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INFORMATION VALUE AND EXTERNALITIES IN REPUTATION BUILDING - AN EXPERIMENTAL STUDY

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Information Value and Externalities in Reputation Building

An Experimental Study

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Abstract: In sequential equilibrium theory, reputation building is independent of whether the reputation builder is matched with one long-run player or a series of short run players. We observe, however, that reputation builders are significantly more challenged by long-run players in both laboratory chain store and buyer-seller games. Reputation builder behavior is not as unpredictable as required by the mixed equilibrium strategies and so information about the reputation builder's past behavior has more economic value than equilibrium predicts. This in turn creates more incentives for long-run players to challenge the reputation builder, because they internalize the information externalities from the continuation game.

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I. Information externalities in reputation building

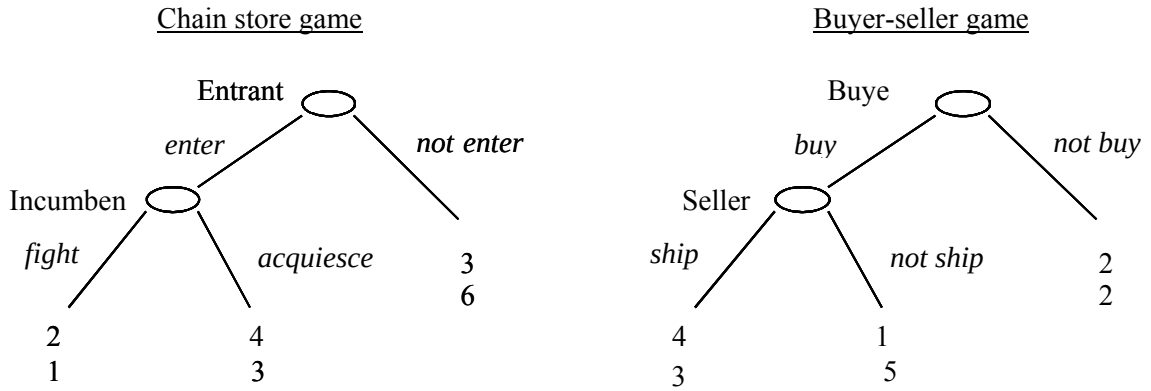
Does the way that information disseminates in the market matter for the effectiveness of reputation building? In economic theory, this is typically not the case. Reputation is described as a matter of information, independent of the interaction pattern. In their seminal paper, Kreps and Wilson (1982, p. 266) mention that the same reputation building is expected from an incumbent protecting a chain store monopoly from entry by one, repeat challenger or a series of one-shot challengers. Or, in the context of a buyer-seller game with seller moral hazard – another well known reputation game (Fudenberg and Tirole, 1991) – the same reputation building is expected from the seller, regardless of whether the building is done with one, repeat buyer or a series of one-shot buyers.

Part of the intuition for why the flow of reputation information through the system does not matter has to do with a certain strategic equivalence in challengers' decision problems: As long as the reputation builder's record is freely available and equally reliable, strangers and long-term associates are in the same position to reward the builder for defending his reputation or to punish him for deviating from it. But as we describe in Section II, the argument also depends on conditions that are special to the sequential equilibrium path. Among other things, the reputation builder need mix her behavior in a way that makes it difficult for the challenger to profit from observing her actions. Since previous studies (references below) show that human players often fail to accurately mix actions, and that reputation building deviates from the predicted path in significant ways, there is reason to suspect that reputation builders have difficulty making themselves as unpredictable as theory implies. If so, we would expect challenges to the builder's reputation to produce more valuable information for those who interact with the builder in the future. A long-run partner would have a greater incentive to check the builder's reputation than would a short-run player, since the benefits of the information obtained are internalized in the former case while external in the latter. The implication is that the pattern of matching – the way the reputation information disseminates in the market – should matter to the reputation building we see.

In Section II, we briefly describe the role of information externalities in the standard sequential equilibrium analysis of chain store and the buyer-seller game.[1] We also observe that the two games differ in subtle ways with regard to the predicted economic value of reputation information. In Section III, we present a laboratory experiment on both games, to our knowledge the first controlled test for information externalities in reputation building.[2] We find evidence that information externalities and the pattern of matching matter to the effectiveness of reputation building. So the efficiency of reputation building activities in markets and industrial organization may depend on the underlying pattern of agent interaction, not just on the flow of information. Section 4 concludes.

