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# THE INFLUENCE OF INFORMATION EXTERNALITIES ON THE VALUE OF REPUTATION BUILDING - AN EXPERIMENT

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# The Influence of Information Externalities on the Value of Reputation Building

## An Experiment

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*Abstract*: We observe that information externalities arise in sequential equilibrium of the chain store game such that the amount of reputation building among partners differs from that among strangers. No matching effects are predicted for the trust game. Our experiment confirms the qualitative chain store prediction, but information externalities also show up in the trust game.

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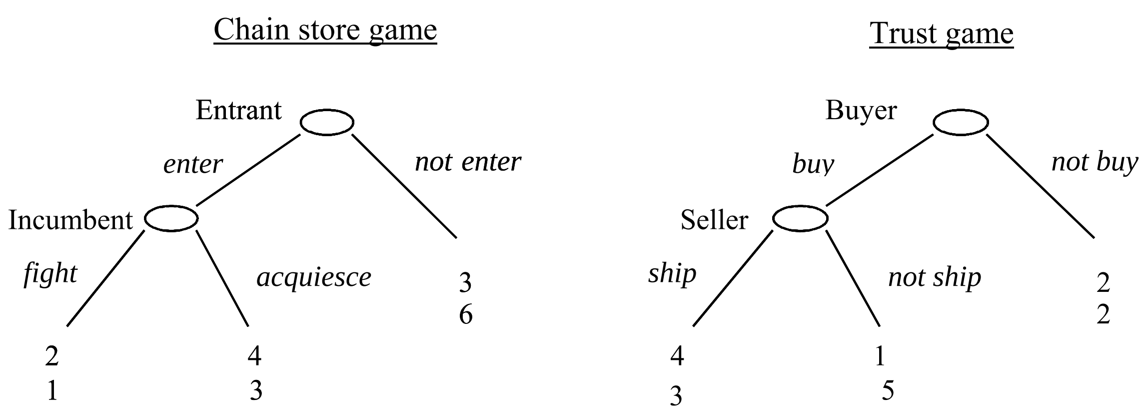
## I. Information externalities in simple reputation building games

Economic theory usually describes reputation building as a matter of information, not matching. Specifically, direct reciprocity relationships, where people are effectively partnered, and indirect reciprocity relationships, where interaction is one-shot among strangers, are typically viewed as equally effective methods for inducing reputation building behavior, so long as equivalent information about reputation is available. This note presents a new experiment, based on an observation we make about the sequential equilibrium analysis of reputation building, to show that stranger matching can provide less powerful incentives to both build and trust a reputation than does partner matching, even when all relevant information about past behavior is equally available. The reason is that, in stranger matching, what a player learns about the reputation builder can be economically valuable information for *other* players, while in partner matching such information externalities are internalized. Surprisingly, this reasoning goes through for the equilibrium analysis of some reputation building games but not others.

Figure 1. Two reputation building games




To illustrate whether and how information externalities can arise, we investigate the particular game forms displayed in Figure 1.[1] The chain store game is a special case of the game studied by Kreps and Wilson (1982; see also Milgrom and Roberts, 1982) which in turn is a variant of a game introduced by Selten (1978). In each period of this game, an entrant decides whether to enter the market of an established monopolist, called the incumbent. If the incumbent fights entry, it hurts the entrant but also hurts the incumbent relative to acquiescing. Hence, for the payoffs shown in Figure 1, the incumbent should acquiesce and the entrant should therefore

[1] We focus here on central implications of information externalities in the standard experimental setting for investigating reputation building, a general theory being beyond the scope of this paper.

enter. It is presumed common knowledge, however, that with some small probability $\delta$, the Figure 1 payoffs understate the payoff the incumbent receives from fighting, and that in fact the incumbent is "strong" in the sense that he prefers fighting to acquiescing. This possibility opens the door to reputation building behavior in repeated interaction environments (Wilson, 1985).

The trust game in Figure 1 is essentially a game of cooperation and exhibits a similar incentive structure as a sequential prisoners' dilemma game. It has been studied by Bolton, Katok and Ockenfels (2004) as a base model for investigating Internet feedback systems, and variants have been studied in other contexts (see references below). In each period of the game, a buyer chooses to buy - committing money - or not. Absent reputational considerations, the seller's incentive is to keep both money and good (not ship). Following the same method of modeling reputation building as in the chain store game, we suppose that, with some small probability $\delta$, the seller is intrinsically trustworthy and so actually prefers to ship than not.

To derive equilibria, we suppose, as in our experiment, that each game is played for 8 consecutive periods. In a cohort of games, there are 8 entrants (buyers), 7 incumbents (sellers) and 1 'artificial' incumbent (seller) who is programmed to be always strong (trustworthy), which is common knowledge; that is, $\delta = 1/8$. The incumbent (seller) is the same player for all periods. *Partner matching* refers to a game in which the entrant (buyer) is the same player for all periods. *Stranger matching* refers to a game in which the entrants (buyers) are randomly rematched from the pool of 8 such that no incumbent (seller) faces the same entrant (buyer) more than once. Entrants (buyers) always receive information about the current opponent's play history before deciding. As is the convention, periods are numbered backwards: 8, 7, …, 1.

Taking as our baseline Kreps and Wilson's (1982) analysis of the chain store game with stranger matching (one-sided uncertainty), we can develop hypotheses for how partners and strangers will play. The sequential equilibrium Kreps and Wilson derive has the property that the probability that the incumbent is strong, $p_n$, is a sufficient statistic for the history of play up to period $n$. That is, the choices of players in period $n$ depend only on $p_n$ (and the choices made in period $n$ by the entrant), and $p_n$ is a function of $p_{n+1}$ and the moves in period $n + 1$ for $n < 8$. The equilibrium path has three stages: In the first stage, the entrant stays out with probability 1; in the second stage, both entrant and incumbent pursue a mixed strategy; the third stage begins once the incumbent acquiesces, after which the entrant always enters. In the analogous equilibrium stages of the trust game, first the buyer buys with probability 1, then both buyer and seller pursue a mixed strategy, and finally, once the seller defects, the buyer does not buy anymore.

