Fairness and Sharing in Innovation Games: A Laboratory Investigation*

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Abstract

This paper studies whether psychological considerations can exacerbate distributional conflicts and prevent agents from adopting innovations that are potential Pareto improvements. In the innovation game without the sharing option, a participant *A* subject chooses whether to introduce an innovation that increases *A*'s payoff, but reduces *B*'s payoff, relative to the "status quo" payoff of each participant. If *A* innovates, *B* then decides whether to accept or reject the innovation. In all payoff treatments, *(innovate, accept)* is the unique subgame perfect equilibrium if both participants are only concerned with maximizing their pecuniary payoffs. We find that this outcome is observed less than one-half of the time overall when the sharing option is not available. *A* participants only innovate about 75 percent of the time, and *B* participants reject the innovation nearly 40 percent of the time. In the innovation game with the sharing option, *A* has the additional option to invest resources to share his gain from the innovation with *B*. We find that the availability of the sharing option increases the rate at which participant *A* subjects innovate in one of the two payoff treatments.

Key words: Innovation, Fairness, Sharing, Distributional Conflicts, Laboratory Experiment

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1. Introduction

Many economic changes--for example, the introduction of a new product by an entrepreneur, an increase in the openness of an economy, or reforms within an organization--increase the welfare of some people but at the same time hurt others. These changes constitute potential Pareto improvements when the "winners'" gains are larger than the "losers'" losses. In the absence of actual redistribution, however, such changes create distributional conflicts and do not constitute actual Pareto improvements over the status quo. This paper introduces laboratory innovation games to identify possible mechanisms through which psychological considerations like envy and reciprocity may exacerbate distributional conflicts and prevent agents from adopting innovations that are potential Pareto improvements.

The fact that distributional conflicts can prevent changes that are potential Pareto improvements from taking place has long been emphasized by economists (we hereafter refer to such changes as *innovations*). Kuznets (1968) stressed that "the early phase of transition to the modern industrial economy is characterized by great internal strains and conflicts, consequences of the shifts in relative economic position and power of various groups affected differentially by the increase in numbers and by the opportunities of the new technology" (Kuznets, 1968, p.21). In a study of the history of technological innovations, Mokyr (1990) shows that resistance by those who would be adversely affected by the introduction of a new technology have prevented innovations from being adopted, especially when those who were resisting the innovation were politically powerful. Alesina and Drazen (1991) demonstrate how distributional conflicts can lead to the delay of economic stabilization in a "war-of-attrition" model. Fernandez and Rodrik (1991) analyze how distributional conflicts can prevent efficiency-enhancing policy changes such as trade liberalization from taking place when some citizens do not know whether they will eventually gain or lose if the reform is adopted. These studies illuminate important mechanisms through which distributional conflicts can prevent efficiency-enhancing changes from taking place. As in most economic analysis, this work assumes that individuals are only motivated to maximize their narrow self-interest--namely, their monetary payoffs. In such a framework, an individual will resist an innovation if and only if resisting the innovation yields a higher pecuniary utility than accepting the innovation.

As many scholars have emphasized, however, non-economic considerations may also be important in determining how people--especially those who are hurt by the changes--react to economic changes (see, for example, Lewis (1955), Foster (1967), Kennedy (1988); also see Inglehart (1997, especially chapters 1 and 7) and the references cited there). Drawing from a literature that emphasizes the importance of envy in developing countries and transitional economies, Mui (1995) studies how differences in legal institutions affect envious individuals' incentives to undertake pre-innovation sabotage or post-innovation retaliation against an innovator, which can in turn affect the latter's incentive to innovate and to share the surplus from his innovation with others. Platteau (1996) reviews important contributions regarding the relationship between non-economic considerations and the incidence of innovation, and argues that negative emotional reactions toward innovators in tribal societies may explain why innovators in such societies often suffer from witchcraft accusations.

Mui (1995) and Platteau (1996) study how non-economic considerations like envy and concern for social status can be important in determining the incidence of innovation. But their work suggests that non-economic and economic considerations can interact in potentially complex way, so it is difficult to evaluate whether the (often anecdotal) field data provides clear evidence of the importance of non-economic considerations on the incidence of innovation. This paper introduces laboratory innovation games to gather systematic evidence regarding the importance of psychological considerations on subjects' decisions regarding whether to introduce or reject an innovation that will improve the innovator's monetary payoff but decrease the payoff of his opponent. Our findings provide evidence that non-economic considerations can play an important role in determining the incidence of innovation in these circumstances. Moreover, the laboratory method also enables us to examine whether these deviations from narrow self-interest respond in predictable ways to changes in relative payoffs.

In our basic innovation game, a participant *A* subject chooses whether to introduce an innovation that increases *A*'s payoff, but reduces *B*'s payoff, relative to each participant's "status quo" payoff. If *A* innovates, a participant *B* subject then decides whether to accept or reject the innovation. In all payoff treatments, *(innovate, accept)* is the unique subgame perfect equilibrium if both participants are only concerned with maximizing their pecuniary payoffs. If non-economic considerations are important in motivating subjects' decisions, however, then *B* might reject the innovation introduced by *A*. This possibility can deter some *A* participants from adopting the innovation. We find that the "pecuniary subgame perfect equilibrium" *(innovate, accept)* is observed less than one-half of the time overall for this basic game. The *A* participants only innovate about 75 percent of the time, and *B* participants reject the innovation nearly 40 percent of the time. Rejection rates are higher when the innovation payoffs are more unequal, consistent with envious and reciprocal motivations. We also introduce a treatment that allows *A* participants to incur a monetary cost to establish a sharing mechanism. The availability of a sharing option increases the rate of innovation and overall efficiency for some payoff structures.

The rest of this paper is organized as follows. Section 2 introduces the innovation game and summarizes some relevant contributions in the behavioral and experimental economics literature. Section 3 discusses the experimental procedures, and Section 4 reports the results. Section 5 concludes.

