rep*

The non-integrated firm can meet an integrated firm with or without reputation building. If the integrated firm does not build a reputation, the prediction for U_2 would not depend on whether she builds a reputation; in both cases, the static Nash prediction is the unique equilibrium. If, on the other hand, the integrated firm builds a reputation, the Stackelberg outcome, implying monopoly profits, would be an equilibrium in either case. Reputation building of U_2 is not necessary, it may

[12]It might be possible to reach a payoff of 119.46 with a mixed strategy of the long-lived player but I do not consider mixed strategies here. In addition, as Fudenberg, Maskin and Kreps (1990) have shown, for equilibria with unobservable mixed strategies, observed actions and one long- and one short-lived player the Folk theorem does not hold.

even harm the achievement of the most favored equilibrium as predictions are less distinct. In any case, there is no incentive for U_2 to choose reputation building.

In contrast, if U_2 opts against reputation building, the integrated firm would have an incentive to build a reputation. As shown in the previous subsection, one-sided reputation building of the integrated firm can lead to substantially higher payoffs. Also, if the non-integrated firm decides to reveal previous prices, there would be an incentive to show the price history as well. While one-sided reputation building of U_2 leads to the static Nash prediction, equilibria with two long-lived players are by definition strictly favorable to the static game outcome (except $\left(p_1^N, p_2^N\right)$ itself).

5 Procedures

Participants were invited via ORSEE (Greiner, 2015). Upon arrival in the laboratory, subjects were assigned the role of U_1 or U_2 which stayed the same during the whole session. After reading the instructions and having the opportunity to ask questions privately, the experiment proceeded. The experiments were programmed using zTree (Fischbacher, 2007). The number of periods for each of the four supergames were randomly predetermined to be 16, 6, 10 and 7.[13] Every subject was randomly matched with another subject in every period of the session both within and between supergames.

The experiments were conducted in the DICE laboratory at the University of Düsseldorf in June and July 2015. In each of 8 sessions between 16 and 18 subjects participated, the total number of subjects was 136. The three treatments as well as the number of subjects per treatment are summarized in table 2. Sessions took about one hour and at the end 300 ECUs (Experimental Currency Units) were exchanged for 1 Euro. Earnings were on average 15.13 Euro.

Table 2: Treatments

	No_Rep	*Choose_Rep*	*U_1_Rep*
reputation building U_1	no	optional	yes
reputation building U_2	no	optional	no
number of subjects	32	70	34

[13]Note that the expected number of periods with a random continuation rule of $\delta = 0.9$ is 10.

6 Results

In my analysis outcomes are based on all periods and all supergames. I distinguish four different subgroups of *Choose_Rep*; in *NoRep* two randomly matched firms both choose not to show their price history, in $U_i Rep$ solely firm $i \in \{1, 2\}$ decided to build a reputation whereas in *BothRep* both firms reveal previous price choices. Note that choices of one participant affect averages of at least two subgroups in the reported results. Therefore, outcomes in subgroups of *Choose_Rep* are not independent. Figure 2 and Table 2 summarize the results. Figure **??** illustrates average session prices by firm type.

6.1 Prices, Foreclosure and Monopolization

Figure 2 shows average session prices p_1 and p_2 for each treatment using all observations. Reputation building of U_1 leads to substantially higher prices for both firms, confirmed to be significant at the 1% level (Table 4, regressions (1) and (2)). Although the average price choice of U_1 is slightly larger when firms opt themselves for reputation building in *Choose_Rep*, the difference between U_1*_Rep* and $U_1 Rep$ turns out to be insignificant. Reputation building of U_2 raises prices p_1 and p_2 slightly but the effect is insignificant. I do not find any differences between supergames but there is a slight downward trend for both pricing decisions.

In a vast majority of sessions, average prices of integrated firms are larger than average price choices of non-integrated firms. In line with my predictions, the integrated firm chooses a higher price than her opponent if she builds a reputation (significant to the 1% level, see Table 4, regression (4)). Comparing outcomes in U_1*_Rep* and *No_Rep*, the integrated firm chooses in 68.78% and 48.72% of markets a strictly larger price than the non-integrated firm. Via self-selection into the subgroups of *Choose_Rep* the effect is amplified, in $U_1 Rep$ the frequency equals 75.12% and in *NoRep* I obtain 42.29%. However, the difference between subgroups of *Choose_Rep* and treatments U_1*_Rep* and *No_Rep* is insignificant (Table 4, regression (4)). Reputation building of U_2 has a negative impact on the frequency of $p_1 > p_2$ (significant to the 10% level), frequencies in *BothRep* and $U_2 Rep$ equal 67.44% and 33.33%. Compared to my predictions, the decline in *BothRep* can partly be explained by the existence of equilibria with $p_1 = p_2$ (we obtain 2% more observations with $p_1 = p_2$), the difference between *NoRep* and $U_2 Rep$ is not predicted by theory.