II. Irrelevance of matching in theory

Figure 1. Two reputation building games



To illustrate whether and how information externalities can arise both in theory and in the laboratory, we investigate the game forms displayed in Figure 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

[1] While, so far as we are aware, no one has previously pointed out that information externalities play a role in the analysis of reputation building, information externalities have been recognized as a critical force in other areas. Porter (1995), for instance, describes how the strategic decision whether and when to explore oil fields is affected by drilling activities in neighboring areas. The results of such activities are publicly available and thus produce economically valuable information about oil field profitability to other firms, so that non-cooperative drilling may result in non-optimal exploration. Other examples include informational cascades and herding behavior, where a player's action may reveal economically valuable information about the state of nature to other players, resulting in too little information revelation (e.g., Chamley and Gale, 1994).

[2] Bolton, Katok and Ockenfels' (2004) study of Internet market feedback mechanisms maybe comes closest, even though they only looked at buyer-seller games and the experiment was exploratory, lacking various controls for the theory. Bolton et al. found evidence that partners are more likely than one-shot strangers to trust people who are new to buyer-seller transactions in the market.

stage 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 enter. It is assumed common knowledge, however, that with some small probability δ, 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 buyer-seller game in Figure 1 is essentially a game of cooperation and exhibits a similar incentive structure as a sequential prisoners' dilemma game. In each stage 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 δ, the seller is intrinsically trustworthy and so prefers to ship than not.

For further analyses, we suppose as in our experiment that each game is played for 8 consecutive stages. 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 stages. *Partner matching* refers to a game in which the entrant (buyer) is the same player for all stages. *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, stages 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 stage n. That is, the choices of players in stage n depend only on p_n (and the choices made in stage n by the entrant), and p_n is a function of p_{n+1} and the moves in stage $n + 1$ 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 buyer-seller 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. For the convenience of the reader, the sequential equilibria for both chain store and buyer-seller games is reprinted in Appendix A.[3]

How information externalities enter into these games is evident from the point of view of the potential beneficiary of this information, that is the challenger (entrant or buyer). Our main point will be that information externalities have no economic value in the sequential equilibrium analysis not because of any general equivalence of stranger and partner decision problems, but rather because of conditions special to the equilibrium path. We begin with the chain store game. First consider the stranger matching case and, for our illustration, assume that we are in stage 2. Then, the only payoffs that are relevant to the entrant's decision are those that result from stage 2. Specifically, it is optimal for the entrant to enter only if doing so yields an expected payoff at least as great as not doing so:

(2.1) $$(1-p_2)[2y_2 + 4(1-y_2)] + 2p_2 \geq 3$$

where $y_2 = prob(weak\ monopolist\ fights \mid p_2)$.

For partners matching, the equation analogous to (2.1) must include the continuation payoffs, the expected stage 1 payoffs the entrant receives conditional on stage 2 play. Adding in the continuation payoffs implied by the sequential equilibrium (derived from Appendix A), the partner entrant's decision problem is

(2.2) $(1-p_2)[(2+C)y_2 + (4+4)(1-y_2)] + (2+C)p_2 \geq 3 + D$, where C and D depend on p_2.

When $p_2 < ½$, equilibrium stipulates $C = 3$, $D = 2p_2 + 4(1-p_2)$ and $y_2 = p_2/(1-p_2)$. Substituting shows that (2.2) and (2.1) are equivalent. When $p_2 \geq ½$, equilibrium stipulates that $C = D = 2p_2 + 4(1-p_2)$ and $y_2 = 1$. Substitution shows the entrant should not enter, as is also the case for (2.1). Thus information externalities are irrelevant to the entrant's actions along the sequential equilibrium path because of equilibrium conditions concerning the incumbent's future actions.

For stage 2 of the buyer-seller game, the buyer enters only if

[3] We thank an anonymous referee for pointing out a mistake in an earlier draft.

(2.3) $$(1-q_2)[4y_2 + (1-y_2)] + 4q_2 \geq 2$$

where $q_2 = prob(\textit{seller is intrinsically honest})$,
$y_2 = prob(\textit{not intrinsically honest seller ships} \mid q_2)$.

For partners matching, we add the sequential equilibrium continuation payoffs (derived from Appendix A):

(2.4) $$(1-q_2)[(4+C)y_2 + (1+2)(1-y_2)] + (4+C)q_2 \geq 2 + C,$$ where C depends on q_2.