2. Pareto Improvement, Distributional Conflict and Innovation

2.1 The Innovation Game without the Sharing Option

To see how psychological considerations may exacerbate the effects of distributional conflicts on the incidence of innovation, consider the innovation game illustrated in Figure 1. Player *A* chooses between "not innovate" and "innovate." If *A* chooses not to innovate, *A* and *B* receive s_a and s_b dollars, respectively. If *A* chooses to innovate, *B* then chooses between "rejecting" or "accepting" the innovation. Rejection payoffs are (w, w) and acceptance payoffs are (x_a, x_b). In the experiment, s_a, s_b, w, x_a and x_b are all positive, with $w < s_a < x_a$, $w < x_b < s_b$ and $2w < s_a + s_b < x_a + x_b$. This simple game captures the idea that *A* can choose between maintaining the status quo or adopting an innovation. The innovation can be interpreted as any change in the economic environment introduced by *A*. If the innovation is introduced by *A* and accepted by *B*, it will increase *A*'s payoff ($s_a < x_a$) but will decrease *B*'s payoff ($x_b < s_b$); however, *A*'s gain is larger than *B*'s loss.

If both players are only concerned about maximizing their monetary payoffs, then the unique subgame perfect equilibrium of this game is *(innovate, accept)*. However, several strands of recent literature suggest the observed outcome may deviate from this prediction based on narrow self-interest.

In the innovation game, if *A* innovates, the subgame played by *A* and *B* can be considered a "truncated" ultimatum game. In the ultimatum game introduced by Güth et al. (1982), the first player (the Proposer) proposes to split a fixed amount of money, and the second player (the Respondent) then decides whether to accept or reject the proposed allocation. If the Respondent rejects, both players get nothing. If both players seek to maximize their pecuniary payoffs, then the Proposer will offer and the Respondent will accept the smallest amount available. Contrary to this prediction, respondents frequently reject highly unequal offers and Proposers offer substantial amounts. (For recent surveys on the ultimatum game and the related dictator game, see Camerer and Thaler (1995), Roth (1995) and Fehr and Schmidt (1999).) In the innovation game illustrated in Figure 1, when *A* innovates*,* the two subjects can be thought as playing a game of how to divide $x_a + x_b$, except that *A* is constrained to offer only a highly unequal allocation in which he receives most of the total. We employ x_a = \$3.00 in all sessions, and x_b = \$0.60 and x_b = \$0.30 in the Low Inequality and High Inequality treatments, respectively.[1]

To explain subjects' behavior in the ultimatum game, Bolton (1991) postulates that a subject does not only care about his absolute payoff, but also his payoff relative to the payoff of his opponent. This approach has been extended recently by Bolton and Ockenfels (2000) and Fehr and Schmidt (1999). Kirchsteiger (1994) develops a related model to demonstrate that envy may be important in determining subjects' behavior in the ultimatum game.[2] Beckman et al. (1997) reports experimental evidence that envy can motivate subjects to reject a Pareto dominating income distribution. If A innovates in the innovation game without the sharing option, *A* will reduce both *B*'s absolute pecuniary payoff and increase the disparity between the two players' monetary payoffs. If *B* has a sufficiently strong concern for his relative pecuniary payoff, *B* may be willing to incur a monetary cost of $(x_b - w)$ dollars to reject the innovation.

The models developed in Bolton (1991), Mui (1995), Bolton and Ockenfels (2000) and

[1] If *B* rejects the offer, both players receive 20 cents rather than nothing as in an ultimatum game. This game also differs from the ultimatum game in that *A* has the choice of ending the game by not innovating, thereby ensuring that both players receive the status quo payoffs s_a and s_b. We shall explore the implication of this feature shortly in our discussion of reciprocity. In all sessions $s_a = s_b$ = \$1.00.

[2] The importance of people's concern for relative income has also been emphasized by many economists outside the experimental literature. See, for example, Dusenberry (1949) and Frank (1985).

Fehr and Schmidt (1999) all postulate that an individual's utility depends only on his absolute and relative monetary payoff, but they do not allow for the possibility that a similar allocation can give an individual a different level of utility depending on differences in the social context. As Rabin (1993; 1998) emphasizes, people like to help those who are helping them, and to hurt those who are hurting them. When such considerations of reciprocity are important, a person's preferences will not just depend on the final allocation for the relevant group, but will also depend on her beliefs about others' intentions--in particular, whether she believes others have been kind or unkind to her.[3]

Many experimental studies have found support for the hypothesis that reciprocity can have an important impact on behavior.[4] In our innovation game, reciprocity can prevent agents from adopting innovations that are potential Pareto improvements over the status quo. In particular, in the game represented in Figure 1, *A* has the choice of not innovating and preserving the status quo. By innovating, *A* essentially is forcing *B* to accept a lower payoff of $x_b < s_b$. Therefore, some *B* participants may view *A*'s decision to innovate as an act of hostility, which can induce these *B* participants to incur the monetary cost of x_b - w to punish the *A* participants. Anticipating this possibility, some *A* participants may decide not to innovate. Therefore, reciprocity considerations, in addition to the considerations of envy, can cause the observed outcome to deviate from the standard prediction of *(innovate, accept).* [5]

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[3] Levine (1998) provides a related model in which a person's decisions depend upon her beliefs regarding the preference type of others (e.g., whether others are altruistic, spiteful, or simply maximize monetary earnings).

[4] For example, Fehr et al. (1993) provide an experimental test of the gift exchange model of the labor market advanced in Akerlof (1982) and Akerlof and Yellen (1990). They find that employers offer a wage that is higher than the market clearing level, and a significant fraction of workers respond to a higher wage by choosing an effort level that is higher than the level that maximizes their pecuniary payoffs. In an investment game experiment, Berg et al. (1995) also find support for reciprocity.

