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Reputation and Foreclosure with Vertical Integration – Experimental Evidence

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Abstract: Building on the seminal paper of Ordover, Saloner and Salop (1990), I study the role of reputation building on foreclosure in laboratory experiments. In one-shot interactions, upstream firms can choose to build a reputation by revealing their price history to the current upstream competitor. In particular, integrated firms can establish a reputation to foreclose the input market—an outcome that would otherwise not be tenable due to a commitment problem. I get three main results: First, withdrawal from the input market is three times more common with reputation building of the integrated firm. Second, the anticompetitive effects are much stronger when the integrated firm builds a reputation. Third, integrated firms choose to build a reputation significantly more often than non-integrated firms. Markets with reputation building of the integrated firm are ten times more often monopolized than without.

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1 Introduction

In 2008, the European Commission conducted an antitrust investigation against E.ON AG Düsseldorf. E.ON was accused of withholding capacity in the wholesale market for energy. In an official statement, the European Commission raised the concern that E.ON had been "deliberately not offering for sale the production of certain power stations which was available and economically rational, with a view to raising electricity prices to the detriment of consumers".[1] E.ON offered to divest energy generation capacity which was accepted by the European Commission.

Input foreclosure was first analyzed in Ordover, Saloner and Salop (1990, henceforth OSS), Hart and Tirole (1990) and Salinger (1988). With duopolies on either production level and one vertically integrated firm, OSS (1990) state that the integrated firm refrains from supplying the downstream rival. This strategy is profitable because the remaining upstream competitor gains monopoly power and therefore increases the price for the input good dramatically. On the downstream level, the non-integrated competitor suffers from increased input prices and the downstream division of the integrated firm profits through the raising-rivals'-costs effect. However, Hart and Tirole (1990) and Reiffen (1992) challenged the assumption of the capability to commit and argued that absent this assumption foreclosure is not a Nash equilibrium. Assuming Bertrand competition upstream, they argue that the integrated firm has an incentive to undercut the upstream rival. In addition to the still existent cost advantage downstream, the upstream division would gain almost monopoly profits.

The critique of Hart and Tirole (1990) and Reiffen (1992) leaves open the possibility that integrated firms may seek opportunities to commit whereas non-integrated firms would not. Indeed, in their reply, OSS (1992) 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). Such differences in behavior may occur when chances to commit are present: what OSS (1992) show is that integrated firms have an incentive to jump at such opportunities whereas non-integrated firms have no such incentives.

[1]See *Antitrust: Commission market tests commitments proposed by E.ON concerning German electricity markets*, Memo European Commission, 12 June 2008, available at `http://europa.eu/rapid/press-release_MEMO-08-396_en.htm?locale=en`

In this paper I analyze the impact of the possibility to build a reputation on prices and upstream foreclosure if one firm is vertically integrated. Reputation is built by revealing the price history to the competitor. I address four questions: Do integrated and non-integrated firms behave differently with respect to building a reputation? Does reputation building entail anticompetitive effects by raising the price for the input good? Does establishing a reputation enable the integrated firm to commit to a high price? Consequently, does foreclosure translate into monopolization of the input market?

In an experiment, I conducted three treatments.[2] The treatment *Choose_Rep* is structured in two stages. In the first stage, both upstream firms decide whether they want to build a reputation, hence, reveal their price history to the competitor. 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 changes and the second stage is exactly the same as in *Choose_Rep*. In U_1*_Rep* one-sided reputation building of U_1 is imposed. That is, the non-integrated upstream firm learns all previous price choices of the opponent, while the integrated firm cannot observe the price history of the competitor. A setting without reputation building is studied in *No_Rep*. Thus, no upstream firm learns the previous price choices of the actual competitor.

While one-sided reputation building seems intuitive for seller – buyer relationships, it might be less plausible in a setting with two firms. Intuitively, one-sided reputation building of the integrated firm can be interpreted as the incentive of the non-integrated rival to behave like a "maverick". Maverick firms are tough competitors and attract attention from antitrust authorities as they are known to ensure effective competition. In the Non-Horizontal Merger Guidelines of the European Commission a maverick is defined as "a supplier that for its own reasons is unwilling to accept the co-ordinated outcome and thus maintains aggressive competition."[3].[4] By opting against reputation building, the non-integrated firm can commit to best

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

[3]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`

[4]Note that 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)

respond to any action taken by the opponent. Accordingly, the integrated firm can use reputation building to pick an outcome on the best response function of the opponent. In my setting, a non-integrated maverick firm might even support the cooperative foreclosure outcome instead of destabilizing it.

In theory, one-sided reputation building turns out to be an equilibrium in the predictions of *Choose_Rep*, i.e. the integrated firm builds a reputation whereas the non-integrated firm does not. Why is that? Whether foreclosure and monopolization is an equilibrium does not depend on the non-integrated firm's decision about reputation building. In contrast, reputation building of the integrated firm is essential for foreclosure to be an equilibrium (Hart and Tirole, 1990, Reiffen, 1992). With two-sided reputation building, the grim trigger strategy[5] (Friedman, 1971) supports multiple outcomes in equilibrium, including foreclosure and monopolization. One-sided reputation building restricts the set of equilibria to the outcomes on the best response function of the non-integrated firm (Fudenberg, Maskin and Kreps, 1990). Obviously, equilibria beyond her best response function are strictly worse for the non-integrated firm. Moreover, with two-sided reputation, foreclosure and monopolization is not the payoff dominant[6] equilibrium in pure strategies anymore. Hence, the non-integrated firm might opt against reputation building to facilitate coordination on her favorite outcome and obtain monopoly profits.

Introducing uncertainty about the "type" of integrated firm who builds one-sided reputation leads to a unique prediction in pure strategies. The theoretical model of Fudenberg and Levine (1989) predicts the withdrawal of the integrated firm and monopoly prices in the input market after a finite number of periods. Results of Normann (2011) suggest that even in a static setting a small fraction of integrated firms are committed to foreclose the market. I will name these firm "Stackelberg"[7] types. The model of Fudenberg and Levine (1989) has the following intuition: Non-

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

[6]Payoff dominance is a refinement of equilibria established by Harsanyi and Selten (1988). A payoff dominant Nash equilibrium is Pareto superior to all other equilibria.