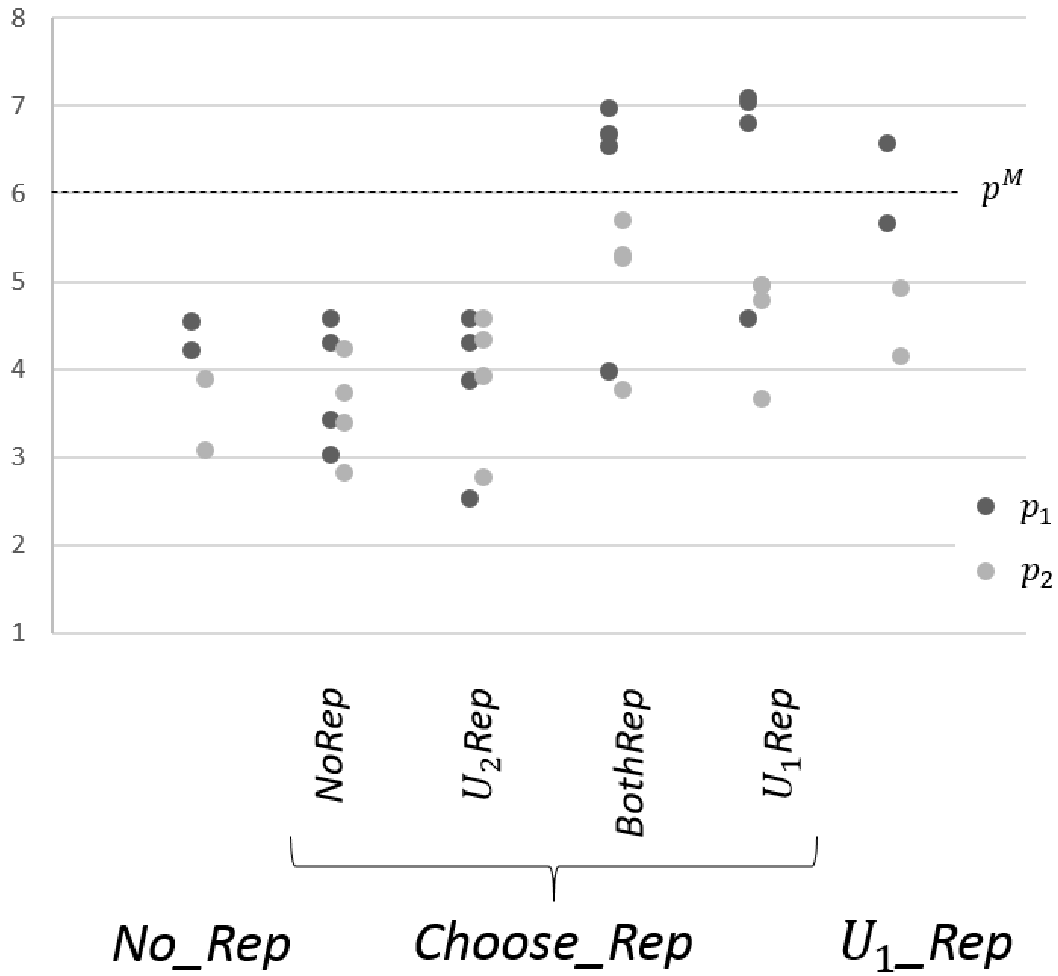

Figure 2: Average session prices

Table 3: Descriptive statistics: Prices

	No_Rep	*Choose_Rep*				*U_1_Rep*
		NoRep	*U_2Rep*	*BothRep*	*U_1Rep*	
p_{min}	2.88	2.91	3.26	4.78	4.33	4.20
	(1.35)	(1.16)	(1.44)	(1.82)	(1.78)	(1.73)
$p_1 > p_2$	48.72%	42.29%	33.33%	67.44%	75.12%	68.78%
$\tilde{p}_1$	18.11%	5.64%	5.63%	62.21%	60.70%	48.72%
$\tilde{p}_2$	9.62%	6.20%	19.05%	42.44%	36.28%	35.29%
$(\tilde{p}_1, \tilde{p}_2)$	1.12%	0.75%	2.16%	30.81%	29.07%	26.40%
Obs.	624	532	231	172	430	663

Notes: In the *Choose_Rep* treatment I distinguish four different outcomes; in *NoRep* two randomly matched firms both choose not to show their price history, in U_i*Rep* only firm $i \in \{1, 2\}$ decided to build a reputation whereas in *BothRep* both firms reveal previous price choices. Note that these outcomes are not independent, even within one supergame decisions of one firm are commonly present in two groups. I define p_{min} as the minimum price, p_i as price of U_i. $\tilde{p}_1$ denotes a price above monopoly level, i.e. total foreclosure of U_1, and $(\tilde{p}_1, \tilde{p}_2)$ total foreclosure of U_1 and the monopoly price set by U_2 which results in monopolization.

Table 3 reports the resulting minimum price for each treatment. Reputation building of U_1 has a positive and significant impact on the minimum price (significant to the 1% level, Table 4, regression (3)) whereas reputation building of U_2 does not affect the market price. The average minimum price of 4.20 in treatment *U_1_Rep* is almost 50% larger than in treatment *No_Rep* with an average minimum price of 2.88. Minimum prices in the corresponding subgroups of *Choose_Rep* are similar (4.33 in U_1*Rep* and 2.91 in *NoRep*). Reputation building of the non-integrated firm raises the average minimum price slightly (4.78 in *BothRep* and 3.26 in U_2*Rep*).

From the minimum price it is apparent that reputation building of the integrated firms leads to substantially more coordination, however, I am interested in a particular outcome: market foreclosure and monopolization.