[5] Our innovation game without sharing is also closely related to an earlier study conducted by Beard and Beil (1994), who offer an argument that is consistent with the idea of reciprocity to support the conjecture that observed behavior may deviate from the pecuniary subgame perfect equilibrium. In particular, they note how *A*'s action could trigger anger in *B*, prompting a special kind of non-(money) maximizing play, i.e., "vengeance." In 6 of the 7 payoff

2.2 The Innovation Game with the Sharing Option

Since we observe significant deviations from the pecuniary subgame perfect equilibrium outcome *(innovate, accept)* in the innovation game without sharing, one could say that an innovation that increases *A*'s income but at the same time decreases *B*'s income can generate an "emotional externality," which can prevent the innovation from taking place. In view of Coase's (1960) classic analysis of externality and the importance of sharing norms in many societies (see, for example, Mui (1995), Platteau (1996) and the references cited there), it is natural to ask whether introducing the possibility of side-payments may help mitigate the effects of the emotional externalities and increase the incidence of innovation.

To investigate whether the availability of a sharing option will alter subjects' choices, we introduce a treatment that allows participant *A* to incur a monetary cost *c* to establish a sharing mechanism. In this innovation game with sharing, *A* first chooses between "not invest in sharing" and "invest in sharing." If *A* chooses not to invest in sharing, the two players play the innovation game without sharing described above. If *A* chooses to invest in sharing, the two players play an ultimatum game with a total surplus of $x_a + x_b - c$ dollars. The cost of establishing the sharing mechanism is small, so that the total surplus available for division between *A* and *B* after innovation and sharing is still larger than the total surplus without innovation (i.e., $0 < c < (x_a + x_b) - (s_a + s_b)$). In this case, *A* can offer a portion of the total surplus $x_a + x_b - c$ dollars to *B*, and *B* then decides whether to reject or to accept the offer. If *B* rejects the offer, *A* receives $w - c$ dollars while *B* receives w dollars.

Figure 2 illustrates a particular parameterization of this game that was used in sessions 7

treatments considered by Beard and Beil, both subjects gain relative to the status quo if the innovation is accepted. By contrast, our experiment always reduces *B*'s payoff if *A* chooses to innovate (relative to the status quo), because our goal was to trigger distributional conflict.

and 8 of our experiment. In Figure 2, if *A* chooses to invest in sharing and offers a surplus of t_1 dollars to *B*, then if *B* accepts the innovation *A* receives 3.10-t_1 while *B* receives t_1. (Table 2 below displays the nine offers t_1, …, t_9 available in each treatment.)

Note that if *A* chooses to share some of the gains from innovation, it will then be more costly (in dollar terms) for *B* to reject the innovation. Moreover, the act of sharing may also reduce *B*'s inclination to reject the innovation for other reasons. For example, suppose that envy causes *B* to reject the innovation. When the sharing option is available, *A* can decrease the probability that *B* rejects the innovation by choosing to share his gain from the innovation with *B*. In deciding which of the available surplus divisions he will propose, *A* balances the tradeoff between a decrease in his own pecuniary payoff as a result of a higher transfer to *B* against a decrease in the expected probability of rejection.[6]

3. Experimental Design and Procedures

The experiment included four treatment cells in a 2-by-2 design. One of the treatment variables was the payoff structure, and the other was the presence or absence of a sharing option. We conducted two sessions in each of the four cells, for a total of eight sessions. Each session employed between 14 and 20 subjects. Table 1 summarizes the experimental design and the number of subjects who participated in each treatment. We refer to the payoff treatment with

[6] Introducing the possibility of sharing also enables us to conduct a preliminary investigation regarding the relative importance of pure envy vis-a-vis reciprocity in determining *B* participants' choices. As pointed out earlier, reciprocity implies that individuals are concerned both about the final allocation as well as about others' intentions. The innovation game treatment without the sharing option versus the treatment with the sharing option permits the following comparison: For the same payoff treatment, if *A* chooses to innovate under the no sharing treatment or if he chooses to innovate and not invest in sharing under the sharing treatment, *A* will essentially be presenting *B* with a choice between an allocation of (x_a, x_b) and an allocation of (w, w) under both treatments. If reciprocity is unimportant--for example, if the dominant psychological consideration that motivates *B*'s choices is pure envy--then the rejection rate for these equivalent payoffs should be similar. On the other hand, *A* participants have the option of sharing some of the gains from innovation with a *B* participant under the sharing treatment, so participant *B* subjects may interpret the *innovate and not invest in sharing* choice under the sharing treatment as "more hostile" than the *innovate* choice under the no sharing treatment. This may lead to a higher rejection rate for this choice in the sharing treatment.

potential innovation payoffs of \$3.00+0.60=\$3.60 as the Low Inequality treatment (sessions 1, 2, 5 and 6). We call the other payoff treatment the High Inequality treatment.

The instructions explained the payoffs that each participant would earn based on any combination of choices; these instructions are included in an Appendix available upon request. After reading the computer-displayed instructions and passing a quiz to verify understanding, one-half of the subjects in each session were randomly assigned the role of participant *A*, with the other half assigned the role of participant *B*. Subjects remained in the same role throughout the session, and they played this game exactly once with each subject in the other role (the instructions emphasized this fact). The absence of repeated interaction between any two subjects allows learning, but rules out reputation considerations. So rather than playing a repeated game, subjects play a sequence of one-shot, static games against different opponents.

Each play of the game followed an identical sequence. Participant *A* moved first, selecting an integer by pressing a button on her web browser. A choice of "1" by participant *A* corresponded to the status quo, in which case participant *B*'s choice was irrelevant. A choice of "2" by *A* corresponded to selecting the innovation. *Participant A's choice was then revealed to participant B*, who could accept the innovation by pressing his "2" button. Alternatively, *B* could reject the innovation by pressing his "1" button.