[7]As other authors have done before, I name the total foreclosure outcome also as "Stackelberg outcome" with the corresponding "Stackelberg strategies". The reason is that the Stackelberg outcome would result with sequential price choices with the integrated firm being the first mover (Mouraviev and Rey, 2011). Because the raising-rivals'-costs effect is largest, the Stackelberg strategy is the pure strategy the integrated firm favors the most on the best-response function of the non-integrated firm. Consequently, the Stackelberg outcome involves withdrawal of the integrated firm and monopolization of the input market.

integrated firms have identical beliefs about types of integrated firms they face in the market. They believe that some integrated firms are committed to the Stackelberg strategy whereas others simply maximize their profits. With one-sided reputation of the integrated firm, profit maximizers start to imitate Stackelberg types. Why is that? By acting like the Stackelberg type and a sufficiently high discount factor, the profit maximizer can obtain almost Stackelberg profits. How? The integrated firm chooses the Stackelberg strategy in each period. The non-integrated firm observes the price history of her opponent and decides upon her own price. In the first periods she is still not convinced that the integrated firm will forgo upstream profits and sets a price strictly below the monopoly level. After a finite number of periods, the probability she attaches to total foreclosure of the integrated firm in the current period is sufficiently high and she best responses by setting the monopoly price. While she is not convinced that her opponent is actually the Stackelberg type, she believes that he will act as if he was. For the integrated firm his patience is beneficial as long as the future is "important enough".

My experimental evidence supports the predictions. The integrated firm chooses to build a reputation significantly more often compared to the non-integrated firm. In fact, one-sided reputation building seems to be empirically relevant. Furthermore, while reputation building of the non-integrated firm does not entail anticompetitive effects, reputation building of the integrated firm leads to substantially higher market prices and more foreclosure. This includes the price of the integrated firm, which increases on average by more than 50%, and the price of the non-integrated firm raises by more than 25%. Resulting in an increase of costs for the independent downstream firm by around 45%. Foreclosure occurs at least three times more often when the integrated firm builds a reputation. In *Choose_Rep* the integrated firm opts himself for reputation building which leads to an even larger difference: withdrawal of the integrated firm raises from around 6% to more than 60% of markets. Finally, foreclosure results in monopolization in less than 2.5% of observations without reputation building of the integrated firm and in more than 25% of observations with reputation building.

While it is clear from a theoretical perspective that reputation building introduces repeated-game effects to the static game and may result in (loosely speaking) collusive or foreclosure effects, there are many ways of how precisely collusive or foreclosure effects may occur. I tested the relevance of three different strategies for non-integrated firms based on the observed price history of the opponent. The described grim trigger strategy is applied for predictions in games with repeated interaction. It translates into choosing the monopoly price in the first period and in every subsequent period if the opponent always withdrew from the input market. Another strategy is based on a model by Fudenberg and Levine (1989). Here, the non-integrated firm needs to be convinced, that the integrated firm withdraws from the input market and monopolization occurs only after several periods. Finally, assuming that not all participants consider the whole price history, I tested a myopic best reply strategy[8]. This strategy assumes that the participant will always best reply to any action taken by the opponent in the previous period. I find evidence for the existence of all three strategies. Hence, the strategies are empirically relevant and were actually exerted by participants.

The paper is structured as follows. I will start with a short summary of the related literature, bringing together theoretical and experimental papers on vertical markets and reputation. In the subsequent section I describe the experimental design followed by the predictions. The results section studies anticompetitive effects, i.e. selling prices for the input good, proceeds with individual prices of upstream firms and partial foreclosure and closes with total foreclosure, monopolization and foreclosure strategies. Finally, I conclude.

2 Related literature

In this section, I summarize part of 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 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

[8]The myopic best reply strategy is in line with the tit-for-tat strategy suggested in Axelrod (1984).

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. Möllers, 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 if 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 preplay 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.

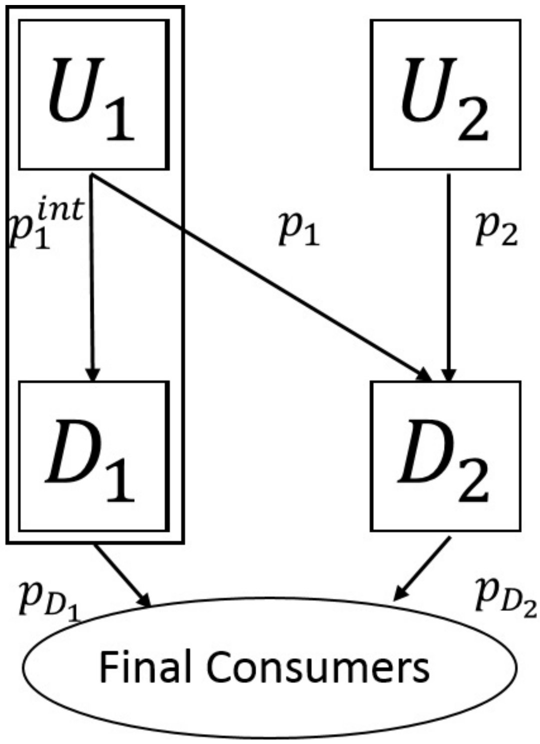

Figure 1: Market Structure

3 Experimental market

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, U_1 and U_2, produce a homogeneous input good with constant marginal cost 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 $i, j \in \{1, 2\}$.[9]

[9] 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. 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) and 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 baseline treatment, *No_Rep*, none of the firms gets information about previous prices of the opponent, thus, this setting represents a static game. In contrast, in treatment *U_1_Rep* firm U_2 observes the price history 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.

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).[10] 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 $\mu^* := \mu(\omega^*) > 0$, 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

[10] 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.

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*.[11] 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:[12]

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

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:

[11] 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 $\tilde{p}_1$.

[12] 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).

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

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.[13] Therefore, commitment to the Stackelberg outcome $(\tilde{p}_1, \tilde{p}_2)$ is the unique prediction in my experimental market.

5 Hypotheses

In this section I will state my hypotheses based on the theoretical predictions. Before I hypothesize outcomes of all three treatments, I make some definitions for the sake of clarity.

Definition. Let anticompetitive effects be defined as a comparative static change which raises p_{min} significantly.