The critical difference between chain store and trust game stationary equilibria has to do with whether the player who challenges the reputation builder can benefit in future periods from a "successful" challenge. Let us first look at the entrants' incentives in the chain store game. For the stranger matching case, in a stationary sequential equilibrium, the entrant enters if

$$(1-p_n)[2y_n + 4(1-y_n)] + 2p_n \geq 3 \qquad (1.1)$$

where $y_n = prob(weak\ monopolist\ fights \mid p_n)$.

In equilibrium, if the incumbent fails to fight when challenged in period *n*, the next entrant enters for certain and will make 4 which is greater than the 3 he would get if he did not enter. In the case of strangers, this guaranteed future payment goes to others and so does not appear in the left hand side of equation (1.1). But in the case of partners, it accrues to the same entrant. Thus for partners, the equation analogous to (1.1) is

$$(1-p_n)[2y_n + 4n(1-y_n)] + 2p_n \geq 3.$$

The incentive for a partner to challenge is higher than it is for a stranger: In the second (mixed strategy) stage of the game the equations are binding and $y_n$, $p_n \in (0,1)$. As a consequence, in equilibrium, there will be generally more entry, and subsequently less fighting (since its deterrent effect is lower), for partners than for strangers. Appendix A states full equilibria, and Figure 2 below presents round-by-round frequencies for the particular game in Figure 1. Overall, we have:

*Chain store game hypothesis*: There is more entry and less fighting in partners than in strangers.

In the trust game, the buyer chooses to buy if the expected value of doing so is at least as great as the payoff from not buying; that is, in a stationary sequential equilibrium the buyer buys if

$$(1-q_n)[4y_n + (1-y_n)] + 4q_n \geq 2 \qquad (1.2)$$

where $q_n = prob(seller\ is\ intrinsically\ honest)$,
$y_n = prob(not\ intrinsically\ honest\ seller\ ships \mid q_n)$.

This condition is the same regardless of whether the buyer is a partner or a stranger. To see this, observe that, starting with the second (mixed strategy) phase of the game, in equilibrium the expected payoff to the buyer in any period is 2, regardless of whether the seller failed to ship after a buy order and revealed his type (in which case the buyer will not buy anymore) or the type is not revealed yet (in which case the sellers make the buyer indifferent between buying and not buying). Thus, since in equilibrium there is no monetary benefit from learning the seller's type, equation (1.2) is the same for both matching schemes. Appendix A states full equilibria, and Figure 3 below presents round-by round frequencies for the game in Figure 1. We have:

*Trust game hypothesis*: No difference in buying and shipping between partners and strangers.

The underlying source of the difference between chain store and trust game hypotheses is the differing value of reputation information across games. While in both games reputation has forecast value for predicting the second mover's future behavior, only in the chain store game does reputation have *economic* value: Chain store entrants strictly prefer to deal with incumbents revealed weak, while buyers in the trust game are indifferent along the equilibrium path with regard to the seller to be matched with, no matter what the seller's record. In this sense, in equilibrium, a seller's reputation information has no economic value to the buyers, implying that information externalities do not arise in the trust game.

The information externalities described here have not been generally recognized in the literature. Kreps and Wilson (1982) derive the chain store game equilibrium only for the case of strangers matching, but go on to say partner matching has "no effect on the equilibrium" for strangers (p. 266).[2] Matching effects of a related sort are mentioned in work that examines equilibrium payoffs in repeated games with long horizons. Fudenberg and Levine (1989) analyze the interaction between short-run and long-run players, and Schmidt (1993) studies the case of two long-run players (see also Cripps and Thomas, 1995, and Cripps, Schmidt and Thomas, 1996, among others). For instance, Schmidt observes that if players care about future payoffs, they "might invest in screening […] Even if this yields losses in the beginning of the game the investment may well pay off in the future" (p. 332). We specify equilibrium strategies and show, in the context of information externalities, that matching can have this effect, and we demonstrate how this effect may vary across standard reputation games.

[2] Kreps and Wilson also analyze the case of two-sided information for the game, and here they identify a difference for strangers and partners.

## II. Experiment: Earlier Work and the New Design

Several earlier studies tested sequential equilibrium predictions experimentally. To our knowledge, however, none of these studies addressed the role of matching. Jung, Kagel and Levin (1994) studied reputation building in the chain store game and found that sequential equilibrium captures a number of qualitative behavioral patterns, but also emphasized inconsistencies with theory (see also Brandts and Figueras, 2003). They used a mix of partner and stranger matching (each incumbent faced each of four entrants twice), but derive predictions for pure stranger matching. We test whether matching in the chain store game matters.