In the sessions with the sharing option, participant *A* had more choices, labeled as buttons 3 through 11. These choices led to the payoffs summarized in Table 2, and they allowed *A* to share the total innovation surplus with *B*. Participant *B* then decided whether to accept or reject this allocation. Thus, if *A* decides to innovate and chooses to share the surplus, the two subjects will be playing an ultimatum game. However, to choose one of these "sharing" options (the term "sharing" was *not* used in the instructions), participant *A* had to invest 20 cents of the total available surplus. For example, for Session 4 the total earnings if *A* chose 2 and *B* chose 2 was \$3.00+\$0.30=\$3.30. The instructions explained that if *A* instead selected any button between 3 and 11, she was "investing" 20 cents, because if *B* chose 2 then the total earnings available to both participants is always 20 cents less--that is, \$3.10. If *A* made a choice between 3 and 11 and *B* chose 1, then participant *A* earned 0 instead of \$0.20. Therefore, *A* pays the 20-cent "investment" whether or not *B* accepts the offer. These rejection payoffs are slightly different from the standard ultimatum game.

In addition to reporting the choice of the other subject in each game, subjects' computers presented their own accumulated earnings throughout the session (this was the subject's private information). Subjects were also required to keep a hardcopy log of their earnings, their own and their opponents' choices for each game. Therefore, subjects always had easy access to their own history of play. They never learned their opponents' history or identity. Each complete session (including instructions, quiz, play and payoff distribution) lasted only 30 to 40 minutes. Salient earnings ranged between \$2.50 and \$29.00 per subject, with an average of \$11.19.

4. Results

This section presents the results, organized by a set of hypotheses that summarize the preceding discussion. The statistical tests employ data from the final period choices only, after learning has taken place. Individual subjects therefore contribute one observation to each of the statistical tests.[7] Section 4.1 presents the sessions without the sharing option and Section 4.2

[7] As discussed in the previous section, subjects play exactly once against each player of the opposite type. This permits learning but eliminates repeated play incentives. It does not eliminate the potential nonindependence of experimental observations across subjects, however. Although we are careful to maximize independence by only including one observation per subject in the statistical tests, subjects do face common opponents in different periods. These common opponents may introduce some statistical dependence for some subjects. We think this dependence is minor, but it could cause a slight downward bias in the significance levels we report. We are unaware of any experimental design that would permit complete statistical independence but still permit learning in a sequence of one-shot games, for any reasonable sample size given realistic constraints on overall subject payment budgets.

presents the sessions with the sharing option available. In both of these subsections we first present participant *B*'s (second stage) choices before participant *A*'s (first stage) choices. Section 4.3 compares outcomes in the sharing and no sharing treatments.

4.1 Sharing Option Not Available

We first present two hypotheses that summarize the equilibrium play when subjects are only motivated by pecuniary considerations.

Hypothesis 1: In the innovation game without sharing, (A) the pecuniary equilibrium outcome *(innovate, accept)* is observed most of the time in both the High Inequality and the Low Inequality treatments; and (B) no significant difference exists in the incidence of this pecuniary equilibrium across the two payoff treatments.

As alternatives to the income-maximizing self-interest equilibrium prediction, non-economic considerations like envy and reciprocity have specific implications that we summarize in the following alternative hypothesis:

Hypothesis 2: In the innovation game without sharing, the more unequal allocation in the High Inequality treatment leads to a higher rejection rate than in the Low Inequality treatment.

To test Hypotheses 1 and 2, we first examine participant *B*'s behavior when *A* chooses to innovate.

Result: Participant *B* rejects the innovation more frequently in the High Inequality treatment than in the Low Inequality treatment.

Support: Table 3 reports the overall frequency of innovation and rejection rates for the treatment without the sharing option. Participant *B* subjects reject the innovation 26 percent of the time in the Low Inequality treatment, compared to 56 percent of the time in the High Inequality treatment. In the final period, the rejection rates differ even more--19 percent in the

Low Inequality treatment versus 64 percent in the High Inequality treatment. These final period rejection rates are significantly different (Fisher's exact test p-value=0.04 (two-tail test)).

These relatively high rejection rates are inconsistent with Hypothesis 1. This suggests that subjects do not only seek to maximize monetary earnings. The significantly higher rejection rate in the High Inequality treatment is exactly what both envy and reciprocity predict, providing support for Hypothesis 2. In the absence of the sharing option, participant *A* can only choose between maintaining the status quo or adopting the innovation with the constraint that he can offer only a relatively unequal allocation to *B*. The concern that participant *B* may reject such an unequal allocation due to envy or reciprocity can deter *A* from innovating, particularly in the High Inequality treatment. Hypothesis 2 therefore naturally leads to the following:

Hypothesis 3: In the innovation game without sharing, participant *A* subjects choose the status quo more frequently in the High Inequality treatment than in the Low Inequality treatment.

Result: Participant *A* chooses the innovation option about 75 percent of the time, with no substantial difference in the innovation rate across the Low Inequality and High Inequality treatments.