As p_{min} equals input costs for the independent downstream firm, it determines the price setting downstream and therefore the consumer surplus.

[13] 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.

Definition. Partial input foreclosure (alternatively partial foreclosure) occurs when the integrated firm sets on average larger prices than the non-integrated firm, i.e. the fraction of $p_1 > p_2$ is larger than the percentage of $p_1 < p_2$.[14]

Definition. Total input foreclosure (alternatively total foreclosure) occurs when the price of the integrated firm is above the monopoly price, i.e. $\tilde{p}_1 \in \tilde{S}_1$. That is, the integrated firm withdraws from the market.

The decision about reputation building in *Choose_Rep* is relevant for the predictions in the pricing stage, consequently, I begin with the hypothesis about the choice of reputation building.

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 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).

Hypothesis 1. In *Choose_Rep* the integrated firm decides in favor of reputation building whereas the non-integrated firm opts against it.

Hypotheses do not differ between *U_1_Rep* and *Choose_Rep* because I do not expect differences between imposed reputation building of U_1 and the outcome of reputation building decisions, i.e. U_1 opts for reputation building whereas U_2 decides against it. Concerning anticompetitive effects I hypothesize:

[14]Because only U_1 has an incentive to foreclose the market, I focus on foreclosure of the integrated firm.

Hypothesis 2. In *No_Rep* the selling price is $p_{min} = 1$.[15]

Hypothesis 3. *U_1_Rep* entails anticompetitive effects compared to *No_Rep*.

Hypothesis 4. *Choose_Rep* entails anticompetitive effects compared to *No_Rep*.

In general, total foreclosure implies partial foreclosure. Theoretically, one-sided reputation building of U_1 restricts the set of equilibria to the total foreclosure outcome.[16] Therefore, I hypothesize about foreclosure:

Hypothesis 5. In *No_Rep* neither partial nor total foreclosure occurs.

Hypothesis 6. In *U_1_Rep* total foreclosure occurs more often than in *No_Rep*.

Hypothesis 7. In *Choose_Rep* total foreclosure occurs more often than in *No_Rep*.

The response of the non-integrated upstream firm to total foreclosure is relevant for the input prices of the independent downstream firm D_2, therefore, also for prices downstream and consumer surplus. According to the theoretical prediction, I expect that U_2 chooses a price $p_2 < \tilde{p}_2$ in the first k periods and afterwards, provided that U_1 totally foreclosed the market in every previous period, sets a price $p_2 = \tilde{p}_2$. Consequently, I hypothesize:

Hypothesis 8. Total foreclosure of U_1 in *U_1_Rep* and *Choose_Rep* leads to monopoly prices after k periods.

6 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.[17] Every subject was

[15]Note that from earlier experiments (Normann, 2011) it is known that even with random matching and finitely repeated interaction, partial foreclosure, i.e. $p_1 > p_2$, and selling prices above Nash occur.

[16]However, without the introduction of different types ω, several outcomes were supported in equilibrium. Except the static Nash prediction all of them implied $p_1 > p_2$ but not necessarily $p_1 \in \tilde{S}_1$.

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

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*
random matching	yes	yes	yes
reputation building U_1	no	optional	yes
reputation building U_2	no	optional	no
number of subjects	32	70	34

7 Results

In the first subsection I present the results of the choice of reputation building in *Choose_Rep*. I proceed with anticompetitve effects, partial foreclosure and finally analyze total foreclosure. Whenever necessary I distinguish four different outcomes in the *Choose_Rep* treatment; 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.