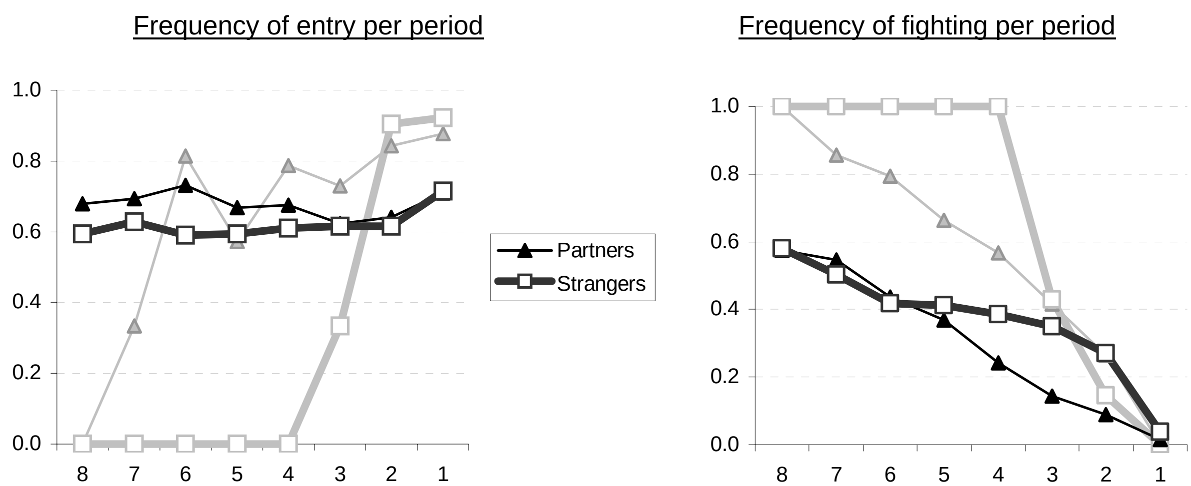
Camerer and Weigelt (1988) found evidence for the sequential equilibrium model in a lending game (with the same incentive structure as our trust game) if one takes into account that first movers have a positive "homemade" prior probability in addition to the controlled probability (McKelvey and Palfrey, 1992, and Andreoni and Miller, 1993, reach similar conclusions). In a further test, Neral and Ochs (1992) also used the lending game, but found that behavior does not respond as predicted to changes in payoff parameters. Camerer and Weigelt used a stranger, while Neral and Ochs a partner, matching design. The different choices of the matching schemes were not discussed in these studies. We test whether matching in the trust game matters.

Our experiment has a fully crossed 2*2 design (Partners vs. Strangers and Chain Store vs. Trust Game). In each of the four treatments, subjects played 20 sequences of 8 period games. The Chain Store and Trust Game played were the same as those in Figure 1. In the Partner treatments, there was no rematching within a sequence, while in the Stranger treatments, players were rematched at random such that no pair was matched more than once. In both Partners and Strangers, rematching *across* sequences was random. Also, regardless of matching scheme, first movers received full information about the current second mover's play history within the current sequence before deciding. The history showed what move, if any, the second mover took in each of the preceding rounds (see Appendix B for the instructions used in the experiments).

Each of the 4 treatments of the experiment was run in 2 sessions. For each session there were 30 players, making for a total of 240 subjects. The 30 player groups were partitioned into two independent subgroups of 15 subjects, 8 first movers and 7 second movers; we then added an 'artificial' second mover to the pool of second movers, programmed to always fight or ship, respectively, which was public knowledge (similar to Neral and Ochs, 1992). Interaction was only within these subgroups, which was known to players, while which players were in the subgroup was not known. In total, 20,480 games were played across a computer interface.

The subjects were undergraduate students at the University of Jena. At the beginning of the session, they read instructions and answered a questionnaire that checked their understanding of the rules. Actual matches were anonymous before, during and after the experiment. Subjects were paid a €2.50 show-up fee plus their earnings from all games. The average total payoff €17 (about $20 at the time of the experiment) for about 100 minutes session-time; the minimum earned was €12 and the maximum was €22.

Figure 2. Entrant and incumbent behavior in the chain store game
(experienced subjects, sequences 11-20).




Paths in black are the frequencies from the data. Paths in gray are the expected equilibrium frequencies. For Entry, there are 320 observations per period for both Partners and Strangers. For Fighting, total per period observations are {186, 192, 208, 190, 194, 180, 192, 208} for Partners and {169, 179, 165, 172, 179, 180, 185, 214} for Strangers.

## III. Results

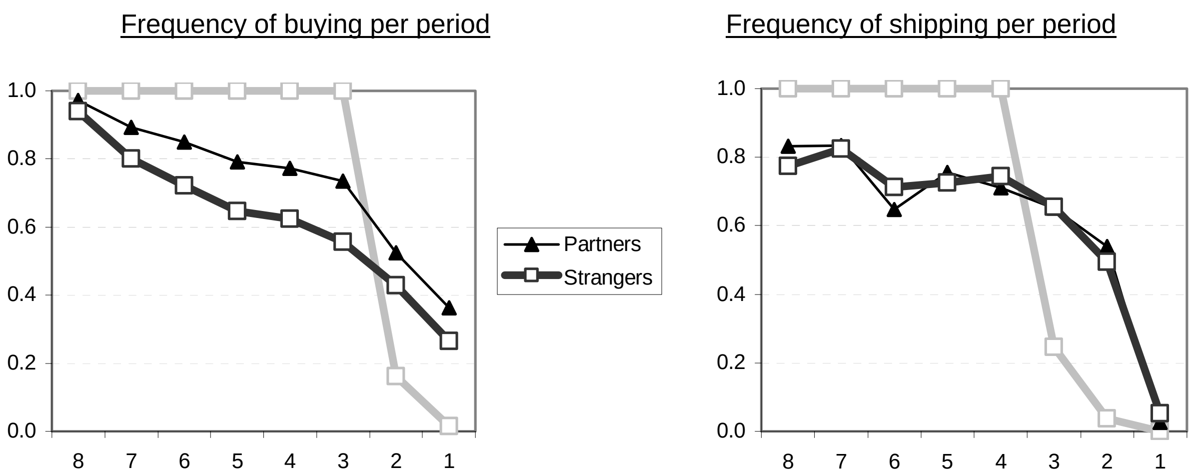
### *III.1 Matching effects*

We begin by examining behavior in the second half of the experiment, after players have had experience (sequences 11 to 20); we then go back to examine learning effects. Figures 2 and 3 display the choice frequencies observed for experienced players, alongside the expected equilibrium frequencies.[3] From inspection, theory captures some qualitative features of the data, although observed and expected frequencies differ considerably.