Reputation building of the integrated firm has a major impact on the withdrawal of the integrated firm, i.e. a price choice of $\tilde{p}_1$, the choice of the monopoly price of the non-integrated firm, $\tilde{p}_2$, and successful monopolization $(\tilde{p}_1, \tilde{p}_2)$ (all significant to the 1% level, regressions (5)-(7), Table 4). Comparing outcomes in *U_1_Rep* and *No_Rep*, we observe more than 2.5 times more withdrawals of U_1 (48.72% vs. 18.11%), the integrated firm sets more than 3 times more often the monopoly price (35.29% vs. 9.62%), and successful monopolization increases by a factor of 23.6 (26.4% vs. 1.12%). The size of the effect is larger in *Choose_Rep*, that is, we observe self-selection into subgroups of *Choose_Rep*. Withdrawal of the integrated firm and successful monopolization are 10 times more common. We observe 61.13% withdrawals with and 5.64% withdrawals without reputation building which results in monopolization in 29.57% and 1.18% of markets. The effect of self-selection is solely significant for the difference of withdrawals between treatment *No_Rep* and subgroup *NoRep*.

Reputation building of the non-integrated firm in *Choose_Rep* does not affect the withdrawal of U_1, thus, it increases the frequency of the monopoly price (significant to the 1% level, regression (6) in Table 4), $\tilde{p}_2$, and monopolization $(\tilde{p}_1, \tilde{p}_2)$ (significant to the 5% level, regression (7) in Table 4). The impact of U_2's reputation building is smaller than the effect of U_1's reputation building.

Table 4

	Dependent variable						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	p_1	p_2	p_{min}	$1_{p_1>p_2}$	$1_{\tilde{p}_1}$	$1_{\tilde{p}_2}$	$(1_{\tilde{p}_1}, 1_{\tilde{p}_2})$
$1_{Rep.\ U_1}$	2.49***	1.06***	1.42***	0.87***	1.87***	1.18***	1.89***
	(0.40)	(0.11)	(0.17)	(0.21)	(0.16)	(0.15)	(0.22)
$1_{Rep.\ U_2}$	0.17	0.54	0.37	-0.23*	0.04	0.70***	0.47**
	(0.12)	(0.29)	(0.22)	(0.13)	(0.14)	(0.14)	(0.19)
$1_{Both\ Rep.}$	-0.17	0.07	0.09**	0.01	0.01	-0.53***	-0.42*
	(0.22)	(0.11)	(0.03)	(0.16)	(0.15)	(0.14)	(0.22)
1_{No_Rep}	0.61	-0.01	-0.03	0.16	0.69***	0.24	0.15
	(0.37)	(0.42)	(0.40)	(0.11)	(0.18)	(0.19)	(0.27)
$1_{U_1\_Rep}$	-0.17	-0.04	-0.13	-0.19	-0.30	-0.02	-0.07
	(0.69)	(0.44)	(0.59)	(0.26)	(0.31)	(0.28)	(0.33)
$1_{Per.\ 4-6}$	-0.35***	-0.29*	-0.24*	-0.01	-0.09	0.04	0.26***
	(0.10)	(0.15)	(0.11)	(0.08)	(0.07)	(0.09)	(0.10)
$1_{Per.\ 7-10}$	-0.67***	-0.41**	-0.40***	-0.13	-0.27***	-0.05	0.17
	(0.14)	(0.12)	(0.10)	(0.10)	(0.06)	(0.10)	(0.12)
$1_{Per.\ 11-13}$	-0.70***	-0.64***	-0.54***	-0.03	-0.22**	-0.07	0.18*
	(0.09)	(0.17)	(0.12)	(0.09)	(0.09)	(0.13)	(0.10)
$1_{Per.\ 14-16}$	-0.64***	-0.66***	-0.54**	0.02	-0.02	0.18	0.46***
	(0.15)	(0.17)	(0.18)	(0.09)	(0.04)	(0.11)	(0.12)
$1_{SG\ 2}$	-0.02	-0.09	-0.01	-0.04	0.24**	0.22*	0.45**
	(0.16)	(0.09)	(0.12)	(0.11)	(0.12)	(0.12)	(0.18)
$1_{SG\ 3}$	-0.01	-0.17	-0.12	0.05	0.23*	0.29**	0.47***
	(0.16)	(0.11)	(0.15)	(0.04)	(0.13)	(0.13)	(0.17)
$1_{SG\ 4}$	-0.05	-0.27	-0.17	0.06	0.19	0.31***	0.55***
	(0.20)	(0.20)	(0.18)	(0.11)	(0.14)	(0.11)	(0.19)
Constant	4.16***	3.90***	3.23***	-0.18**	-1.64***	-1.73***	-2.94***
	(0.33)	(0.26)	(0.32)	(0.08)	(0.14)	(0.15)	(0.19)
Obs.	2652	2652	2652	2652	2652	2652	2652
R^2	0.21	0.12	0.19				
Pseudo R^2				0.06	0.21	0.12	0.24

Notes: Columns (1)-(3) represent ordinary least square regressions and columns (4)-(7) represent probit regressions clustered at session level. All periods are included. Price choices of U_1 and U_2, the minimum price, a dummy for $p_1 > p_2$, $1_{p_1>p_2}$, total foreclosure $1_{\tilde{p}_1}$, the monopoly price set by U_2, $1_{\tilde{p}_2}$, and monopolization as a result of the withdrawal of U_1, $(1_{\tilde{p}_1}, 1_{\tilde{p}_2})$, are regressed upon dummy variables for reputation building $1_{Rep.\ U_i}$, $1_{Both\ Rep.}$, treatment dummies $1_{U_1\_Rep}$ and 1_{No_Rep}. I include dummies for different phases in the game, e.g. $1_{Per.\ 6-10}$ for periods 6 - 10, and fixed effects for the supergames, e.g. $1_{SG\ 2}$ for supergame 2. Dummies for supergames are included because Selten and Stöcker (1986) find learning effects between supergames in a finitely repeated prisoners' dilemma. Standard deviations are reported in parentheses. Significantly different from 0 in a two-tailed test at the *10% level, **5% level, ***1% level.