If $q_2 \leq 2/3$, then $C = 2$ and all the additional terms cancel, making condition (2.4) equivalent to (2.3) (independent of the value of y_2). If $q_2 > 2/3$, then $C = (1-q_2)1 + 4q_2$ and $y_2 = 1$, and combining terms shows that (2.3) and (2.4) are equivalent. Again, the equivalence reflects sequential equilibrium conditions concerning the reputation builder's future behavior.

Remark. Observe in the above derivations that, for a fixed reputation, the continuation payoffs are always the same for all scenarios in the buyer-seller game, whereas they can differ across scenarios for the chain store game. This implies that information externalities have different expected values in chain store and buyer-seller games. As a simple way to see this, suppose that a challenger – playing either a partner or a stranger game – is considering his move at the beginning of stage 1 (last stage). Just before deciding, the challenger is given a choice between playing two reputation builders: one with a reputation that makes the challenger just indifferent between entering (buying) or one who has been revealed to be weak (dishonest). For the chain store game, the strong history choice has an expected value of 2 and the revealed weak choice has an expected value of 4. So the entrant chooses the weak incumbent. For a buyer in the buyer-seller game, however, both choices have an expected value of 3. So, the buyer is indifferent. That is, if the chain store incumbent could choose he would choose his partner, but if the buyer could choose, he would be indifferent.

To summarize, information externalities derive from the continuation payoffs that result from challenger decisions. The externalities have no economic value in the standard

analyses because of conditions specific to the sequential equilibrium analysis.[4] Even so, the sequential equilibrium analysis implies that information externalities differ across chain store and buyer-seller games. Our experiment looks at both games.

III. Information externalities in the laboratory

Our null hypothesis from standard sequential equilibrium analysis is that matching and information externalities do not influence behavior in chain store or buyer-seller games. This stems from the analysis in the last section, that shows that the sequential equilibrium paths of play do not differ for partners and strangers matching schemes,

Our alternative hypothesis is that there is more challenging in partners than in strangers both in chain store and buyer-seller games. For one, sequential equilibrium theory has been tested before with mixed evidence. Jung et al. (1994) found that that sequential equilibrium captures a number of qualitative behavioral patterns, such as endgame-effects and other strategic behaviors, but they also emphasized inconsistencies with theory (see also Brandts and Figueras 2003). Camerer and Weigelt (1988) found evidence for the sequential equilibrium model 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, reached similar conclusions). Neral and Ochs (1992) found, however, that behavior does not respond as predicted to changes in payoff parameters. Deviations from the sequential equilibrium path per se are not sufficient to imply that information externalities have value; for example, to the extent that deviations represent confusion or noise, the information generated may not be very useful. However, observe that the derivations of no economic value in equilibrium (Section II) depend on reputation builders playing mixed strategies at certain stages of play in both games. A line of experiments has shown that people have difficulties employing equilibria in mixed strategies, even in much simpler static environments; there is typically more information leakage than

[4] In other reputation environments, matching may play a more relevant role. Kreps and Wilson (1982) identify matching effects for the case of two-sided uncertainty. Fudenberg and Tirole (1991) survey studies on games with many long-run players with two-sided reputation building, where equilibria tend to be less robust (e.g., with respect to the exact nature of the incomplete information). Our observations are made in games with one-sided reputation building. Matching effects of a different 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). In the context of his model, Schmidt mentions that if long-run players care about future payoffs, investing "in screening" the opponent might pay out in the long run. Such screening incentives are not present in our environment, though.

predicted (e.g., Erev and Roth 1998, O'Neill 1987, Shachat 2002, although there is some evidence that professional athletes do better, e.g., Walker and Wooders 2001). Taken together, the evidence suggests that information externalities might, in actual behavior, have economic value, creating more reason to challenge the reputation builder in partners than in strangers.

III.1 Design

Our experiment has a fully crossed 2*2 design (partners vs. strangers and chain store vs. buyer-seller game). In each of the four treatments, subjects play 20 sequences of 8 stage games. The chain store and buyer-seller games played are 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.

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.

III.2 Results

Information externalities in stranger matching arise, or do not, depending on the extent reputation information not only has forecast value but also economic value to future

players (Section II). Forecast value implies that the challenger can predict the reputation builder's behavior from his reputation profile – which is true for both game equilibria and for our data.[5] Economic value additionally implies that the challenger can actually profit from this information, which is only true in chain store equilibrium. Table 1 shows in line with our alternative hypothesis, however, that reputation information in the experiment has (more) economic value than predicted in both games; that is, reputation builders reveal more information than they should.