[3] Expected equilibrium frequencies are derived from simulations with equations in Appendix A (20,000 iterations).

Focusing on Figure 2, the data is consistent with the chain store hypothesis. Overall, there is 7% more entry and 16% less fighting in partners compared to strangers, and there is more entry in partners in every period save for the final period (1). If we assume that each observation is independent, then for each period save the final, the hypothesis that the frequency of entry is equal for partners and strangers is rejected in favor of the chain store hypothesis at the .05 level of significance. The frequency of fighting is lower in partners than in strangers in every period save 6 and 7. The differences are significant at the .05 level for periods 4, 3, and 2, and at the .10 level for period 1. (Tests are difference in two proportions, one-tailed; sample sizes in Figure 2.)

Figure 3. Trust and trustworthiness behavior in the trust game
(experienced subjects, sequences 11-20).




Paths in black are the frequencies from the data. Paths in gray are the expected equilibrium frequencies. For Buying, there are 320 observations per period for both Partners and Strangers. For Shipping, per period observations are {272, 247, 233, 213, 207, 195, 128, 78} for Partners and {262, 217, 191, 168, 160, 139, 103, 58} for Strangers.

Turning to Figure 3, evidence for the trust hypothesis is mixed: There is, overall, 21% more buying in partners than in strangers, while the difference in shipping is less than one percent. Buying is significantly greater in partners in every period, at the .05 level, save 8, where it is significant at the .10 level, and 3, where it is not significant at standard levels. For frequency of shipping, there is no statistical difference in any round at standard levels save period 8 at the .10 level.[4] (All two-tailed tests of difference in proportions, sample sizes in Figure 3.)

[4] Bolton, Katok, and Ockenfels (2004) report a similar effect in an experimental setting that differs, however, in many respects including no artificial players, more limited learning opportunities, and role rotation.

From the point of view of theory, strategic reputation building ends once the builder defaults on his reputation; i.e., fails to fight or fails to ship. So it is of interest to look at the frequencies of action, conditional on no previous default. We also use this investigation as a vehicle for describing the experience effects in our data.[5]

Table 1. Chain store game: Entry conditional on no previous acquiescence

| | Inexperienced subjects (sequences 1-10) | | Predicted | | Experienced subjects (sequences 11-20) | |
|---|---|---|---|---|---|---|
| Stage | Partners | Strangers | Partners | Strangers | Partners | Strangers |
| 8 | .853*** | .722 | 0 | 0 | .678** | .594 |
| | 273/320 | 231/320 | | | 217/320 | 190/320 |
| 7 | .829** | .741 | .333 | 0 | .702 | .637 |
| | 204/246 | 180/243 | | | 165/235 | 144/226 |
| 6 | .780* | .708 | .775 | 0 | .724** | .613 |
| | 174/223 | 150/212 | | | 155/214 | 117/191 |
| 5 | .695 | .672 | .483 | 0 | .683* | .572 |
| | 146/210 | 125/186 | | | 136/199 | 91/159 |
| 4 | .665 | .723 | .677 | 0 | .659 | .599 |
| | 123/185 | 115/159 | | | 120/182 | 88/147 |
| 3 | .566 | .605 | .546 | .333 | .581 | .579 |
| | 94/166 | 89/147 | | | 93/160 | 81/140 |
| 2 | .595 | .672 | .634 | .776 | .630 | .636 |
| | 94/158 | 90/134 | | | 92/146 | 82/129 |
| 1 | .615 | .702 | .577 | .484 | .686 | .721 |
| | 91/148 | 92/131 | | | 94/137 | 88/122 |

* (**,***) means the matching effect is significant at the 10 (5, 1) percent-level, $\chi^2$ test.

Table 1 shows matching effects and learning behavior in chain store entry behavior, conditional on no previous acquiescence. As to the matching effects, the differences tend to be largest in the beginning and the middle phase of play, as predicted by theory; although the magnitude of the differences are far smaller than theory predicts for both inexperienced and experienced players. With experience, the matching effect is preserved, but the frequencies of entry generally tend to fall, in particular in the Strangers treatment, where the data move towards the equilibrium frequencies.

Table 2 shows that there is a strong learning trend towards our chain store hypothesis in that for inexperienced subjects we have the opposite effect in the first 4 periods, namely there is more total fighting in partners, whereas for experienced subjects there is always less fighting in

[5] Straightforward probit analyses confirm what we present in this section; we omit them here for brevity.

Partners.[6] However, the quantitative predictions fail to organize the data; experienced players fight much less, generally moving behavior away from the equilibrium paths.

Table 2. Chain store game: Fight conditional on no previous acquiescence

| | Inexperienced subjects (sequences 1-10) | | Predicted | | Experienced subjects (sequences 11-20) | |
|---|---|---|---|---|---|---|
| Stage | Partners | Strangers | Partners | Strangers | Partners | Strangers |
| 8 | .853*** | .722 | 1 | 1 | .575 | .580 |
| | 273/320 | 231/320 | | | 107/186 | 98/169 |
| 7 | .829** | .741 | .857 | 1 | .520 | .524 |
| | 204/246 | 180/243 | | | 90/173 | 77/147 |
| 6 | .780* | .708 | .836 | 1 | .414 | .448 |
| | 174/223 | 150/212 | | | 67/162 | 47/105 |
| 5 | .695 | .672 | .801 | 1 | .339 | .384 |
| | 146/210 | 125/186 | | | 38/112 | 33/86 |
| 4 | .665 | .723 | .756 | 1 | .232*** | .435 |
| | 123/185 | 115/159 | | | 23/99 | 30/69 |
| 3 | .566 | .605 | .673 | .429 | .136*** | .379 |
| | 94/166 | 89/147 | | | 11/81 | 22/58 |
| 2 | .595 | .672 | .525 | .205 | .099*** | .364 |
| | 94/158 | 90/134 | | | 7/71 | 16/44 |
| 1 | .615 | .702 | 0 | 0 | .000 | .000 |
| | 91/148 | 92/131 | | | 0/57 | 0/44 |

* (**,***) means the matching effect is significant at the 10 (5, 1) percent-level, $\chi^2$ test.