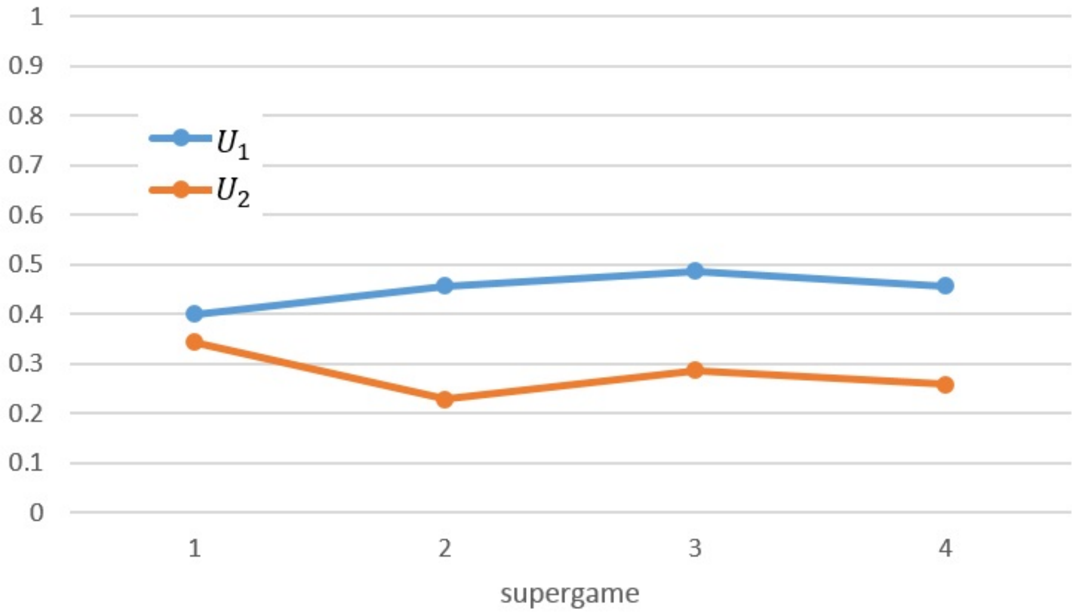

Figure 2: Fraction of reputation building

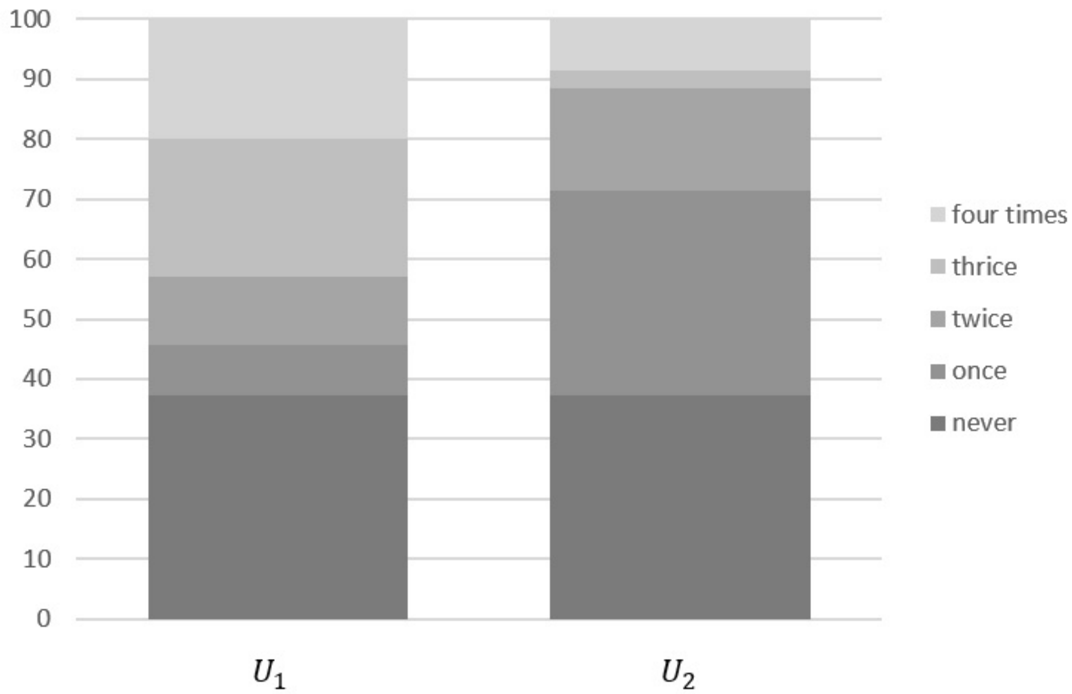

Figure 3: Frequency of reputation building

7.1 Choice of reputation building

Figure 2 depicts the fraction of U_1 and U_2 choosing to build a reputation in *Choose_Rep* for each supergame. On average, the integrated firm U_1 chooses more often to build a reputation than the non-integrated firm U_2 in all four supergames. However, in contrast to the conjecture, a substantial fraction (more than 50%) of integrated firms opts against reputation building in each supergame and around 25% of U_2's build a reputation.

Turning to the frequency of the individual choice to build a reputation (figure 3), exactly the same percentage of U_1 and U_2 (37.14%) never opts for it. The remaining 62.86% of all participants differ in their behavior depending on the firm type. The majority of integrated firms choose to build a reputation three or four times (22.86% and 20%) whereas the majority of non-integrated firms build a reputation once or twice (34.29% and 17.14%). This might be interpreted as learning effects.

The difference between firm types is confirmed to be significant at the 1% level (regression (1) in table 4[18]). While the comparative static result holds, differences are less pronounced than expected.

Result 1. Hypothesis 1 cannot be rejected, integrated firms opt for reputation building significantly more often than non-integrated firms.

[18]Throughout the analysis, I define dummy 1_E to be equal to 1 if statement E, i.e. equality or inequality E, holds and 0 otherwise.

Table 3: Descriptive statistics

	No_Rep	*Choose_Rep*				U_1*_Rep*
		NoRep	U_2*Rep*	*BothRep*	U_1*Rep*	
p_{min}	2.87	2.91	3.26	4.72	4.32	4.18
	(1.35)	(1.16)	(1.44)	(1.82)	(1.78)	(1.73)
p_{min}	2.87	3.65				4.18
	(1.35)	(1.68)				(1.73)
$p_1 > p_2$	48.71%	42.29%	33.33%	67.44%	75.12%	68.78%
$p_1 < p_2$	30.61%	31.2%	40.69%	18.02%	12.33%	18.25%
$p_1 = p_2$	20.67%	26.5%	25.97%	14.53%	12.55%	12.97%
$\tilde{p}_1$	18.11%	5.64%	5.63%	62.21%	60.7%	48.72%
$(\tilde{p}_1, \tilde{p}_2)$	1.12%	0.75%	2.16%	30.81%	29.07%	26.4%
Obs.	624	532	231	172	430	663
$\tilde{p}_1$	6.25%	8.57%				5.88%
whole session						
Obs.	16	35				17
$\tilde{p}_1$	9.38%	1.3%		42.86%		22.06%
whole supergame						
Obs.	64	77		63		68

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 probably present in two groups. I define p_{min} as the selling price upstream, 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 of the input market. I have three different levels for total foreclosure, $\tilde{p}_1$ counts each period as single observation, $\tilde{p}_1$ "whole session" means that this participant chose $\tilde{p}_1$ in each and every period of the whole session and finally, $\tilde{p}_1$ "whole supergame" is the fraction of total foreclosure in each and every period of one supergame. Standard deviations are reported in parentheses. Note that I normalized prices above 7 to to 7 for both firms.

Table 4: Choice of reputation building and anticompetitive effects

	Dependent variable			
	(1)	(2)	(3)	(4)
	1_{Rep}	p_{min}	p_{min}	p_{min}
1_{U_1}	0.46***			
	(0.11)			
$1_{Rep.\ U_1}$				1.43***
				(0.16)
$1_{Rep.\ U_2}$				0.37
				(0.22)
$1_{Both\ Rep.}$				0.07
				(0.04)
1_{No_Rep}		-0.78	-1.04**	-0.03
		(0.44)	(0.43)	(0.4)
$1_{U_1\_Rep}$		0.54	0.6	-0.14
		(0.55)	(0.56)	(0.59)
$1_{Per.\ 6-10}$		-0.32***	-0.3***	-0.32***
		(0.06)	(0.06)	(0.06)
$1_{Per.\ 11-16}$		-0.42**		-0.42**
		(0.12)		(0.12)
$1_{SG\ 2}$		0.04		0.03
		(0.09)		(0.12)
$1_{SG\ 3}$		-0.05	-0.1	-0.1
		(0.15)	(0.12)	(0.15)
$1_{SG\ 4}$		-0.11	-0.16	-0.14
		(0.2)	(0.16)	(0.18)
Constant	-0.59***	3.85***	3.94***	3.13***
	(0.08)	(0.38)	(0.36)	(0.33)
Obs.	280	2652	1564	2652
R^2		0.09	0.12	0.19
Pseudo R^2	0.02			

Notes: Column (1) shows results of a probit regression of the reputation building on firm type clustered at session level. Columns (2)-(4) represent an ordinary least squares regression clustered at session level. Except in regression (2) all periods are included. Minimum prices are regressed upon dummy variables for reputation, imposed reputation and no reputation building. I include dummies for different phases in the game, e.g. $1_{Per.\ 6-10}$ for periods 6 - 10, and the number of the supergame, e.g. $1_{SG\ 2}$ for supergame 2. Dummies for supergames are included as Selten and Stöcker (1986) find learning effects between supergames in a finitely repeated prisoners' dilemma. Standard deviations are reported in parentheses. Note that I normalized prices above 7 to 7 for both firms. Significantly different from 0 in a two-tailed test at the *10% level, **5% level, ***1% level.