Table 1. Expected payoffs of experienced first movers when challenging second movers

	Type	Chain store		Buyer-seller	
Stage	revealed	Partn.	Stran.	Partn.	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 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.

Regarding the chain store game, Table 1 shows 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). So, given the payoffs, there is no reason to enter at all for short run entrants (while on the equilibrium paths in the mixing phase, traders should be indifferent). Moreover, the incentive to enter for

[5] Indeed, reputation information has significant forecast value in both laboratory games. In the chain store game, as long as the incumbent's type is not revealed (there was no acquiesce in earlier stages) the total average probability of fight, without the artificial players, is 68.2%, while when the type is revealed it is only 2.5%. In the buyer-seller game, as long as the seller's type is not revealed (there was always shipping in earlier stages)

partners is stronger than predicted in equilibrium in the sense that the actual difference in payoffs between entering when the type is revealed versus not revealed is larger than the theoretically expected 1 Euro in all but the last two rounds. So, overall, there is more valuable information in the market guiding the entrants' choice than predicted.

In the buyer-seller game, under the null hypothesis, there is no economic value of reputation information at all. However, Table 1 shows that for all but the last round, buying from a reputable seller yields a higher expected payoff than buying from a defector. 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.

The next analyses show that, indeed, partners reputation builders are significantly more challenged than strangers. Figure 2 displays entry and fighting frequencies for chain store play during the reputation building phase of the game (that is, prior to any incumbent acquiescence). The data encompasses the experienced game sequences 11 though 20. Below, corresponding inferential results encompass all sequences and control formally for experience effects along with other factors. Observed frequencies are in black, expected equilibrium frequencies are in gray.[6] Not surprising, the quantitative fit with the theory is not good. Nevertheless, the analysis is consistent with our alternative hypothesis, that information externalities are evident in the data. For all stages, the frequency of entry weighted by the number of observations per stage averages 15% higher in partners than in strangers. At the same time, the frequency of fighting over the same stages is 15% lower, probably responding to the increased tendency of entering.

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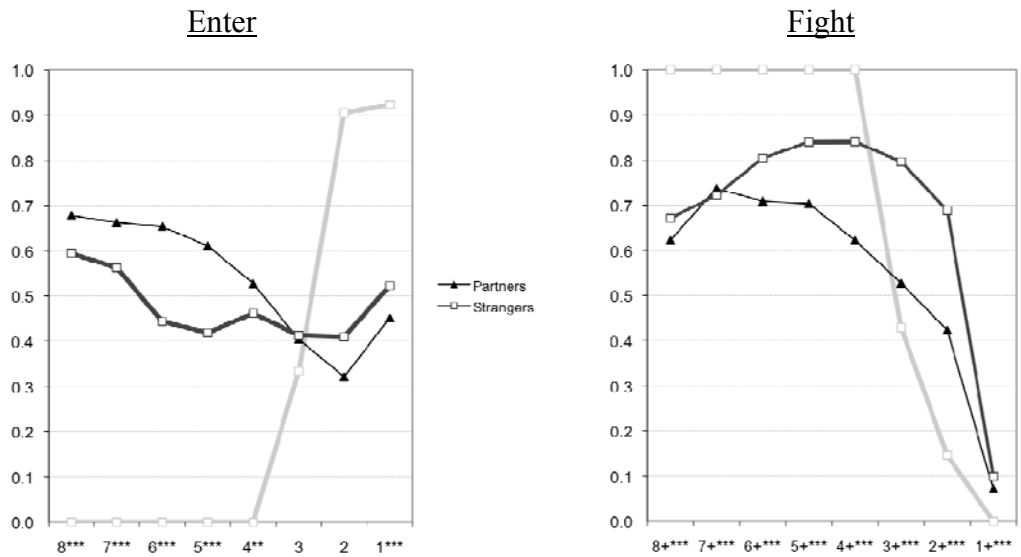
the total average probability of ship, without the artificial players, is 75.8%, while when the type is revealed it is 47.5%. All comparisons are significant at the .05 level (χ^2-tests).

[6] Expected equilibrium frequencies are derived by Monte Carlo simulation (20,000 iterations) of the equilibrium equations in the Appendix.