Table 3. Trust game: Buying conditional on no previous defection

| | Inexperienced subjects (sequences 1-10) | | Predicted | Experienced subjects (sequences 11-20) | |
|---|---|---|---|---|---|
| Stage | Partners | Strangers | All | Partners | Strangers |
| 8 | .950** | .897 | 1 | .972* | .941 |
| | 304/320 | 287/320 | | 311/320 | 301/320 |
| 7 | .859 | .822 | 1 | .915*** | .785 |
| | 189/220 | 189/230 | | 216/236 | 183/233 |
| 6 | .770* | .694 | 1 | .869*** | .723 |
| | 147/191 | 129/186 | | 186/214 | 138/191 |
| 5 | .773*** | .610 | 1 | .815*** | .627 |
| | 143/185 | 97/159 | | 154/189 | 96/153 |
| 4 | .707 | .631 | 1 | .787*** | .579 |
| | 118/167 | 89/141 | | 133/169 | 81/140 |
| 3 | .685 | .604 | 1 | .763*** | .602 |
| | 111/162 | 81/134 | | 119/156 | 74/123 |
| 2 | .619* | .500 | 0.667 | .524 | .424 |
| | 91/147 | 58/116 | | 75/143 | 50/118 |
| 1 | .345 | .398 | 0.443 | .388 | .324 |
| | 48/139 | 41/103 | | 50/129 | 34/105 |

* (**,***) means the matching effect is significant at the 10 (5, 1) percent-level, $\chi^2$ test.

[6] This may reflect a naive intuition that because it is more beneficial to build up a reputation of being strong it is more beneficial to fight in partners. In equilibrium, however, building up more reputation means that the probability of fight must be smaller, and experience appears to move behavior in this direction.

Moving to the trust game, Table 3 shows that buying in partners is greater than in strangers. Moreover, the differences appear to increase with experience; that is, behavior moves away from the qualitative prediction. Table 4 confirms that there is no obvious systematic matching effect for shipping, nor is there any obvious learning trend.

Table 4. Trust game: Shipping conditional on no previous defection

| | Inexperienced subjects (sequences 1-10) | | Predicted | Experienced subjects (sequences 11-20) | |
|---|---|---|---|---|---|
| Stage | Partners | Strangers | All | Partners | Strangers |
| 8 | .832* | .775 | 1 | .797 | .746 |
| | 227/273 | 203/262 | | 212/266 | 188/252 |
| 7 | .812 | .814 | 1 | .698 | .742 |
| | 173/213 | 153/188 | | 141/202 | 144/194 |
| 6 | .669 | .696 | 1 | .648 | .676 |
| | 107/160 | 94/135 | | 94/145 | 96/142 |
| 5 | .736 | .695 | 1 | .716** | .581 |
| | 78/106 | 57/82 | | 78/109 | 54/93 |
| 4 | .747 | .792 | 1 | .769 | .679 |
| | 56/75 | 38/48 | | 60/78 | 36/53 |
| 3 | .607 | .727 | .246 | .531 | .500 |
| | 34/56 | 24/33 | | 26/49 | 17/34 |
| 2 | .560 | .545 | .143 | .500* | .227 |
| | 14/25 | 12/22 | | 12/24 | 5/22 |
| 1 | .000 | .000 | 0 | .000 | .125 |
| | 0/9 | 0/9 | | 0/10 | 1/8 |

* (**,***) means the matching effect is significant at the 10 (5, 1) percent-level, $\chi^2$ test.

Summing up, while our data confirm earlier work suggesting that the quantitative predictions of sequential equilibrium theory perform rather poorly, we find support for the matching effect predicted by chain store game equilibria. Matching effects, however, are also observed in buyer behavior in the trust game.

*III.2 The value of reputation information and information externalities*

As observed in section I, in theory, the information dilemma in stranger matching arises, or does not, depending on whether reputation information has economic value to future players. A natural hypothesis to explain the trust game deviation we observe from theory then is that (out-of-equilibrium) seller behavior in the trust game, as well as incumbent behavior in the chain store game, generate economically beneficial information. We examine the data for such evidence here.

To begin, both chain store and trust sequential equilibria imply that reputation information has forecast value. Table 5 shows that reputation is predictive of second movers' future behavior,

Table 5. The predictive value of reputation for future behavior

| Second mover's type | Chain store game: Fight | Chain store game: Enter | Trust game: Ship | Trust game: Buy |
|---|---|---|---|---|
| Revealed | 2.5 | 92.6 | 47.5 | 29.9 |
| Not revealed | 68.2 | 50.4 | 75.8 | 96.0 |

Numbers are in percent, and only include experienced players but not the artificial players.

and that first movers respond to this information value in a straightforward way. For instance, in the chain store game, as long as the incumbent's type is not revealed (there was no acquiesce in earlier periods) the total average probability of fight, without the artificial players, is 68.2%, while when the type is revealed it is only 2.5%. As a result, the probability of challenging the incumbent conditioned on the type not being revealed is 50.4%, and conditioned on the type being revealed 92.6%. Table 5 shows these and analogous data for the trust game.[7]