Support: Table 3 shows that the innovation rate is nearly identical for the Low Inequality and High Inequality treatments when pooling over all periods. In the final period, the innovation rate is slightly higher in the Low Inequality treatment, but the differences across treatments are not statistically significant (Fisher's exact test p-value=0.67 (two-tail test)).[8]

The failure to observe differences in the innovation rates in the Low Inequality and High Inequality treatments fails to support Hypothesis 3 and is surprising in light of the finding that

[8] The equal split (status quo) rate in this experiment is substantially below the 71 percent of equal and "near" equal splits (at least 40 percent of the surplus to each player) rate reported across ten ultimatum game studies, summarized by Fehr and Schmidt (1999). Our percentage of "unfair" (innovation) offers also substantially exceeds that observed

participant *B* rejects the innovation more frequently in the High Inequality treatment than in the Low Inequality treatment. The low rejection rate in the Low Inequality treatment clearly makes innovation profitable for participant *A*; innovation leads to an expected payoff of $2.47 based on the final period rejection rate of 19 percent. Because of the higher rejection rate in the High Inequality treatment, the expected payoff from innovation in this treatment (calculated as $1.21 based on the final period rejection rate of 64 percent) is much closer to the status quo payoff of $1.00. Nevertheless, innovation provides greater expected profit in both treatments, which could explain the lack of an inequality treatment effect for the innovation rates.[9]

Conclusion 1: The pecuniary subgame perfect equilibrium *(innovate, accept)* is observed frequently in the Low Inequality treatment, but it is observed infrequently in the High Inequality treatment. Overall, the incidence of the pecuniary equilibrium outcome is significantly different in the two treatments. The data therefore reject both parts of Hypothesis 1 and support Hypothesis 2. Although the data fail to support Hypothesis 3, the choices in the no sharing treatment are more consistent with envy and reciprocity than narrow pecuniary motivations.

Support: The equilibrium rates presented in Table 3 support this conclusion, which follows directly from the higher rejection rates in the High Inequality treatment (the result associated with Hypothesis 2). In the final period, support for this equilibrium is relatively strong for the Low Inequality treatment (68 percent of the games), but is very weak in the High Inequality treatment (27 percent of the games). This difference is statistically significant

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in standard ultimatum games. These differences are likely due to the fact that the total surplus available is much greater following innovation and that equal splits are not possible following innovation.

[9] Note, however, that the lack of a significant difference in innovation rates in spite of the large difference in expected payoffs from innovation in the two payoff treatments is inconsistent with a quantal response equilibrium (QRE) (McKelvey and Palfrey, 1998). In a QRE, the probability that a player selects any choice is related directly to its payoff relative to alternative choices. The expected payoffs from innovation are nearly equal to status quo in the High Inequality treatment, but the innovation expected payoffs far exceed the status quo payoffs in the Low Inequality treatment. Therefore, if subjects are making “noisy best responses” as in QRE, the innovation rate should be much lower in the High Inequality treatment than in the Low Inequality treatment--contrary to what we observe.

(Fisher's exact test *p*-value=0.04 (two-tail test)).

4.2. Sharing Option Available

Next we consider whether or not subjects' behavior deviates from the pecuniary subgame perfect equilibrium with the sharing option.

Hypothesis 4: In the innovation game with sharing, (A) the pecuniary equilibrium outcome *(innovate and not share, accept)* is observed most of the time in both the High Inequality and the Low Inequality treatments; and (B) no significant difference exists in the incidence of this pecuniary equilibrium across the two payoff treatments.

Result: The pecuniary subgame perfect equilibrium (*innovate and not share (choice 2), accept*) is observed infrequently when sharing is available, and this equilibrium rate is not significantly different in the Low Inequality and High Inequality treatments.

Support: The final column of Table 4 indicates that the pecuniary equilibrium outcome is observed in about one-quarter of the games, rejecting Hypothesis 4(A). In the final period, this outcome is observed more frequently in the High Inequality treatment (37 percent) than in the Low Inequality treatment (22 percent), but this difference in equilibrium rates is not significant (Fisher's exact test *p*-value=0.48 (two-tail test)). This is consistent with Hypothesis 4(B). Although the difference here across payoff treatments is not statistically significant, the (insignificantly) greater equilibrium rate in the High Inequality treatment is counter-intuitive and contrasts sharply with Conclusion 1, which is that the equilibrium rate when sharing is not available is significantly higher in the Low Inequality treatment.[10]

[10] The first column of Table 4 indicates a somewhat puzzling nontrivial rate for the status quo choice. This choice provides an equal split of $1 to each player. This status quo is inferior to the equal split offered by choice 7, which unlike the status quo choice must be accepted by participant B. Table 4 shows that this safe status quo rate falls from 14 percent over all periods to 8 percent in the final period. Independent evidence provided by Beard and Beil (1994) suggests that some of this secure play could instead be due to subjects' lack of trust in the self-interested maximation of others. Using substantially different parameters, Beard and Beil observe subjects choosing a strictly Pareto inferior but safe (unrejectable) allocation between 20 and 67 percent of the time.

We now consider the acceptance and rejection decisions of participants *B*.

<u>Hypothesis 5:</u> In the innovation game with sharing, (A) more unequal allocations offered by participant *A* subjects are more likely to be rejected by participant *B* subjects in both the High Inequality and the Low Inequality treatments; and (B) when participant *A* subjects do not invest in sharing (i.e., they select choice 2), the participant *B* rejection rate is significantly lower in the Low Inequality than in the High Inequality treatment.

Note that Hypothesis 5(B) is simply the sharing treatment analogue to Hypothesis 2.

We begin with the results regarding part (A) of Hypothesis 5. Figures 3 and 4 present the entire frequency distribution of participant *A* choices and participant *B* rejection rates for all games (Figure 3) and for the final period (Figure 4). The upper panel of each figure presents the Low Inequality treatment, and the lower panel presents the High Inequality treatment. Recall the payoffs for these two sessions shown in Table 2. These figures provide visual evidence in support of Hypothesis 5(A). For quantitative evidence, we estimated the following probit model of participant *B* rejections across rounds:

(1) $\text{Prob}(Reject) = f(a + b_{off}*offer + b_{avrej}*average\ rejection\ rate_i)$,

where *offer* is the proportion of the total earnings offered to participant *B*. Slonim and Roth (1998) estimate a very similar model using ultimatum game data. For our innovation game with the sharing option, the estimated coefficient on the amount offered (b_{off}) is -6.59 and is highly significant (standard error=1.25). This indicates that lower offers to participant *B* are rejected with higher probability.[11] Thus, as in the standard ultimatum game, offers of more unequal

[11] See Slonim and Roth (1998) for a discussion of this specification. As in Slonim and Roth, our sample size is too small for a random-effects error specification, and a fixed effects specification is impractical because some subjects exhibit no variation in their rejection behavior. The average rejection rate for subject *i* (excluding the current offer) is included to capture individual rejection propensity differences, as multiple observations of the same subject are not independent. As expected, this coefficient is positive (estimated b_{avrej}=1.17) and significant (standard error=0.29).

payoffs are more likely to be rejected by participant B.