Figure 2. Frequency of entry and of fighting by stage, conditional on no previous acquiesce (sequences 11-20)



Paths in black are frequencies from the data, averaged over individual movers. Fight data excludes robots. Paths in gray are the expected equilibrium frequencies. The sign after the stage *j* number is the sign of the coefficient estimate for the $PartnersStage_j$ variable in model 3.2; * (**,***) means the coefficient is significant at the 10 (5, 1) percent-level (two-tailed). There were 64 entrants and 56 incumbents. Total observations for stage {8, …1} for entrants {320, 241, 220, 197, 178, 158, 143, 131} partners, {320, 249, 228, 217, 211, 201, 191, 177} strangers. For incumbents {182, 119, 107, 83, 58, 34, 24, 31} partners, {169, 111, 76, 76, 77, 67, 63, 84} strangers.

To check for statistical significance, we examine a probit model estimated from the reputation building phase data from both sequences of play. The model explains individual *i*'s action, y_{ijt}, in terms of the matching procedure (a dummy variable $Partners_i$), game stage (a dummy variable $Stage_j$ for stage *j*), sequence of play (t = 20, …,1 so that estimates of stage effects are for experienced players) and a random effect ($u_i + v_{ijt}$) to account for individual and session differences:

$$z_{ijt} = \beta_0 + \beta_1 Partners_i + \sum_{j=2}^{8} \beta_j Stage_j + \beta_9 t + u_i + v_{ijt} \tag{3.1}$$

$y_{ijt} = 1$ if $z_{ijt} > 0$, and 0 otherwise,

$u_i + v_{ijt}$ error term.

Estimates of the coefficient of the $Partner_i$ dummy, β_1, provide a baseline test for matching effects. Estimating equation 3.1 with the entrant data, β_1 is significantly positive (one-tailed *p*-value = 0.0426). Estimating equation 3.1 with the incumbent data, β_1 is significantly negative (one-tailed *p*-value < 0.001). So, the model rejects the null hypothesis of irrelevance of matching. A full report of model (3.1) estimates is given in Appendix C.

Model (3.1) is parsimonious but aggregates over information. A more detailed analysis is gotten by opening up (3.1) to test for information externalities in each stage of the game:

$$(3.2) \qquad z_{ijt} = \beta_0 + \sum_{j=1}^{8} \beta_j Partners_i Stage_j + \beta_9 Partners_i\, t + \sum_{j=2}^{8} \beta_{j+8} Stage_j + \beta_{17}\, t + u_i + v_{ijt}$$

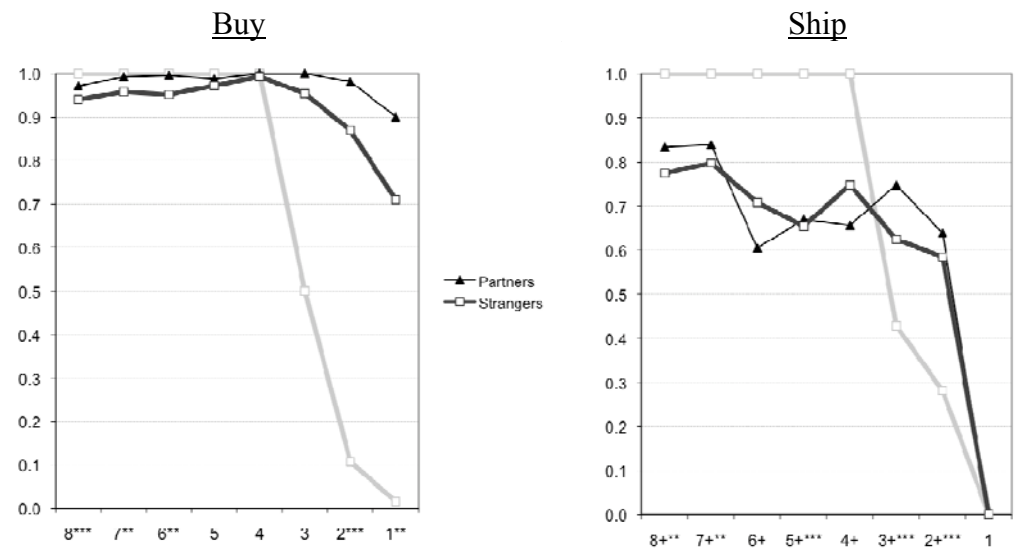
Again, we estimate separate models for entrants and incumbents. The significance of information effects at each stage of the game (that is, the significance of the $\beta_8, \ldots \beta_1$ coefficients) are reported on the horizontal axes in Figure 2. Most of the coefficients for entrants are in the direction suggested by the alternative hypothesis and are significant; the coefficient for stage 1 for the entrants is the one exception.[7]

Figure 3 suggests information externalities in the buyer-seller game as well, although smaller in magnitude than found in the chain store game. For all stages, the frequency of buying weighted by the number of observations per stage averages 8% higher in partners than in strangers. While the buying frequencies are higher in partners in all stages, the shipping frequencies are higher in partners in five stages, but lower in stages 4 and 5, and equal (to zero) in stage 1. Overall, the frequency of shipping weighted by the number of observations per stage is 2% higher in partners than in strangers.