Table 6. Expected payoffs of experienced first movers when challenging second movers

| Period | Type revealed | Chain store: Partn. | Chain store: Stran. | Trust game: Partn. | Trust game: Stran. |
|---|---|---|---|---|---|
| 8 | No | 2.74 | 2.74 | 3.56 | 3.41 |
| 7 | No | 2.29 | 2.33 | 3.59 | 3.60 |
| | Yes | 3.72 | 3.75 | 3.06 | 1.38 |
| 6 | No | 2.36 | 2.25 | 3.11 | 3.31 |
| | Yes | 3.73 | 3.67 | 2.88 | 2.38 |
| 5 | No | 2.38 | 2.14 | 3.39 | 3.35 |
| | Yes | 3.72 | 3.73 | 3.31 | 2.95 |
| 4 | No | 2.59 | 2.23 | 3.48 | 3.58 |
| | Yes | 3.65 | 3.72 | 3.01 | 2.81 |
| 3 | No | 2.77 | 2.26 | 3.68 | 3.51 |
| | Yes | 3.67 | 3.66 | 2.66 | 2.42 |
| 2 | No | 2.88 | 2.39 | 3.62 | 3.13 |
| | Yes | 3.70 | 3.74 | 1.82 | 1.87 |
| 1 | No | 3.70 | 3.60 | 1.38 | 1.38 |
| | Yes | 3.73 | 3.74 | 1.59 | 1.79 |

*Type revealed* is *Yes* if the incumbent (seller) acquiesced (did not ship) at least once before and *No* else. *Expected payoffs* are the expected first movers' payoffs in Euro computed on the basis of actual second movers' behavior including the artificial ones.

[7] All comparisons are significant at the .05 level ($\chi^2$-tests); the same for most comparisons when the data is divided by matching condition and period, replicating findings in the experimental studies referenced in section II.

Table 6 shows that, beyond forecast value, reputation information in the experiments also has economic value in *both* chain store and trust games. Regarding the chain store game, Table 6 reveals a strong relationship between the incumbent's reputation and an entrant's expected payoff from entering. Since not entering yields a sure payoff of 3 to the entrant, the data suggest that the entrant should not enter in all but the last round whenever the incumbent's type is not yet revealed (because the expected payoff from entering in these cases is below 3), but he should always enter whenever the incumbent revealed his weakness (in which case the expected payoff is above 3). This establishes the existence of information externalities in the chain store game. But information externalities also exist in the trust game: For all but the last round, buying from a reputable seller yields a higher expected payoff than buying from a defector.[8] That is, as long as there is future interaction, buyers strictly prefer to trade with a seller who has been always trustworthy when challenged: If buyers could choose they would choose their trading partners. Thus, since reputation information has economic value, there are more incentives to invest in it among partners.

## IV. Conclusions

One way to state the distinction the sequential equilibrium analysis makes between chain store and trust games is that, in the chain store game, a "good" reputation deters an otherwise profitable activity (entry), whereas in the trust game, a good reputation encourages an otherwise unprofitable activity (buying). This distinction leads to markedly different analyses of the role of matching and information externalities in the two games. The new experiment indicates, however, that this role is more robust than the analysis implies. As suggested by theory, there are information externalities in the chain store game, with more entry and less fighting in Partners than in Strangers. Experience reinforces these differences. Inconsistent with theory, however, we find information externalities also influence the trust game: (out-of-equilibrium) seller behavior reveals information with economic value that is exploitable in the future, which in turn might explain why partners are more willing to buy than strangers (while we find no

[8] For periods 7 and 2, buying from a reputable seller yields a higher payoff than the outside option (2) while buying from defectors yields a smaller payoff, so a buyer should buy only from reputable sellers. In the other periods the buy-decision may depend on, e.g., the degree of risk-aversion.

difference in shipping). Experience reinforces the buyer gap, with no particular effect on seller behavior.

Taken together, the evidence for the sequential equilibrium account of reputation building is mixed. While, given the earlier evidence, it is not surprising that our data rejects the quantitative predictions of sequential equilibrium, the data indicates that subjects respond strategically to reputation information, and that sequential equilibrium theory can capture various qualitative patterns in the data, including some of the rather subtle matching effects. In this sense, the sequential equilibrium approach to reputation building appears to be on the right track. At the same time, the experiment presented here highlights a rather counterintuitive feature of the sequential equilibrium analysis, one not borne out by the data: That reputation information in trust games has forecast, but not economic value. In equilibrium, any economic value is supposed to be mixed (strategied) away.[9] To the extent that this mixing is inherent to the standard story, explaining why reputation information is more robustly valuable may require new modeling approaches.

[9] One natural approach to bringing the theory in line with the data would be adding noise to the analysis. But this does not necessarily help. For instance, applying a quantal response approach would not change the value of reputation information in the trust game: In our setting, where it is public knowledge that the artificial, intrinsically trustworthy players do not make mistakes, 'not shipping' unambiguously reveals the type - with or without noise in the subjects' behavior. Of course, noise may lead to different kinds of externalities, but this too can be problematic. Suppose, for instance, that a seller in the first (pure strategy) phase of the game mistakenly reveals his type. Then, in Partners the corresponding buyer cannot reap further gains from trade, whereas in Strangers other buyers will suffer from this mistake. But this seems to suggest that in a noisy environment there might be *more* incentives to buy early in the game among strangers than among partners.

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## Appendix A. Sequential Equilibria

Here we state the sequential equilibria taken as baselines for the games studied in the paper. The equilibrium for the chain store game with stranger matching is the same as the one given by Kreps and Wilson (1982). They provide a step-by-step verification of equilibrium. Straightforward application of the same step-by-step procedure verifies the sequential equilibria stated below for the chain store game with partner matching and for the trust game (both strangers and partners).