Figure 3 illustrates the frequency of U_1's withdrawal, U_2's monopoly price and successful monopolization (the combination of both) for each treatment over time. In U_1_*Rep* the frequency of withdrawal starts around 60% and decreases over time. The frequency of the monopoly price $\tilde{p}_2$ and successful monopolization increases in the periods 1 - 3 and follows the same time trend as the frequency of $\tilde{p}_1$ subsequently. We observe similar patterns in subgroups U_1*Rep* and *BothRep*. These patterns indicate a clear support of our predictions: While U_1 withdraws from the first period, U_2 gradually choose the best response $\tilde{p}_2$. In contrast, withdrawal is less common without reputation building of U_1 (*No_Rep* and subgroups *NoRep*, U_2*Rep*) and leads only rarely to monopolization.

6.2 Stackelberg Types

Table 5: Existence and Imitation of Stackelberg Types

	No_Rep	*Choose_Rep*		U_1_*Rep*
U_1 builds a reputation		no	yes	
$\tilde{p}_1$	9.38%	1.30%	42.86%	22.06%
whole supergame				
Obs.	64	77	63	68
$\tilde{p}_1$	6.25%	8.57%		5.88%
whole experiment				
Obs.	16	35		17

Notes:

In section 4 I used the conjecture that Stackelberg types ω^* exist, in order to refine the set of equilibria to the total foreclosure outcome $(\tilde{p}_1, \tilde{p}_2)$, $\tilde{p}_1 \in \tilde{S}_1$. In the data I find evidence in favor of the existence of Stackelberg types. In *No_Rep* and U_1_*Rep*, one out of 16 and 17 participants, respectively, chose $\tilde{p}_1$ in all 39 periods over the whole course of the experiment (Table 5). In *Choose_Rep*, 3 out of 35 integrated firms set $\tilde{p}_1$ in all periods. The results suggest that the Stackelberg type is similarly common in each treatment (around 6%, Table 5).

Based on the existence of Stackelberg types, firms learn over time to mimic their behavior. Taking now every supergame, i.e. four observations per participant,