While the size of the effect for the buyer-seller game is modest, estimating model (3.1) for this data finds they are highly significant. For buyers, β_1 is positive with $p = 0.008$; for sellers, β_1 is positive with $p < 0.001$. Applying the more detailed model (3.2), finds that all estimated stage effects (save for stage 1 of the shipping data) indicate both higher buying and shipping in the partners games, most of the stage effects are significant, as indicated on the horizontal axes in Figure 3. Estimates (Appendix C) indicate that the frequency of buying and selling modestly increases in more experienced sequences, and at about the same rate for both stranger and partner matching. Hence experience has little effect on the magnitude of information externalities in the buyer-seller game.

[7] A full report of estimates for model (3.2) is given in Appendix C. The report includes estimates of experience effects across sequences that, while mostly significant, are modest in size.

Figure 3. Frequency of buying and of shipping by stage, conditional on no previous defection (sequences 11-20)



Paths in black are the frequencies from the data, averaged over individual movers. data excludes robots. Paths in gray are the expected equilibrium frequencies. The sign after the stage *j* number is the sign of the coefficient estimate for the $PartnersStage_j$ variable in model 3.2; * (**,***) means the coefficient is significant at the 10 (5, 1) percent-level (two-tailed). There were 64 buyers and 56 sellers. Stage 1 variables for sellers were omitted for lack of variability in the data. Total observations for stage {8, …1} for buyers {320, 274, 238, 171, 141, 121, 111, 101} partners, {320, 261, 229, 182, 148, 131, 115, 93} strangers. For sellers {273, 233, 198, 129, 101, 81, 69, 53} partners, {262, 211, 178, 138, 107, 86, 66, 39} strangers.

IV. Summary

We show that the flow of information through the market can significantly influence the effectiveness of reputation building through information externalities. This is not predicted by standard economic theory, which for the chain store game predicts that all information externalities get washed out on the equilibrium path, and for the buyer-seller game predicts that all economic value of reputation information is mixed (strategied) away. Yet the out-of-equilibrium reputation building behavior reveals (more) valuable information than predicted, which is exploitable in the future and so creates information externalities. To the extent that the experimental matching effect will turn out to be robust in future studies and the mixing away of any economic information value and information externalities is inherent to the conventional story, explaining why reputation information is more robustly valuable than theoretically predicted seems to require new modeling approaches.

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Appendix A. Sequential equilibria for chain store and buyer-seller games

We state the equilibria for the general game forms:

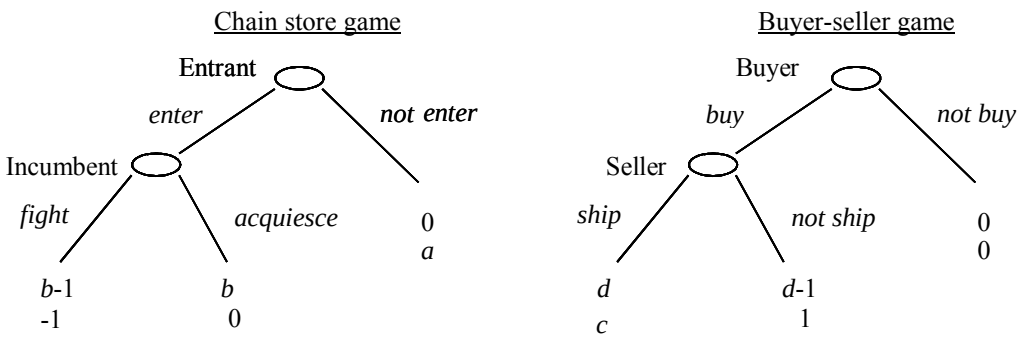


Figure A. Base games with payoff structure: $a > 1$, $0 < b < 1$, $0 < c,d < 1$

The payoff structure of the games studied in the experiments are equivalent to those shown in Figure A up to affine transformation. Stages for all games are labeled in descending order: $n = N, \ldots, 1$.