Table 4 provides evidence against part (B) of Hypothesis 5. Choice 2 is rejected in about 40 percent of the games when sharing is allowed. In the final period, choice 2 is rejected 2 of the 6 times it is chosen in the Low Inequality treatment, and is rejected in 1 of the 8 times it is chosen in the High Inequality treatment. These sample sizes are too small for meaningful statistical tests, but note that these rejection rates are not very different between the Low Inequality and High Inequality treatments. Envy and reciprocity both suggest that the rejection rates should be greater in the High Inequality treatment (Hypothesis 5(B)), as we found in the case when sharing is not allowed. To summarize this evidence, we have:

Conclusion 2: Participant *B* subjects frequently reject the innovation when participant *A* proposes substantially unequal allocations of the surplus, and the rejection rate falls as the proposed allocation for participant *B* increases. This provides support for part (A) of Hypothesis 5. However, when participant *A* subjects do not invest in sharing (i.e., they select choice 2), participant *B* rejection rates are not significantly different in the Low Inequality and High Inequality treatments. The data therefore do not support Hypothesis 5(B).

When the sharing option is available, depending on his conjecture of what constitutes offers that are too unequal to be acceptable to *B*, *A* can choose to share "appropriately" the surplus from innovation with *B* to increase the chance that *B* will accept the innovation. We shall say that participant *A* subjects choose to "share the surplus" when they offer participant *B* more earnings than participant *B* receives when *A* chooses innovation and no sharing (i.e., choice 2). The observation that *A* can strategically choose to share the surplus from innovation so as to increase the chance of its acceptance by *B* leads to the following hypothesis:

Hypothesis 6: In the innovation game with sharing, participant *A* subjects share the surplus more frequently in the High Inequality treatment than in the Low Inequality treatment.

Note from Table 2 that in the Low Inequality treatment, A's choices of 5 through 11 offer participant *B* more than the $0.60 they earn when participant *A* innovates but does not opt to share, so in the Low Inequality treatment participant *A* shares the surplus with choices 5 through 11. In the High Inequality treatment, participant *A* shares the surplus with choices 4 through 11, because participant *B* earns $0.30 when *A* innovates but does not invest in sharing.

Result: Participant *A* subjects share the surplus more frequently in the High Inequality treatment than in the Low Inequality treatment.

Support: Table 4 shows that participant *A*'s rate of sharing the surplus is only 22 percent in the Low Inequality treatment, compared to 42 percent in the High Inequality treatment. In the final period, these rates differ even more--11 percent in the Low Inequality treatment and 58 percent in the High Inequality treatment. This difference is statistically significant (Fisher's exact test p-value<0.01 (two-tail test)). This provides support for Hypothesis 6.[12]

Note from Figures 3 and 4 that the modal choice is always choice *2 (innovate and do not invest in sharing*). Curiously, in the Low Inequality treatment participant *A* subjects also frequently select choice 3, even in the final period. This high choice 3 rate is not due to a small minority of subjects, although almost one-third of the 30 total selections of choice 3 in this treatment were made by one subject (who chose 3 in all 9 of her decisions). Across all periods in this treatment, 11 of the 18 participant *A* subjects select choice 3 at least once. Choice 3 in this treatment provides payoffs of ($3.30, $0.10) if the innovation is accepted, and ($0.00, $0.20) if

[12] Including the status quo choice, over all periods we observe equal split proposals in 25 percent of the Low Inequality observations and in 21 percent of the High Inequality observations. These rates are much lower than the 71 percent rate for equal and near equal splits observed over ten ultimatum game studies summarized by Fehr and Schmidt (1999). Conversely, we observe higher rates of highly unequal offers (with one share less than 20 percent of the total surplus) than in the standard ultimatum game: 25 percent of the Low Inequality observations and 54 percent of the High Inequality observations, compared to 4 percent in the standard ultimatum game. These differences highlight the fact that our experiment is quite different from the ultimatum game.

the innovation is rejected. Some participant *A* subjects who select choice 3 may be betting that the innovation will be accepted because of altruistic preferences of participant *B*. In other words, they may hope that *B* will prefer that *A* earn $3.30 rather than 0, even if this high *A* payoff costs *B* 20 cents. Three of the 11 subjects who tried choice 3 did so once. Of the remaining 8 subjects who selected choice 3 more than once, 6 chose 3 again after observing *B* accept their choice 3 in an earlier period. Indeed, the overall rejection rate of choice 3 was only 70 percent (21 out of 30), so the average participant *A* payoff of choice 3 was $0.99 (0.3*$3.30). This is similar to the status quo payoff ($1.00), which was chosen by participant *A* at a similar rate (25 times).

4.3. Comparing the Treatments with and without the Sharing Option

When the sharing option is available, participant *A* subjects can strategically choose to share the surplus from innovation, so they should be less inclined to maintain the status quo in the treatment with sharing. Define the efficiency of the observed outcome as the percentage of maximum available earnings realized by subjects. Our final hypothesis is as follows:

<u>Hypothesis 7:</u> Holding the payoff treatment constant, (A) the availability of the sharing option decreases the rate that the participant *A* subjects choose the status quo; and (B) the availability of the sharing option increases overall efficiency.