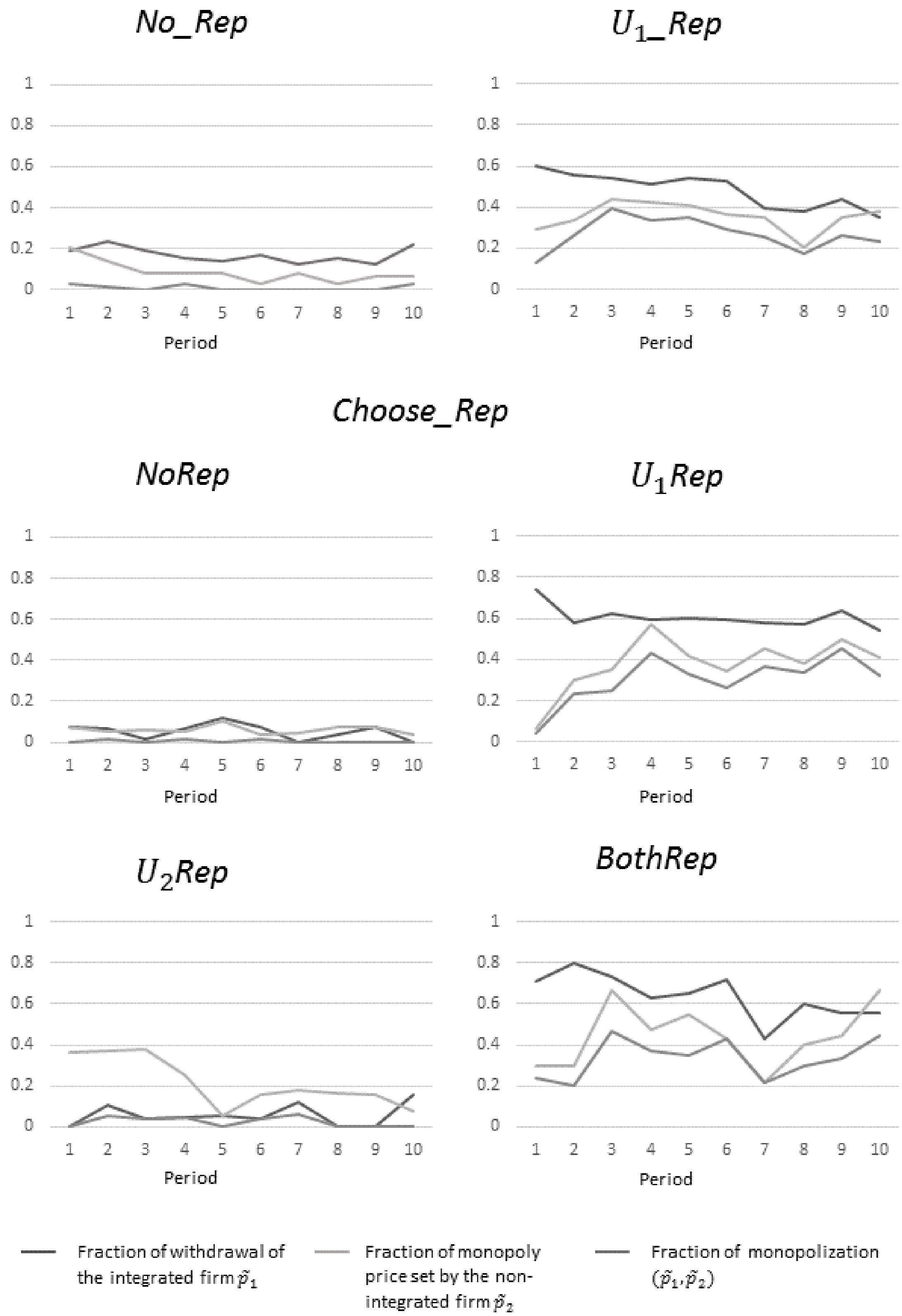

Figure 3: Withdrawal, Monopoly Price and Monopolization over Time

the fraction of firms setting $\tilde{p}_1$ in all periods of one supergame changes. Without reputation building of U_1 in *Choose_Rep*, in 6 out of 64 supergames a firm chooses $\tilde{p}_1$ in every period. In contrast, the fraction of firms withdrawing from the input market in *U_1_Rep* is four times larger than the fraction of Stackelberg types. In 15 out of 68 supergames, an integrated firm choose withdrawal in every period.

In *Choose_Rep*, we observe some self-selection into reputation building. Overall, 77 supergames exist in which the integrated firm opts against reputation building and only in one of these supergames an integrated firm withdraws from the input market in every period. In contrast, 27 of 63 supergames with reputation building of U_1 are characterized by withdrawal from the upstream market in every period. Overall, the number of supergames with withdrawal exceeds more than four times the fraction of Stackelberg types.

6.3 Beliefs of the Non-Integrated Firms

In this subsection I focus on observations in which the integrated builds a reputation. To test how total foreclosure is achieved I consider the response of U_2 to particular histories of U_1. Using a fixed effects logit model I study the relevance of three different histories (the estimation is similar to Engle-Warnick and Slonim, 2006). The grim trigger strategy mentioned in the prediction might be an explanation for successful monopolization. Grim trigger begins with cooperation, i.e. U_2 chooses $\tilde{p}_2$ in the first period, and sets $\tilde{p}_2$ in every subsequent period whenever the history of U_1 contains only $\tilde{p}_1 \in \tilde{S}_1$. I define a variable $1_{tr} := \prod_{i=1}^{t} 1_{p_1^i \in \tilde{S}_1}$ with t defined as the current period and p_1^i as price p_1 at period i. Assuming that participants are not fully rational, a relevant strategy might be the myopic best response. In the first period U_2 sets $\tilde{p}_2$ and in the following she best responds to the action taken by the opponent in the previous period.[14] The corresponding variable is defined as $1_{mbr} := 1_{t=1} + 1_{t>1}\ 1_{p_1^{t-1} \in \tilde{S}_1}$. The third strategy included accounts for the concept in the theoretical prediction, i.e. every integrated firm needs to choose k times $\tilde{p}_1 \in \tilde{S}_1$ in order to convince U_2 that he will set $\tilde{p}_1 \in \tilde{S}_1$ in the current period. The equilibrium outcome equals $p_1 = \tilde{p}_1$ in each period and $p_2 \neq \tilde{p}_2$ the first k periods and in the following periods $p_2 = \tilde{p}_2$. A definition for this strategy is $1_{fl} := 1_{t>k}\ 1_{tr}$ for period t.

[14]The tit-for-tat strategy has a similar idea and turned out to be very successful in a prisoners' dilemma (Axelrod, 1984).

Table 6 summarizes the results. Myopic best responses explain part of the observed behavior and is one of the strategies applied by the subjects (significant at 1% level). I interact strategy 1_{fl} with different phases in a supergame, i.e. periods $k+1$ to 5, periods 6 to 10 and periods 11 to 16. All interaction terms are positive and significant (at 5% level). Although, the included phases do not differ from each other. That means, while the first k periods seem to have substantially lower fractions of $\tilde{p}_2$, later phases do not significantly differ from each other. For $k = 2$ basically all potential effects of 1_{tr} are captured by 1_{mbr} and one of the interaction terms of 1_{fl}. Consequently, the effect of 1_{tr} is insignificant with $k = 2$ but positive and significant at the 1% level for $k > 2$. I conclude that all three strategies explain choice of $\tilde{p}_2$ as a strategic reaction to a price history of U_1.

Table 6: Total foreclosure strategies

	(1)	(2)	(3)
$1_{\tilde{p}_2}$	$k = 2$	$k = 3$	$k = 4$
1_{tr}	0.32	0.80***	1.13***
	(0.31)	(0.26)	(0.24)
1_{mbr}	1.94***	1.95***	1.95***
	(0.24)	(0.24)	(0.24)
1_{fl} $1_{Per.\ (k+1)-5}$	1.59***	1.42***	1.07**
	(0.36)	(0.37)	(0.48)
1_{fl} $1_{Per.\ 6-10}$	1.97***	1.49***	1.15***
	(0.41)	(0.37)	(0.35)
1_{fl} $1_{Per.\ 11-16}$	2.63***	2.19**	1.79**
	(0.91)	(0.90)	(0.88)
Obs.	1001	1001	1001

Notes: Each column (1)-(3) represents a fixed effects logit regression (subjects' choices during a whole supergame) on observations where the integrated firm builds a reputation. Note that because of the lack of variation 264 observations had to be deleted. These are, for example, observations of participants who never chose the monopoly price during a whole supergame. I include 1_{tr} as a dummy which is 1 in the first period and in every subsequent period if the history only contains prices above p^M, 1_{mbr} to control for myopic best responses, i.e. starts with 1 and equal to 1 if $1_{\tilde{p}_1}$ was chosen in the previous period. The parameter k varies between regressions (1)-(3) from $k = 2$, $k = 3$ to $k = 4$. Significantly different from 0 in a two-tailed test at the *10% level, **5% level, ***1% level.