Sequential equilibrium for the chain store game, both partners and strangers matching (Kreps and Wilson, 1982). For the chain store game in Figure 1, $b = 0.5$ and $a = 1.5$.

1) Let p_n = prob(incumbent is strong at the beginning of stage 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 stage n+1 then $p_n = p_{n+1}$. If there is entry in stage 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 stage 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.

Stage 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 buyer-seller game, both partners and strangers matching. For the buye-seller game in Figure 1, $d = 0.667$ and $c = 0.334$.

1) Let q_n = prob(seller is intrinsically honest in stage 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 stage n+1 then $q_n = q_{n+1}$. If there is buying in stage 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 stage 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.

Stage 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; Buyer-seller Game instructions are analogous.]

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

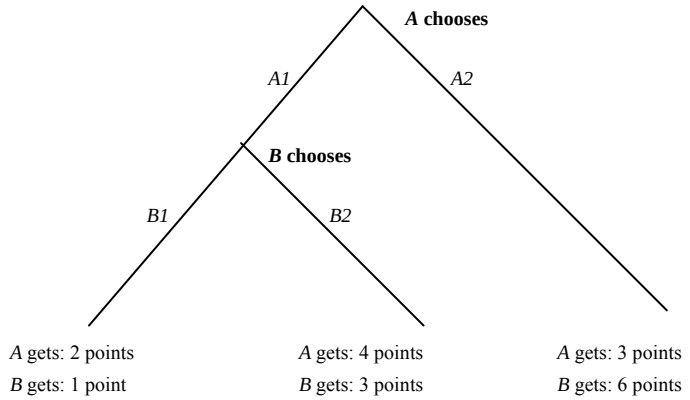
Each decision maker has been randomly assigned to be a member of one of two groups with 15 subjects each. Each group will play separately; there will be no interaction between them.

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.

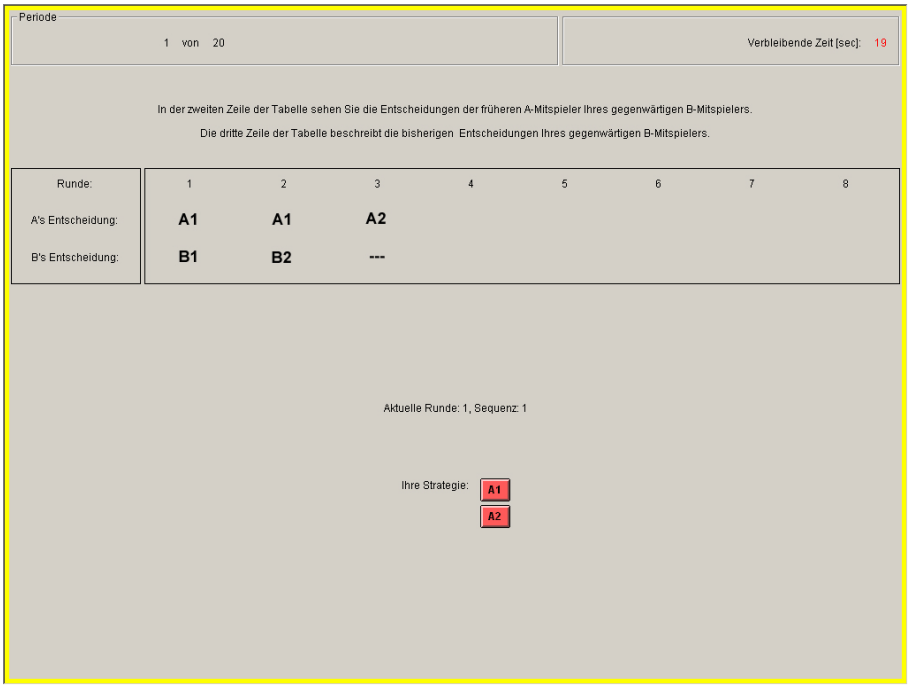
In each round, you can earn points according to the decisions made in this round. 33 points are worth 1 Euro, and all points are paid in cash along with your show-up fee at the end of the experiment. If *A* chooses *A1* and *B* chooses *B1*, then *A* gets 2 points and *B* gets 1 point. If *A1* and *B2* 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