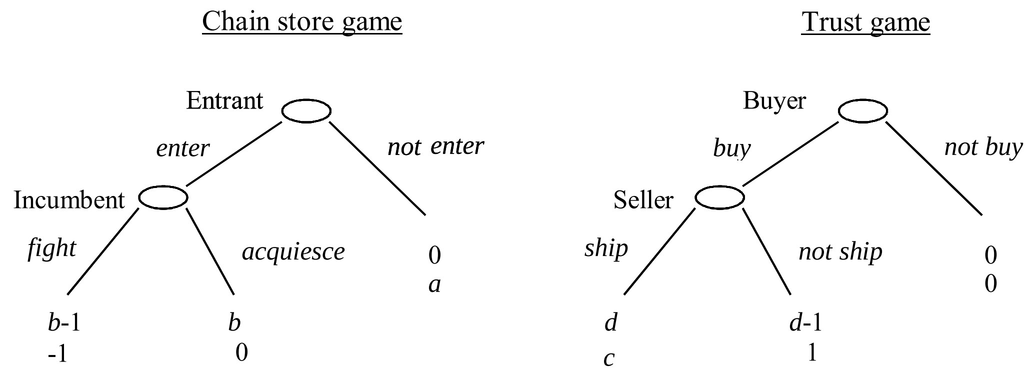



Figure A. Base games with payoff structure: $a > 1$, $0 < b < 1$, $0 < c,d < 1$

The payoff structure of the games studied in the experiments are equivalent to those shown in Figure A up to affine transformation. The chain store game in Figure A is the one studied by Kreps and Wilson (1982). Periods for all games are labeled in descending order: $n = N, \ldots, 1$.

*Sequential equilibrium for the chain store game with strangers matching (Kreps and Wilson, 1982)*

1) Let $p_n$ = prob(incumbent is strong at the beginning of period $n$). Set $p_N = \delta$.
2) Define $b_n = b^n$, where $b$ is the payoff as stated in Figure A.

Updating $p_n$:

3) For $n < N$: If there is no entry in period $n$+1 then $p_n = p_{n+1}$. If there is entry in period $n$+1, and either this is met with acquiesces or $p_{n+1} = 0$, then $p_n = 0$.
4) For $n < N$: If there is entry in period $n$+1 followed by fighting and $p_{n+1} > 0$, then $p_n = \max\{b_n, p_{n+1}\}$.

Incumbent's strategy (conditional on entry):

5) If $n = 1$, acquiesce.
6) If $n > 1$ and $p_n \geq b_{n-1}$, fight.
7) If $n > 1$ and $0 < p_n < b_{n-1}$, fight with probability $\dfrac{(1-b_{n-1})\,p_n}{(1-p_n)\,b_{n-1}}$.
8) If $n > 1$ and $p_n = 0$, acquiesce.

Period $n$ entrant strategy:

9) If $p_n > b_n$, stay out. If $p_n < b_n$, enter.
10) If $p_n = b_n$, stay out with probability $1/a$.

*Sequential equilibrium for the chain store game with partner matching*

Same as for stranger matching save lines:

2) Define $b_1 = b$, and for $n > 1$, $b_n = \dfrac{nb}{(n-1)b+1}\, b_{n-1}$.

7) If $n > 1$ and $0 < p_n < b_{n-1}$, fight with probability $\frac{nb(1-p_n)+p_n(b-1)}{(1-p_n)[(n-1)b+1]}$.

*Sequential equilibrium for the trust game, both stranger and partner matching*

1) Let $q_n$ = prob(seller is intrinsically honest in period $n$). Set $q_N = \delta$.
2) Define $d_n = d(1-d)^{n-1}$, where $d$ is the payoff as stated in Figure A.

Updating $q_n$:

3) For $n < N$: If there is no buy in period $n$+1 then $q_n = q_{n+1}$. If there is buying in period $n$+1, and either this is met with no ship or $q_{n+1} = 0$, then $q_n = 0$.
4) For $n < N$: If there is buying in period $n$+1 followed by shipping and $q_{n+1} > 0$, then $q_n = \max\{d_n, q_{n+1}\}$.

Shipper's strategy (conditional on buying):

5) If $n = 1$, do not ship.
6) If $n > 1$ and $q_n \geq d_{n-1}$, ship.
7) If $n > 1$ and $0 < q_n < d_{n-1}$, ship with probability $\frac{1-d-p_n}{1-p_n}$.
8) If $n > 1$ and $q_n = 0$, do not ship.

Period $n$ buyer strategy:

9) If $q_n < d_n$, do not buy. If $q_n > d_n$, buy.
10) If $q_n = d_n$, buy with probability 1-$c$.

## Appendix B. Experimental Procedure

[Translation of the Chain Store Game instructions from German; Trust Game instructions are analogous.]

*Instructions* This is an experiment in decision making. The German Science foundation has provided funds for this research.

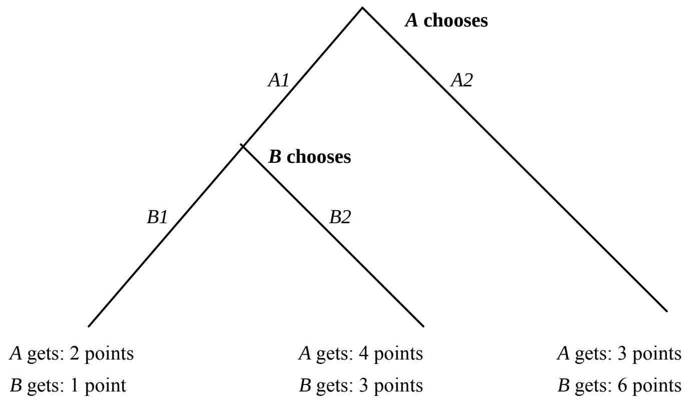
Each decision maker has been randomly assigned to be a member of one of two groups with 15 subjects each. Each group will play separately; there will be no interaction between them.