Table 5: Partial and total foreclosure

	Dependent variable					
	(5)	(6)	(7)	(8)	(9)	(10)
	p_1	p_2	$1_{p_1>p_2}$	$1_{p_1>p_2}$	$1_{\tilde{p}_1}$	$1_{\tilde{p}_1}$
$1_{Rep.\ U_1}$	2.06***	1.06***		0.88***		1.87***
	(0.28)	(0.11)		(0.21)		(0.15)
$1_{Rep.\ U_2}$	0.19	0.55*		-0.23*		0.05
	(0.13)	(0.27)		(0.13)		(0.14)
$1_{Both\ Rep.}$	-0.17	-0.004		0.00		0.00
	(0.11)	(0.12)		(0.16)		(0.16)
1_{No_Rep}	0.44	-0.01	-0.14	0.16	-0.39***	0.69***
	(0.38)	(0.41)	(0.11)	(0.11)	(0.15)	(0.18)
$1_{U_1\_Rep}$	-0.3	-0.04	0.38**	-0.19	0.49**	-0,3
	(0.61)	(0.45)	(0.16)	(0.26)	(0.24)	(0.31)
$1_{Per.\ 6-10}$	-0.46***	-0.31***	-0.13***	-0.14***	-0.14***	-0.16***
	(0.09)	(0.08)	(0.05)	(0.05)	(0.04)	(0.05)
$1_{Per.\ 11-16}$	-0.48***	-0.52***	-0.00	-0.00	0.23	-0.03
	(0.12)	(0.11)	(0.07)	(0.07)	(0.14)	(0.05)
$1_{SG\ 2}$	-0.02	-0.05	0.00	-0.04	0.27**	0.27**
	(0.13)	(0.09)	(0.1)	(0.1)	(0.11)	(0.12)
$1_{SG\ 3}$	-0.06	-0.16	0.1*	0.06	0.27**	0.23*
	(0.13)	(0.13)	(0.05)	(0.04)	(0.13)	(0.13)
$1_{SG\ 4}$	-0.06	-0.23	0.09	0.05	0.23	0.21
	(0.17)	(0.2)	(0.11)	(0.11)	(0.14)	(0.15)
Constant	3.98***	3.74***	0.11	-0.17*	-0.63***	-1,68***
	(0.32)	(0.28)	(0.07)	(0.1)	(0.12)	(0.13)
Obs.	2652	2652	2652	2652	2652	2652
R^2	0.21	0.12				
Pseudo R^2			0.02	0.06	0.05	0.21

Notes: Columns (5)-(6) represent ordinary least squares regressions and (7)-(10) are probit regressions clustered at session level. All periods are included. Price choices of U_1 and U_2 as well as partial foreclosure, i.e. $1_{p_1>p_2}$, and total foreclosure $1_{\tilde{p}_1}$ are regressed upon dummy variables for reputation building $1_{Rep.\ U_i}$, $1_{Both\ Rep.}$, imposed reputation building $1_{U_1\_Rep}$ and no reputation building 1_{No_Rep}. I include dummies for different phases in the game, e.g. $1_{Per.\ 6-10}$ for periods 6 - 10, and the number of the supergame, e.g. $1_{SG\ 2}$ for supergame 2. Dummies for supergames are included as Selten and Stöcker (1986) find learning effects between supergames in a finitely repeated prisoners' dilemma. Standard deviations are reported in parentheses. Note that I normalized prices above 7 to 7 for both firms. Significantly different from 0 in a two-tailed test at the *10% level, **5% level, ***1% level.

7.2 Anticompetitive effects

Table 3 summarizes outcomes in each of the treatments. The lowest minimum prices are obtained in *No_Rep* while averages are significantly larger than 1 (at the 1% level, confirmed in regression (2) table 4).[19] Imposed reputation building of U_1 in U_1*_Rep* leads to a price increase of 45.64% compared to *No_Rep*, the average price paid by D_2 is 4.18. In column (2) of table 4 the effect is confirmed to be significant at the 5% level.

Result 2. Hypothesis 2 can be rejected, average minimum prices in *No_Rep* are significantly (1% level) larger than $p_{min} = 1$.

Result 3. Hypothesis 3 cannot be rejected, average minimum prices in U_1*_Rep* are significantly (5% level) larger than average prices in *No_Rep*.

I distinguish four different outcomes in *Choose_Rep*: *NoRep*, U_2*Rep*, U_1*Rep* and *BothRep*. The averages in table 3 (2.91, 3.26, 4.72 and 4.32) suggest that, while the decision of U_1 to build a reputation has an impact on minimum prices, reputation building of firm U_2 does not play a role. In addition, comparing treatments *No_Rep* and U_1*_Rep* with their corresponding outcomes in *Choose_Rep* give similar results, i.e. the choice whether to build a reputation does not affect outcomes. These observations are confirmed in regression (4) in table 4, the impact of U_1's reputation building is highly significant (1% level) whereas reputation building of firm U_2 as well as treatment variables are not significant.

Considering all periods without the distinction between outcomes, treatment *Choose_Rep* is not significantly different from both treatments (regression (2), table 4). However, the average of 3.65 is closer to results obtained in U_1*_Rep*. And indeed, differences in market prices between *No_Rep* and *Choose_Rep* turn out to be significant (5% level) considering only supergames 2 - 4 (column (3) table 4).