Appendix C. Estimates of Probit Models

Table C1. Random effects probit estimates (*p*-values) of Equation 3.1

	Chain store		*Buyer-seller*	
y_ijt = 1 if	*Enter*	*Fight*	*Buy*	*Ship*
Constant	-0.30	-2.07	1.25	-3.85
	(0.000)	(0.000)	(0.000)	(0.000)
Partners_i	-0.08	-0.34	0.76	0.46
	(0.095)	(0.000)	(0.008)	(0.000)
*Stage_2**	-0.31	2.21	0.60	3.62
	(0.000)	(0.000)	(0.000)	(0.000)
Stage_3	-0.28	2.33	1.42	4.24
	(0.000)	(0.000)	(0.000)	(0.000)
Stage_4	0.00	2.61	1.66	4.35
	(0.991)	(0.000)	(0.000)	(0.000)
Stage_5	0.19	2.75	1.22	4.21
	(0.008)	(0.000)	(0.000)	(0.000)
Stage_6	0.38	3.14	1.16	4.30
	(0.000)	(0.000)	(0.000)	(0.000)
Stage_7	0.65	3.02	1.39	5.03
	(0.000)	(0.000)	(0.000)	(0.000)
Stage_8	0.81	2.47	0.82	5.35
	(0.000)	(0.000)	(0.000)	(0.000)
*T**	0.02	0.01	-0.03	-0.04
	(0.000)	(0.051)	(0.000)	(0.000)
Rho	0.39	0.65	0.37	0.48
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	6514	2823	5599	4118
Number of individuals	64 entrants	56 incumbents	64 buyers	56 sellers
Log-likelihood	-3414.34	-1104.86	-696.13	-1725.21
Chi-squared *p*-value	0.000	0.000	0.000	0.000

*Numbered in reverse order of occurance; see text.

Table C1. Random effects probit estimates (*p*-values) of Equation 3.2

	Chain store		*Buyer-seller*	
y_ijt = 1 if	*Enter*	*Fight*	*Buy*	*Ship*
Constant	0.03	-1.70	1.24	-3.47
	(0.661)	(0.000)	(0.000)	(0.000)
*Partners_i x Stage_1**	-0.25	-1.54	0.84	--**
	(0.006)	(0.000)	(0.025)	
Partners_i x Stage_2	-0.06	-1.68	1.43	0.58
	(0.649)	(0.000)	(0.001)	(0.003)
Partners_i x Stage_3	0.06	-2.09	1.00	0.60
	(0.641)	(0.000)	(0.389)	(0.000)
Partners_i x Stage_4	0.39	-1.81	1.56	0.22
	(0.019)	(0.000)	(0.675)	(0.316)
Partners_i x Stage_5	0.73	-1.46	0.66	0.78
	(0.000)	(0.000)	(0.302)	(0.000)
Partners_i x Stage_6	0.88	-0.97	1.43	0.22
	(0.000)	(0.000)	(0.049)	(0.127)
Partners_i x Stage_7	0.69	-0.71	1.00	0.36
	(0.000)	(0.001)	(0.048)	(0.015)
Partners_i x Stage_8	0.55	-0.74	0.97	0.37
	(0.000)	(0.000)	(0.009)	(0.010)
*Partners_i x t**	0.00	0.05	-0.03	0.00
	(0.049)	(0.000)	(0.187)	(0.597)
Stage_2	-0.41	2.27	0.39	3.18
	(0.000)	(0.000)	(0.023)	(0.000)
Stage_3	-0.43	2.62	1.37	3.80
	(0.000)	(0.000)	(0.003)	(0.000)
Stage_4	-0.32	2.82	1.43	4.06
	(0.003)	(0.000)	(0.000)	(0.000)
Stage_5	-0.31	2.87	1.30	3.69
	(0.003)	(0.000)	(0.000)	(0.000)
Stage_6	-0.19	2.94	0.96	4.03
	(0.017)	(0.000)	(0.000)	(0.000)
Stage_7	0.19	2.69	1.31	4.68
	(0.033)	(0.000)	(0.000)	(0.000)
Stage_8	0.42	2.15	0.76	5.00
	(0.000)	(0.000)	(0.000)	(0.000)
t	0.02	-0.02	-0.02	-0.04
	(0.000)	(0.012)	(0.009)	(0.000)
Rho	0.39	0.62	0.37	0.48
	(0.000)	(0.000)	(0.001)	(0.000)
Number of observations	6514	2823	5599	4118
Number of individuals	64 entrants	56 incumbents	64 buyers	56 sellers
Log-likelihood	-3363.56	-1067.32	-689.51	-1718.92
Chi-squared *p*-value	0.000	0.000	0.000	0.000

*Numbered in reverse of occurance; see text.

**Insufficient variability in data to estimate.