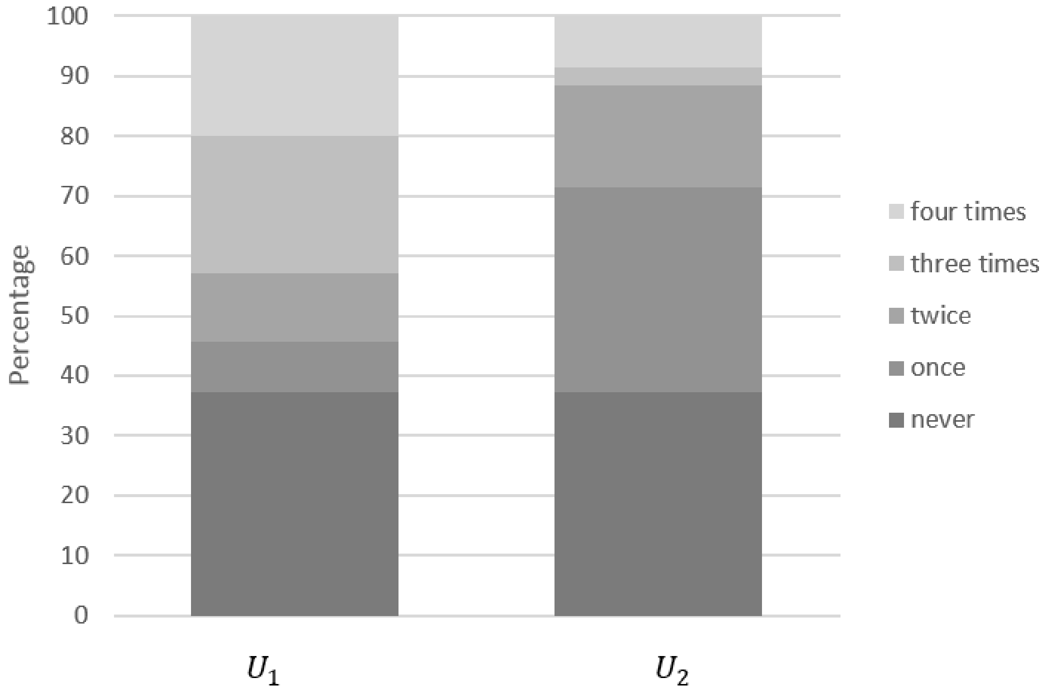

Figure 4: Reputation

6.4 Choice of Reputation building

Figure 4 summarizes the results of the reputation decision in *Choose_Rep*. Overall, the integrated firm chooses on average more often to build a reputation than the non-integrated firm.

Turning to the frequency of individual reputation decisions (Figure 3), interestingly, exactly the same percentage of U_1 and U_2 (37.14%) never build reputation (see figure 3). The remaining 62.86% of all participants differ in their behavior depending on the firm type. Almost 70% of integrated firms choose three or four times reputation (22.86% and 20%) whereas more than 80% of non-integrated firms build once or twice reputation (34.29% and 17.14%). I interpret this as learning effects.

The difference between firm types is confirmed to be significant to the 1% level (regression in Table 4). Though differences are not as pronounced as expected, the comparative static result holds.

7 Conclusion

This paper studies the impact of reputation building in a vertically related market with one integrated firm. In my experiment, I study the empirical relevance of a strategy predicted by Fudenberg and Levine (1989). Based on the assumption that a small fraction of integrated firms always withdraw from the input market, the Stackelberg types, it predicts other integrated firms to mimic this behavior. Due to reputation building of the integrated firm, the non-integrated opponent updates her belief based on previous choices of the opponent in every period. The prevalence of Stackelberg type is not large enough to assure monopolization from the first period, however, after two periods of withdrawal the non-integrated firm best responds by setting the monopoly price.

I find evidence in favor of the existence of Stackelberg types, the imitation of their behavior and the updating of beliefs of non-integrated opponents. Monopolization is reached via reputation building of the integrated firm, the impact of the reputation building of the non-integrated firm is small.

The laboratory provides a controlled environment in which the theory can be tested and causal inferences can be drawn. If anti-competitive effects due to reputation building do not materialize in the laboratory, it is unlikely that they occur in a more complex situation. Additionally, empirical studies about vertical integration and foreclose suffer from a potential endogeneity problem: Vertical integration is never exogenous to the firms.

I do not find much evidence for differences between imposed vs. non-imposed reputation building. However, for further research it might be insightful to test whether imposed reputation building of U_2 and two-sided imposed reputation in a infinitely repeated game support this conjecture. In addition, changing the default from no reputation to reputation building in *Choose_Rep* might support the hypothesis that the non-integrated firm would like to convey the impression of being a maverick. Also, more repetitions of supergames might manifest the impression that the integrated and non-integrated firms behave differently. Alternatively, one might obtain the same learning effect with less repetitions if histories of integrated firms would be revealed to other integrated firms as was done by Melis, Müller and Tremewan (2015).

References

Allain, Marie-Laure, Claire Chambolle, and Patrick Rey (2011) "Vertical Integration, Information and Foreclosure," *Working Paper*.

Allain, Marie-Laure, Claire Chambolle, and Patrick Rey (2016) "Vertical Integration as a Source of Hold-up," *The Review of Economic Studies*, 83(1): 1–25.