Taking learning effects into account, I conclude:

Result 4. Hypothesis 4 cannot be rejected, the possibility of building a reputation has anticompetitive effects.

[19]The outcome is remarkably similar to results obtained by Normann (2011), 2.83 vs. 2.87 in *No_Rep*.

Table 6: Average prices in the first period of the first supergame

Treatment	1	2a	2b	3
	No_Rep	*Choose_Rep*		U_1*_Rep*
		NoRep	*Rep*	
p_1	4.81	4.52	6.14	5.41
	(1.56)	(1.6)	(1.29)	(1.77)
Obs.	16	21	14	17
p_2	5	4	4.67	4.47
	(0.97)	(1.65)	(1.23)	(1.23)
Obs.	16	23	12	17
H_0: $p_1 \equiv p_2$	0.73	0.23	0.01	0.03

Notes: Because it is the first period *Choose_Rep* is only divided in two outcomes depending on the own reputation building decision, i.e. *NoRep* if the firm decided not to show previous prices and *Rep* if she reveals the price history. Standard deviations are reported in parentheses. Note also that I normalized prices above 7 to 7. I performed a Wilxocon rank-sum test and reported p-values for the null hypothesis H_0: $p_1 \equiv p_2$ for each treatment and outcome in *Choose_Rep*.

Table 7: Mann-Whitney U test for treatment differences in the first period of the first supergame

Treatment comparisons	1 vs. 3	2a vs. 2b	1 vs. 2b	2a vs. 3	1 vs. 2a	2b vs. 3
p_1	0.2	0.00	0.02	0.06	0.68	0.19
p_2	0.2	0.18	0.4	0.34	0.03	0.61

Notes: p-values of Mann-Whitney U tests conducted within firm type and between treatments are reported. Treatment 1 is *No_Rep*, outcome 2a is *NoRep* and outcome 2b is *Rep* in *Choose_Rep*, finally, treatment 3 is U_1*_Rep*

7.3 Individual pricing decisions and partial foreclosure

In a first step, I analyze price setting in the first period of the first supergame. The results are reported in table 6. In *Choose_Rep* I only differentiate between participants who decided to show their own price history, i.e. *Rep*, or who do not reveal price choices in *NoRep*.

A Wilcoxon rank-sum tests confirms a positive effect of the own reputation building decision for p_1 in the first period. Compared to *No_Rep* price p_1 increases on average with reputation building in outcome *Rep* of *Choose_Rep* and U_1*_Rep* (table 6), although, differences are larger and turn out to be only significant in *Choose_Rep* (table 7). In contrast, neither the own reputation building nor reputation building of U_1 has an impact on p_2. In particular, U_2 does not seem to be a cooperator from the first period. In contrast to p_1, prices p_2 are not affected by imposed reputation of U_1. This leads to the conjecture that non-integrated firms need to be "convinced" that their opponent is a cooperator which is in line with the predictions based on Fudenberg and Levine (1989).

Comparing prices of the integrated vs. non-integrated firm, I obtain highly significant differences between prices p_1 and p_2 in U_1*_Rep* and outcome *Rep* of *Choose_Rep* (at the 5% and 1% level, respectively; table 6). In contrast, without reputation building there are no differences between prices of the integrated and non-integrated firms. These results suggest that partial foreclosure is related to reputation building of U_1. In *Rep* of *Choose_Rep* a substantial fraction of U_1 seem to withdraw completely from the input market, even average prices are above the monopoly price (compare table 6).

Figure 4 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 5, regressions (5) and (6)). Although the average choice of U_1 seems to be slightly larger when firms opt themselves for reputation building, the difference between imposed and non-imposed reputation effects turns out to be insignificant. Reputation building of U_2 does not seem to have an impact on p_1 whereas there is a weakly significant positive effect on p_2 (10% level). I do not find any differences between supergames but there is a slight downward trend for both pricing decisions after five periods.

In each session, averages of p_1 are larger than p_2, with the only exceptions in outcomes U_2*Rep* and *BothRep* (compare figure 4). The relative difference between

p_1 and p_2 increases with U_1's reputation building and is even more pronounced if the decision to build a reputation is made by themselves. Average session prices in U_1*Rep* and *BothRep* for the integrated firm are several times above the monopoly level which indicates that total foreclosure takes place.