<u>Result:</u> The availability of the sharing option decreases the rate that the participant *A* subjects choose the status quo (i.e., choose not to innovate) in the High Inequality treatment, but does not significantly affect the status quo rate in the Low Inequality treatment.

<u>Support:</u> Table 4 shows that when the sharing option is available, participant *A* subjects choose not to innovate and remain with the status quo in 12 to 15 percent of the games. By contrast, when the sharing option is not available, Table 3 shows that participant *A* subjects remain with the status quo in about 25 percent of the games.

Comparing the final period status quo rates in the sharing available versus the sharing not available treatments (also shown in Tables 3 and 4), the rates are not statistically different in the Low Inequality treatment (Fisher's exact test *p*-value=1.00 (two-tail test)), but the status quo rate is significantly lower in the High Inequality treatment (Fisher's exact test *p*-value=0.03 (two-tail test)). Thus, Hypothesis 7(A) receives support only in the High Inequality treatment.

Result: The availability of the sharing option increases overall efficiency in the High Inequality treatment, but decreases efficiency in the Low Inequality treatment.

Support: Efficiency is defined as the percentage of maximum available earnings realized by subjects. The maximum available earnings for the two subjects jointly is $3.60 in the Low Inequality treatment, and is $3.30 in the High Inequality treatment. In the pecuniary subgame perfect equilibrium, efficiency is 100 percent. Whenever participant *A* invests in sharing, subjects do not realize the $0.20 investment cost. Efficiency therefore necessarily falls below 100 percent when participant *A* invests in sharing, even when participant B accepts the offer.

In the High Inequality treatment, overall efficiency is 53 percent when sharing is not available, compared to 72 when sharing is available. In the final period, in the High Inequality treatment the positive impact of the sharing option is even more pronounced, raising average efficiency from 48 percent to 87 percent. This difference is statistically significant (Wilcoxon test *p*-value=0.03 (two-tail test)). In the Low Inequality treatment, overall efficiency is 71 percent when sharing is not available, compared to 63 when sharing is available. In the final period, in the Low Inequality treatment the availability of the sharing option leads to lower average efficiency (60 percent) than when sharing is not available (79 percent). This difference is also statistically significant (Wilcoxon test *p*-value=0.02 (two-tail test)). A major source of the efficiency loss in the Low Inequality treatment with sharing available is the frequent selection (and rejection) of choice 3. Conclusion 3 summarizes the previous two observations:

Conclusion 3: The data provide support for Hypothesis 7 in the High Inequality treatment only. Data from the Low Inequality treatment are inconsistent with Hypothesis 7.

Finally, although our objective is to investigate whether or not non-economic considerations are important in affecting innovation decisions, this experiment permits one preliminary test concerning the relative importance of envy vis-a-vis reciprocity on subject choices in this experiment. Pure envy implies that the rejection rate toward the *innovate* choice under the no sharing treatment should be similar to the rejection rate toward the *innovate and not invest in sharing* choice (choice 2) under the sharing treatment, because both choices result in the same final allocation. By contrast, reciprocity implies that the rejection rate for these choices is higher in the sharing treatment than in the no sharing treatment because when participant *A* innovates but fails to share in the sharing treatment she is more likely to trigger a negative reciprocal response by participant *B*. We find that in the Low Inequality treatment the rejection rate of choice 2 is 40 percent when sharing is allowed, compared to 26 percent when it is not allowed. In the High Inequality treatment the rejection rate of choice 2 is 39 percent when sharing is allowed, compared to 56 percent when it is not allowed. The results are therefore mixed, and do not provide strong evidence that reciprocity (at least as defined in the usual way) affects decisions in this setting, independent of simple envious motivations.[13]

5. Conclusion

Many economic changes increase the welfare of some people but at the same time hurt

[13] In the previous version of this paper (Cason and Mui, 2000) we relate our experimental findings to two specific models of non-pecuniary preferences: Levine's (1998) signaling model based on different preference types (e.g., altruistic, spiteful or simple money-maximizing) and Fehr and Schmidt's (1999) model of inequality aversion. The rejection rates we observe are not high enough to be consistent with the inequality aversion parameters calibrated by Fehr and Schmidt, and their model also implies more equal payoff divisions than we observe. Levine's model and calibrated parameters also implies higher rejection rates than we observe.

others. Many scholars have argued that such "innovations" often generate emotional reactions that affect how the "losers" react to these changes, which can in turn affect the potential innovators' decisions regarding whether to introduce such innovations. This paper introduces laboratory innovation games to investigate whether non-economic considerations can prevent innovations that are potential Pareto improvements over the status quo from taking place. In all payoff treatments, *(innovate, accept)* is the unique subgame perfect equilibrium if both participants are only concerned with maximizing their pecuniary payoffs. In three of the four treatment conditions of this experiment, in the final period the most frequent outcome is this standard equilibrium. We find, however, that this equilibrium outcome is observed less than one-half of the time overall when the sharing option is not available. Moreover, the availability of the sharing option decreases the rate that the participant *A* subjects choose the status quo (i.e., choose not to innovate) in the High Inequality treatment, but does not significantly affect the status quo rate in the Low Inequality treatment.

This study provides clear evidence of the importance of psychological considerations in determining how distributional conflicts may prevent innovations from taking place. The current study has the important drawback, however, that the innovation game considered here is extremely stylized, and it does not include many important features concerning economic innovations. For example, in the current experiment, participant *A*'s ability to innovate is given exogenously. In reality, costly investments are often necessary before an individual acquires the knowledge and skill to introduce innovations. As Mui (1995) and Platteau (1996) have both emphasized, while innovators may be able to engage in sharing behavior strategically to reduce the spiteful responses by others, the fact that they need to share the surplus generated by their innovation may reduce their incentives to make costly investment in innovative activities ex ante.