Allain, Marie-Laure, Claire Chambolle, and Patrick Rey (2015) "Vertical Integration as a Source of Hold-up: an Experiment," *Working Paper EARIE 2016*.

Axelrod, Robert (1984) "The evolution of cooperation," New York: Basic Books

Bohnet, Iris, Heike Harmgart, Steffen Huck and Jean-Robert Tyran (2005) "Learning Trust," *Journal of the European Economic Association*, 3(2-3): 322–329.

Bohnet, Iris and Steffen Huck (2004) "Repetition and Reputation: Implications for Trust and Trustworthiness When Institutions Change," *The American Economic Review*, 94(2): 362–366.

Bolton, Gary E., Elena Karok and Axel Ockenfels (2004) "How Effective Are Electronic Reputation Mechanisms? An Experimental Investigation," *Management Science*, 50(11): 1587–1602.

Bolton, Patrick and Michael D. Whinston (1991) "The "Foreclosure" Effects of Vertical Mergers," *Journal of Institutional and Theoretical Economics*, 147: 207 – 226.

Camerer, Colin and Keith Weigelt (1988) "Experimental Test of a Sequential Equilibrium Reputation Model," *Econometrica*, 56: 1–36.

Chen, Yongmin (2001) "On Vertical Mergers and Their Competitive Effects," *RAND Journal of Economics*, 32: 466–496.

Choi, Jay Pil, and Sang-Seung Yi (2000) "Vertical foreclosure with the choice of input specifications," *RAND Journal of Economics*, 717–743.

Church, Jeffrey and Neil Gandal (2000) "System Competition, Vertical Merger and Foreclosure," *Journal of Economics & Management Strategy*, 9(1): 25–51.

Dal Bó, Pedro (2005) "Cooperation under the Shadow of the Future: Experimental Evidence from Infinitely Repeated Games," *American Economic Review*, 95: 1591–1604

Dal Bó, Pedro and Guillaume R. Fréchette (2011) "The Evolution of Cooperation in Infinitely Repeated Fames: Experimental Evidence," *The American Economic Review*, 101(1): 411–429

Durham, Yvonne (2000) "An experimental examination of double marginalization and vertical relationships," *Journal of Economic Behavior and Organization*, 42(2): 207–229.

Engle-Warnick, Jim and Robert L. Slonim (2006) "Inferring repeated-game strategies form actions: evidence from trust game experiments," *Economic Theory*, 28: 603–632

Fischbacher, Urs (2007) "ZTree: Zurich Toolbox for Readymade Economic Experiments," *Experimental Economics*, 10: 171–178.

Friedman, James W. (1971) "A Non-cooperative Equilibrium for Supergames," *The Review of Economic Studies*, 38(1): 1-12.

Fudenberg, Drew, David M. Kreps and Eric S. Maskin (1990) "Repeated Games with Long-run and Short-run Players," *Review of Economic Studies*, 57: 555–573.

Fudenberg, Drew and David K. Levine (1989) "Reputation and Equilibrium Selection in a Games with a Patient Player," *Econometrica*, 57: 759–778.

Gayle, Wayne-Roy, Robert C. Marshall, Leslie M. Marx, and Jean-FranÃ§ois Richard (2011) "Coordinated Effects in the 2010 Horizontal Merger Guidelines," *Review of Industrial Organization* 39(1-2): 39–56.

Greiner, Ben (2015) "Subject pool recruitment procedures: organizing experiments with ORSEE," *Journal of the Economic Science Association*, 1(1): 114–125.

Grosskopf, Brit and Rajiv Sarin (2010) "Is Reputation Good or Bad?," *American Economic Review*, 100: 2187–2204.

Hart, Oliver and Jean Tirole (1990) "Vertical Integration and Market Foreclosure," *Brookings Papers on Economic Activity (Microeconomics)*, 205–276.

Huck, Steffen, Gabriele K. Lünser and Jean-Robert Tyran (2012) "Competition fosters trust" *Games and Economic Behavior*, 76: 195–209.

Kartal, Melis, Wieland Müller and James Tremewan (2015) "Gradualism in Repeated Games with Hidden Information: An Experimental Study," mimeo.

Keser, Claudia (2002) "Trust and reputation building in e-commerce," Working paper, IBM, New York.

Kreps, David M. and Robert Wilson (1982) "Reputation and Imperfect Information," *Journal of Economic Theory*, 27: 253–279.

Martin, Stephen, Hans-Theo Normann and Christopher M. Snyder (2001) "Vertical Foreclosure in Experimental Markets," *Rand Journal of Economics*, 32: 466–496.

Marshall, Robert C., Leslie Marx, Lily Samkharadze, and Maarten Pieter Schinkel (2016) "Monopolization conduct by cartels," Working paper.

Mason, Charles F. and Owen R. Phillips (2000) "Vertical integration and collusive incentives: an experimental analysis" *International Journal of Industrial Organization*, 18: 471–496.

Milgrom, Paul and John Roberts (1982) "Predation, Reputation and Entry Deterence," *Econometrica*, 50: 443–460.

Moellers, Claudia, Hans-Theo Normann and Christopher M. Snyder (2016) "Communication in Vertical Markets: Experimental Evidence," NBER Working Paper No. 22219

Mouraviev, Igor and Patrick Rey (2011) "Collusion and Leadership," *International Journal of Industrial Organization*, 29: 705–717.