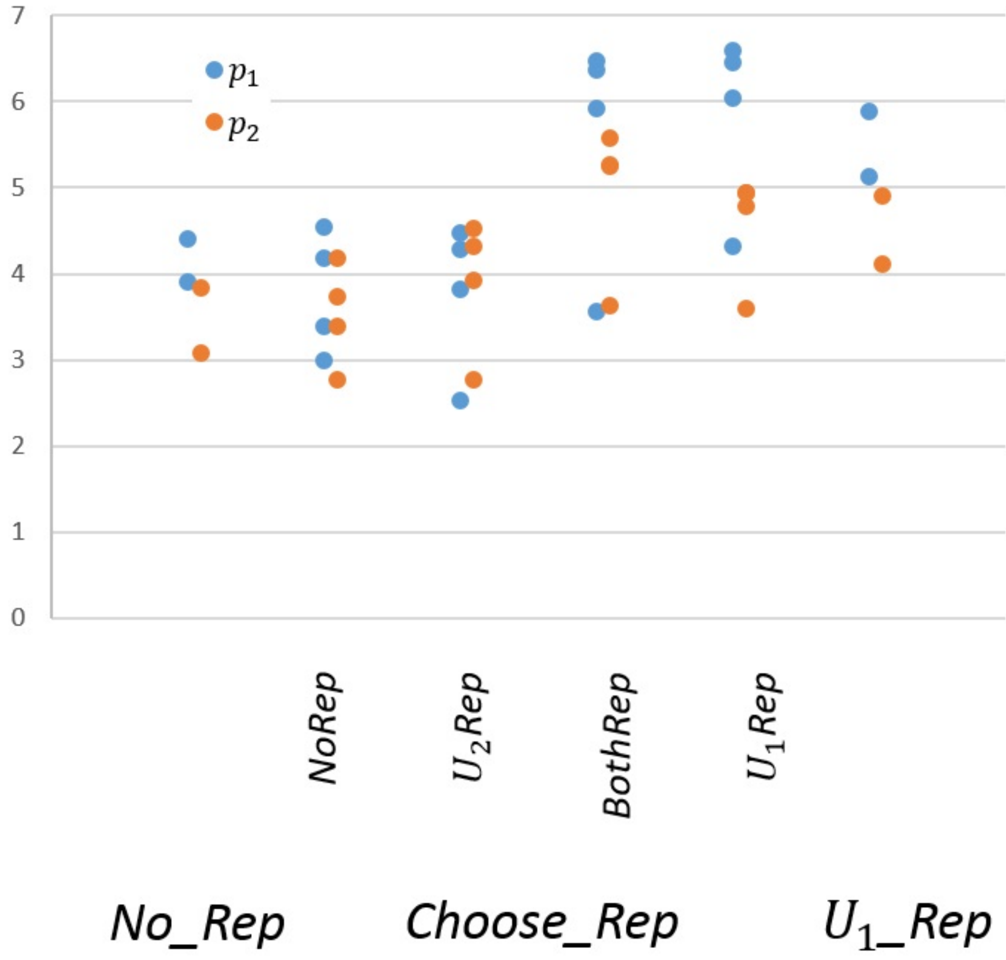

Figure 4: Average session prices

Results for partial input foreclosure are summarized in table 3. The fraction of prices $p_1 > p_2$ is always larger than fractions of $p_2 > p_1$ except in the outcome U_2*Rep* of treatment *Choose_Rep*. In the outcome U_1*Rep* of treatment *Choose_Rep*, partial foreclosure occurs in more than 75% of all observations. Again, reputation building of firm U_1 positively and significantly (regression (8), table 5) affects the percentage of $p_1 > p_2$. With self-imposed reputation building the difference is even more pronounced, however, the results of probit regression (8) of table 5 prove the difference between imposed and non-imposed reputation building to be insignificant. When firm U_2 builds a reputation, it leads to more undercutting of firm U_1. The effect is weakly significant at the 10% level (table 5, column (8)).

Overall, partial foreclosure occurs in 54.29% of observations in *Choose_Rep* (without differentiating outcomes). The fraction is closer to *No_Rep* (in which partial foreclosure is 5.58% less common) as compared to U_1*_Rep* (14.49% larger). Regression (7) in table 5 confirms partial foreclosure to be significantly less common in *Choose_Rep* than in U_1*_Rep* whereas the gap to *No_Rep* is insignificant. In *Choose_Rep* the positive effect of U_1's reputation building on $1_{p_1>p_2}$ is eliminated by the negative effect of U_2's reputation building. The mere possibility for both firms to build a reputation does not have a significant impact on partial foreclosure.

Total foreclosure might be the explanation for anticompetitive effects (supergames 2-4) without significantly more partial foreclosure in *Choose_Rep*.

7.4 Commitment and total foreclosure

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* 6.25% of the participants set $\tilde{p}_1$ in all 39 periods over the whole session (table 3). Without repeated interaction this behavior seems to contradict monetary incentives. However, it supports the approach in the predictions.[20]

The results suggest that the Stackelberg type is similarly common in each treatment (around 6%, table 3). However, in *Choose_Rep* the percentage is slightly larger (8.57%, table 3) and increasing to 11.43% if the first five periods of the first supergame are not considered. Surprisingly, the fraction of Stackelberg types is lowest in U_1*_Rep* (5.88%) whereas theory predicted that types $\omega \neq \omega^*$ would imitate the Stackelberg type in order to obtain almost Stackelberg payoffs.

One possible reason for missing treatment differences is that participants learn over time to mimic the Stackelberg type. The fraction of integrated firms which

[20]Several experimental studies which test reputation building in the lab change the payoff structure of Stackelberg types (Camerer and Weigelt, 1988, Neral and Ochs, 1992, Grosskopf and Sarin, 2010). On the other hand, experimental studies on reputation building in the trust game (for example Keser, 2002, Bohnet and Huck, 2004, Bolton, Katok and Ockenfels, 2004 as well as Bohnet, Huck, Harmgart and Tyran, 2005) do not change incentives exogenously.

totally foreclose the input market during one supergame (in contrast to the whole session) is reported in table 3. Indeed, differences between treatments become apparent. In *No_Rep* the fraction is 9.38%, in U_1*_Rep* 22.06% and jointly for both outcomes in *Choose_Rep* the percentage equals 20%. Separating groups of U_1 firms with and without reputation building in *Choose_Rep* leads to fractions of 42.86% and 1.3%, respectively. The fractions are in any case larger than Stackelberg types who set $\tilde{p}_1$ the whole session and the degree of the increase crucially depends on the reputation building. In addition, the choice of reputation building of U_1 leads to total foreclosure during one supergame compared to U_1*_Rep* twice as often. It seems that a substantial fraction imitates the Stackelberg type but not all of the participants follow this strategy throughout a whole supergame. Anecdotal evidence from a post-experimental survey suggests that some participants in the role of U_1 chose $\tilde{p}_1$ in several periods to gain trust followed by a "surprising" price cut.

Overall, the frequency of $\tilde{p}_1 \in \tilde{S}_1$ differs substantially between treatments (table 3). In *No_Rep* 18.11% of U_1s' price decisions equal $\tilde{p}_1$, this fraction almost triples in U_1*_Rep*, increasing by 30%. In *Choose_Rep* $\tilde{p}_1$ is observed in 5.64% and 5.63% of observations without vs. 62.21% and 60.7% with reputation building of firm U_1. In *Choose_Rep*, total foreclosure occurs ten times more often depending on reputation building of U_1.

Regression (10) in table 5 confirms the positive impact of U_1's reputation building (1% level), however, reputation building of firm U_2 has no significant effect on total input foreclosure. Whereas the coefficient of the treatment dummy U_1*_Rep* is insignificant, in *No_Rep* total foreclosure is significantly more common than in outcome *NoRep* (and U_2*Rep*) in *Choose_Rep* (1% level, column (10) of table 5). After five periods a slight downward trend is observed. Also, the probability of total foreclosure increases significantly in the second supergame compared to the first.