On the other hand, according to the equity theory in psychology (Adams 1953), an individual's reward should be proportional to the value of his input. When *A* "earns" the ability to innovate as a result of costly and risky investment, *B* may be more willing to accept the innovation compared to the case when such investment is unnecessary. This consideration can in turn increase *A*'s willingness to adopt the innovation when he succeeds in acquiring the ability to do so. Enriching the innovation games to test these conjectures should deepen our understanding regarding how and to what extent psychological considerations may be important in influencing the incidence of economic innovation in the presence of distributional conflicts.

Table 1: Experimental Design and Summary of Payoffs

	Status Quo Payoffs (*A* chooses 1)	Innovation Payoffs (*A* chooses 2, *B* chooses 2)	Rejection Payoffs (*A* chooses 2, *B* chooses 1)	Sharing option not available	Sharing option available
Low Inequality	(\$1.00, \$1.00)	(\$3.00, \$0.60)	(\$0.20, \$0.20)	Session 1 (17 subjects) Session 2 (20 subjects)	Session 5 (18 subjects) Session 6 (18 subjects)
High Inequality	(\$1.00, \$1.00)	(\$3.00, \$0.30)	(\$0.20, \$0.20)	Session 3 (14 subjects) Session 4 (16 subjects)	Session 7 (20 subjects) Session 8 (17 subjects

Note: Payoffs are presented in the format (participant *A* earnings, participant *B* earnings).

Table 2: Payoffs for Sessions with Sharing Option Available

	Sessions 5 and 6 (Low Inequality Treatment)	Sessions 7 and 8 (High Inequality Treatment)
Status Quo Payoffs (*A* chooses 1)	(\$1.00, \$1.00)	(\$1.00, \$1.00)
Innovation Payoffs with no sharing (*A* chooses 2 and *B* chooses 2)	(\$3.00, \$0.60)	(\$3.00, \$0.30)
Rejection Payoffs with no sharing (*A* chooses 2 and *B* chooses 1)	(\$0.20, \$0.20)	(\$0.20, \$0.20)
Rejection Payoffs if sharing chosen (*A* chooses 3-11 and *B* chooses 1)	(\$0.00, \$0.20)	(\$0.00, \$0.20)
Total Surplus to be Divided if *A* chooses sharing option	\$3.40	\$3.10
A chooses 3 and *B* chooses 2	(\$3.30, \$0.10)	(\$2.95, \$0.15)
A chooses 4 and *B* chooses 2	(\$2.90, \$0.50)	(\$2.60, \$0.50)
A chooses 5 and *B* chooses 2	(\$2.50, \$0.90)	(\$2.25, \$0.85)
A chooses 6 and *B* chooses 2	(\$2.10, \$1.30)	(\$1.90, \$1.20)
A chooses 7 and *B* chooses 2	(\$1.70, \$1.70)	(\$1.55, \$1.55)
A chooses 8 and *B* chooses 2	(\$1.30, \$2.10)	(\$1.20, \$1.90)
A chooses 9 and *B* chooses 2	(\$0.90, \$2.50)	(\$0.85, \$2.25)
A chooses 10 and *B* chooses 2	(\$0.50, \$2.90)	(\$0.50, \$2.60)
A chooses 11 and *B* chooses 2	(\$0.10, \$3.30)	(\$0.15, \$2.95)

Note: Payoffs are presented in the format (participant *A* earnings, participant *B* earnings).

Table 3: Summary of Choices in the Treatment without the Sharing Option

Payoff Treatment	Participant *A Status Quo*	Participant *A Innovation*	Participant *B Rejects Innovation*	Subgame Perfect Equilibrium *(Innovate, Accept)*
All Periods				
Low Inequality Treatment (sessions 1 and 2)	43/172 (25%)	129/172 (75%)	34/129 (26%)	95/172 (55%)
High Inequality Treatment (sessions 3 and 4)	28/113 (25%)	85/113 (75%)	48/85 (56%)	37/113 (33%)
Final Period Only				
Low Inequality Treatment (sessions 1 and 2)	3/19 (16%)	16/19 (84%)	3/16 (19%)	13/19 (68%)
High Inequality Treatment (sessions 3 and 4)	4/15 (27%)	11/15 (73%)	7/11 (64%)	4/15 (27%)

Table 4: Summary of Choices in the Treatment with the Sharing Option Available

Payoff Treatment	Participant A *Status Quo*	Participant A *Innovation and No Sharing Investment* (Choice 2)	Participant B *Rejects Choice 2*	Participant A *"Shares the Surplus"*	Subgame Perfect Equilibrium (*Innovate and Don't Share, Accept*)
All Periods					
Low Inequality Treatment (sessions 5 and 6)	25/162 (15%)	60/162 (37%)	24/60 (40%)	35/162[a] (22%)	36/162 (22%)
High Inequality Treatment (sessions 7 and 8)	21/171 (12%)	72/171 (42%)	28/72 (39%)	72/171[b] (42%)	44/171 (26%)
Final Period Only					
Low Inequality Treatment (sessions 5 and 6)	3/18 (17%)	6/18 (33%)	2/6 (33%)	2/18 (11%)	4/18 (22%)
High Inequality Treatment (sessions 7 and 8)	0/19 (0%)	8/19 (42%)	1/8 (13%)	11/19 (58%)	7/19 (37%)

Note: Participant *A* "shares the surplus" by offering participant *B* more earnings than participant *B* receives when *A* chooses innovation and no sharing. For the Low Inequality treatment, this corresponds to choices 5 through 11; for the High Inequality treatment, this corresponds to choices 4 through 11.

[a]In the Low Inequality treatment, participant A made choices 3 or 4 (invest but do not share the surplus) 42 times (26%) over all periods.

[b]In the High Inequality treatment, participant A made choice 3 (invest but do not share the surplus) 6 times (4%) over all periods.

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