Neral, John and Jack Ochs (1992) "The Sequential Equilibrium Theory of Reputation Building: A Further Test," *Econometrica*, 60: 1151–1169.

Nocke, Volker and Lucy White (2007) "Do Vertical Mergers Facilitate Upstream Collusion?" *American Economic Review*, 97: 1321–1339.

Normann, Hans-Theo (2009) "Vertical integration, raising rivals' costs and upstream collusion," *European Economic Review*, 53(4): 461–480.

Normann, Hans-Theo (2011) "Vertical mergers, foreclosure and raising rivals' costs - Experimental evidence," *The Journal of Industrial Economics*, 59: 506 –527.

Ordover, Janusz A., Garth Saloner and Steven C. Salop (1990) "Equilibrium Vertical Foreclosure," *American Economic Review*, 80: 127–142.

Ordover, Janusz A., Garth Saloner and Steven C. Salop (1992) "Equilibrium Vertical Foreclosure: Reply," *American Economic Review*, 82: 698–703.

Reiffen, David (1992) "Equilibrium Vertical Foreclosure: Comment," *American Economic Review*, 82: 694–697.

Salinger, Michael A. (1988) "Vertical mergers and market foreclosure," *The Quarterly Journal of Economics*, 345-356.

Salop, Steven C. and Daniel P. Culley (2015) "Revising the US vertical merger guidelines: policy issues and an interim guide for practitioners," *Journal of Antitrust Enforcement*, 4(1): 1–41.

Selten, Reinhard (1978) "The chain store paradox," *Theory and Decision*, 9: 127–159.

Selten, Reinhard and Rolf Stoecker (1986) "End behavior in sequences of finite prisoner's dilemma supergames: A learning theory approach," *Journal of Economic Behavior and Organisation*, 7: 47–70.

Appendix: Instructions

Instructions in *No_Rep*

In this experiment you will make decision in a fictitious market. Please take your time to read the instructions carefully. By understanding the instructions accurately and by well conceived decisions you can earn a substantial amount of money in the experiment. Your earnings will be paid out to you in cash at the end of the experiment.

Your role and your task in this experiment

Every participant will represent a firm in this experiment. There are two types of firms: firm 1 and firm 2. The computer will allocate half of the participants the role of firm 1 and the other participants the role of firm 2. Your role as firm 1 or firm 2 stays the same over the whole experiment. You will get to know at the beginning of the experiment whether you are firm 1 or firm 2.

One firm 1 and one firm 2 will meet in a market for a fictitious good. This market will be named market A. Firm 1 - but not firm 2 - operates in a second market, market B.

The computer will randomly determine in every period one firm 1 and one firm 2 who meet in market A. Which firms are selected is completely random, i. e. there is no connection between the participant with whom you were matched last period and the participant who is assigned to you by lot in this period.

Your task is the same in each period, irrespectively of whether you are firm 1 or firm 2: You have to decide upon a price. This price can be an integer between 1 and 9. The profit, which you can make via your price choice, can be calculated as follows.

Profit calculation

In market A holds that

- the firm with the lowest price makes the profit which you can learn from the following table (profits in points).
- the firm with the highest of both prices does not get any profit in this period.
- in case both choose the same price, the profit in the table will be separated

Here are two examples for market A.

Price	Profit in market A in points	Profit in market B in points (only firm 1)
1	39	66
2	54	75
3	69	84
4	81	96
5	90	105
6	99	132
7	90	159
8	72	180
9	51	198

i If you set a price of 7 and the other firm a price of 4, you will get a profit of zero and the other firm a profit of 81 points in market A.

ii If both of you choose a price of 3, then both firms get a profit of $69/2 = 34.5$ points in market A.

In market B only firm 1 gets a profit - the profit in the column with "market B". Like already in market A the lower of both prices decides about the profit, regardless of whether firm 1 or firm 2 has chosen it. Here an example for market B. If firm 1 sets a price of 7 and firm 4 a price of 4, then firm 1 will get a profit of 96 in market B.

Let us consider both markets together, firm 1 gets a profit from market A plus the one from market B. In our example this would be 96 points. Firm 2 gets no profit in market B, but in market A and therefore 81 points.

Procedure and End of the experiment

In every period both firms choose a price. At the end of each period every firm gets the following feedback: the own price, the price of the other firm and the own profit gained in this period.

There will be 4 rounds. In each round it is randomly determined how many periods take place. Before the beginning of each period it is drawn by lot whether the period will take place. With a chance of 90% the period takes place, with a chance of 10% the round stops.

After 4 rounds you get your whole profit. For each 300 points you get 1 Euro cash. In addition, you get 4 Euros.

Additional Instructions for U_1_***Rep***

Information

As already mentioned, the firm you will meet in market A is randomly determined in each period. However, firm 2 gets information about firm 1. In contrast, firm 2 does not get the information about firm 2.

Firm 2 can observe prices of firm 1 in the previous periods of the current round while setting the price. That means, there is a table displayed on the screen with all previous periods and the corresponding price of firm 1. Firm 2 can only observe prices of the current market participant firm 1. (There is an example for the table presented below.)

In contrast, firm 1 only knows the own pricing decisions.

Additional Instructions for ***Choose_Rep***

Information

As already mentioned, the firm you will meet in market A is randomly determined in each period. However, both firms might get additional information about the other firm.

At the beginning of each round you can decide whether the other firms can observe your previous prices. If you decide to reveal your price information, the other firm will observe prices from every previous period in the current round while setting the price. That means, there is a table displayed on the screen with all previous periods and your corresponding price choices. (There is an example for the table presented below.)