Concerning treatment effects, total foreclosure occurs overall in 30.11% of the observations in *Choose_Rep* which is somewhat in between the fractions observed in *No_Rep* and U_1*_Rep*. Differences turn out to be significant, the highest levels of total foreclosure are obtained in U_1*_Rep*, significantly lower fractions of $\tilde{p}_1 \in \tilde{S}_1$ in *Choose_Rep* (5% level, column (9), table 5) and least often in *No_Rep* (significant at the 1% level for both comparisons).

Result 5. Hypothesis 5 cannot be rejected. Although I find some evidence in favor of partial and total foreclosure, effects are insignificant in *No_Rep*.

Result 6. Hypothesis 6 cannot be rejected. Partial and total foreclosure in U_1_*Rep* are significantly (1% level) larger than in *No_Rep*.

Result 7. Hypothesis 7 cannot be fully rejected. Partial foreclosure in *Choose_Rep* is not significantly different from *No_Rep*. However, total foreclosure is significantly (1% level) more common as compared to *No_Rep* and occurs less frequently (significant at 5% level) than in U_1_*Rep*.

Having discussed total foreclosure of U_1, the response of U_2 is relevant for input prices. In table 8 the fractions of $\tilde{p}_2$ are displayed separately for periods 1-4. The difference in the first period between *No_Rep* and U_1_*Rep* are less pronounced than expected (9%, table 8). Whereas the fraction of $\tilde{p}_2$ in *No_Rep* decreases over time, the fractions in U_1_*Rep* increase. In period 3 the difference is more than 36%. In the first period of *Choose_Rep* the choice of reputation building determines whether fractions of $\tilde{p}_2$ are high (around 30%) or low (around 7%). With observable previous prices of the opponent, fractions increase whereas without reputation building of U_1 fractions decrease over time.

Table 8: Frequency of monopoly price $\tilde{p}_2$

$\tilde{p}_2$						
	No_Rep	*Choose_Rep*				*U_1_Rep*
Period		*NoRep*	*U_2Rep*	*BothRep*	*U_1Rep*	
1^{st}	20.31%	7.27%	36.36%	29.41%	6.50%	29.41%
2^{nd}	14.06%	5.17%	36.84%	30.00%	30.23%	33.82%
3^{rd}	7.81%	5.66%	37.50%	66.67%	35.42%	44.12%
4^{th}	7.81%	5.26%	25.00%	47.37%	56.82%	42.65%
Obs.	64	140				68
$\left(\tilde{p}_2 \vert p_1^t \in \tilde{S}_1,\ \forall t < Period\right)$						
2^{nd}				33.33%	46.43%	53.66%
3^{rd}				63.64%	46.43%	85.71%
4^{th}				69.23%	87.50%	76.67%

Notes: In the upper part the frequency of $\tilde{p}_2$ in every treatment, periods 1-4, is displayed. In the part on the bottom, the sample is restricted to observations in which firm U_2 observes the price history of U_1. In addition, it is restricted to a subset of histories which only contain price $\tilde{p}_1 \in \tilde{S}_1$ in all previous periods.

In table 8 I report fractions of $\tilde{p}_2$ restricted to a subset of observations. It contains only U_2 firms which observe previous prices of U_1 and, additionally, U_1 totally foreclosed the market, i.e. $\tilde{p}_1 \in \tilde{S}_1$, in every previous period. The fractions in the second period of the subset are not yet much different from the overall frequency of $\tilde{p}_2$ in the upper part. However, this clearly changes in period 4, where fractions are substantially larger.

Resulting from the large fraction of total market foreclosure with reputation building of firm U_1, monopolization changes. Without reputation building of U_1 downstream firm D_2 has to pay the monopoly price in less than 2.5% of all observations, with reputation building of U_1 more than 25% of all markets are monopolized (table 3).

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 $1_{tr} := 1_{t=1} + 1_{t>1} \prod_{i=1}^{t-1} 1_{p_1^i \in \tilde{S}_1}$ with t defined as the current period and p_1^i as price p_1 at period i. The second 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. 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.[21] The corresponding variable is defined as $1_{mbr} := 1_{t=1} + 1_{t>1}\ 1_{p_1^{t-1} \in \tilde{S}_1}$.

Table 9 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). However, I do not find a time trend after period k. 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.

Result 8. Hypothesis 8 cannot be rejected. With total foreclosure of U_1 the strategy 1_{fl} has a highly significant impact on price choice of U_2. However, the well-known trigger strategy and myopic best responses are highly influential as well.

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

Table 9: Total foreclosure strategies

	(11)	(12)	(13)
$1_{\tilde{p}_2}$	$k=2$	$k=3$	$k=4$
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 (11)-(13) 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 (11)-(13) 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.

8 Conclusion

This paper studies the impact of reputation building in a vertically related market with one integrated firm. OSS (1990) studied anticompetitive effects of vertical integration in a setting with two upstream and two downstream firms. Their assumption that the integrated firm can commit not to sell the input good to the downstream rival provoked a discussion among theorists. 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 address both concerns: First, I show theoretically and empirically that integrated firms can achieve commitment via reputation building. The integrated firm chooses significantly higher prices, undercuts the competitor significantly less often and withdraws from the input market at least three times more often when a reputation is built. Indeed, reputation building of the integrated firm seems to reduce competition upstream.

My results emphasize OSS's (1990) idea: they justify their assumption of commitment by stating that intuitively one would expect the integrated firm to behave differently. I find evidence in favor of this intuition. Indeed, when having the opportunity to build a reputation, the integrated firm decides more often to reveal previous price decisions. In addition, the mere opportunity to reveal previous prices leads to anticompetitive effects and significantly more total foreclosure.

Second, I find that in a substantial fraction of markets, the withdrawal of the integrated firm leads to monopoly prices. More than 25% of markets are monopolized as compared to not even 2.5% without reputation building of the integrated firm. In fact, I was able to identify three strategies which led to monopolization in my experiment. The non-integrated firms applied a myopic best response strategy, grim trigger and a strategy predicted by a theoretical model on reputation building by Fudenberg and Levine (1989).

The model of Fudenberg and Levine (1989) predicts that non-integrated firms need to be convinced via the reputation of the rival, that the integrated opponent will withdraw from the market. Strategies leading to cooperation in an infinitely repeated game often predict cooperation of both parties from the first period. I find evidence that the integrated firm has to invest in reputation building, i.e. total foreclosure which does not result in monopolization from the first period, in order to sustain the Stackelberg outcome.

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).

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