Each subject is assigned the role of an *A*-subject or a *B*-subject. The assignments will be the same for the whole session. Whether you are *A* or *B* will be determined randomly and shown on your computer screen once the experiment starts.

*The decision situation*

The experiment is divided into a series of 20 sequences. A sequence consists of 8 rounds. In each round, an *A* subject will be paired with a *B*-subject. Each round will proceed as follows. Each *A*-subject begins the round by choosing one of two alternatives. These alternatives are labeled *A1* and *A2*, respectively. If *A1* is chosen, *B* has to choose between alternatives *B1* and *B2*. If *A2* is chosen, *B* has no choice.

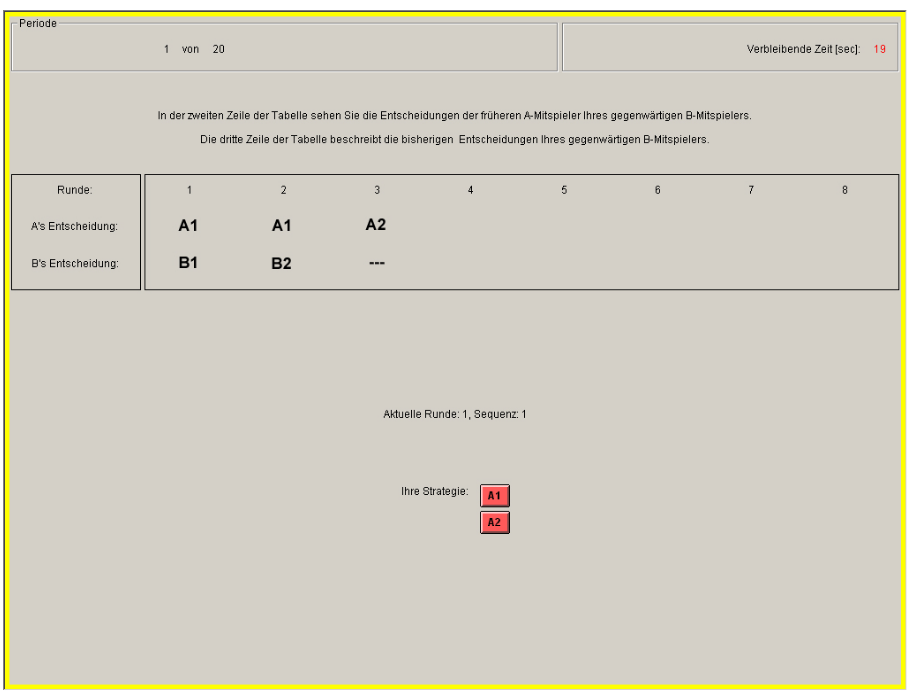
In each round, you can earn points according to the decisions made in this round. 33 points are worth 1 Euro, and all points are paid in cash along with your show-up fee at the end of the experiment. If *A* chooses *A1* and *B* chooses *B1*, then *A* gets 2 points and *B* gets 1 point. If *A1* and *B2* is chosen, *A* earns 4 points and *B* earns 3 points. If, finally, *A2* is chosen, then *A* gets 3 points and *B* gets 6 points. The following figure summarizes the payoff rules:




*What is the matching procedure?* [Partners; analogous for Strangers] Before each sequence (which consists of 8 rounds of the above described decision situation) you will be randomly paired with a new subject who is assigned the other role. Within a sequence, you are matched with the same opponent for all 8 rounds. The identity of your opponent, however, will not be revealed to you, neither during nor after the session.

Please notice that there are 8 *A*-subjects within your group, but only 7 *B*-subjects. The missing eight *B*-subject is a computer agent who is programmed to always choose *B1*. That is, if you are an *A*-subject, you might be randomly matched with an artificial *B*-subject (which happens with probability 1/8) who is programmed to choose *B1* whenever you choose *A1*.

*Sequences* Before making a choice, all *A*-subjects get a summary of the *B*-subject's decisions in the earlier rounds of the current sequence.




In this fictitious example, *A* is informed that *B* chose *B1* in round 1 and *B2* in round 2. In round 3, *B* had no choice, because *A* chose *A2*. (If *B* is our programmed computer agent, the history will, of course, never display *B2*.)

*Summary*

- This experiment consists of 20 sequences each consisting of 8 rounds. In each round, you will face the same decision situation as described above.
- Before each sequence, you will be matched with a new opponent. Within a sequence, however, you will be always matched with the same opponent. The identity of your opponent will not be revealed.
- One of the 8 *B*-subjects is a programmed computer agent. This agent will always respond to *A1* with *B1*.
- Before the *A*-subject is asked to make a decision, he will be informed about the behavior of the *B*-subject in the earlier rounds of the current sequence.
- All earned points will be summed up and paid in cash at a conversion rate of 33 points = 1 Euro at the end of the experiment.

If you have any question, now or during the experiment, please raise your hand and the monitor will be right with you.

**Questionnaire.** This questionnaire tests whether you fully understood the instructions. The experiment can only start when all subjects correctly answered all questions.

1. A sequence consists of how many rounds?
    a. 8
    b. 15
    c. 20
2. Within a sequence I'll be matched …
    a. always with the same opponent
    b. never more than once with the same opponent
    c. always with the programmed computer agent
3. The probability that an *A*-subject is matched with the programmed computer agent is …
    a. 1/10
    b. 1/4
    c. 1/8
4. If an *A*-subject observes that *B* chose *B2* he knows for sure that this *B* …
    a. is the programmed computer agent
    b. cannot be the programmed computer agent
    c. neither a. nor b.
5. If *A* chooses *A1* and *B* chooses *B2*, than *A*'s payoff is:
    a. 1
    b. 3
    c. 4
6. Before making a choice, each *A*-subject receives information about the choices made by *B* in earlier rounds of the same sequence.
    a. true
    b. wrong
    c. not decidable