

Essays in Behavioral Economics

A Dissertation Presented for the
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I would like to dedicate this dissertation

To my families, friends, and mentors who always guide me with love in the right direction.

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Abstract

In chapter one, I propose a model consolidating the norm- and preferences-based approaches to explain laboratory bargaining outcomes. Social norms are identified by the axioms of cooperative bargaining theory, and other-regarding preferences are captured using Fehr and Schmidt's inequity aversion utility function. The model applies to bargaining situations where other-regarding agents abide by social norms in their decision-making. Preferences and norms interact to determine bargaining outcomes, and their interaction undermines the recoverability of the other-regarding preference parameters based on observations from the lab.

In chapter two, I employ a lab experiment to study whether men receive lucrative tasks more often than equally capable women so that a gender pay gap arises due to the difference in the earnings potential. Subjects allocate a standard task and a lucrative task between two workers, knowing their past performance, task preference, and sex. I find that men receive the lucrative task more often than women, but past performance and a gender difference in task preference account for the difference. Many workers shy away from the challenging yet lucrative task, suggesting that a psychic cost may arise when the tasks are challenging. Managers choose the efficient task allocation less often when the workers' preferences go against rather than with their money-incentive. The result suggests that managers show concern for the subjective utilities of the workers.

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Chapter 1

Axiomatic bargaining with inequity aversion: Norms vs. preferences

1.1 Introduction

Laboratory evidence on bargaining behavior has shown that subjects do not fit the standard economic paradigm of selfish agents. Two distinct strands of literature emerged to better organize laboratory bargaining outcomes, one theorizing other-regarding preferences and the other social norms. The preference-based approach expands the utility function to reflect both self-interest and fairness concerns. By assuming that at least *some* players are other-regarding, the models of such as [17] and [12] are able to account for many stylized facts of laboratory bargaining games. However, the preference-based models provide unsatisfactory explanations for the frequent appearance of even splits and do poorly in explaining cross-game variations unless preferences are context-dependent. Norm-based models arise in response to these weaknesses. [6] formalize the norm of equal sharing and argue that people like to be perceived as fair. [24] and [42] capture social norms in a non-cooperative game with repeated interactions. [8] and [26] build a preference for adhering to norms directly into the utility function, assuming that agents suffer disutility when they deviate from the specified social norm.

So far the two approaches have stood apart. When other-regarding attitudes are explicitly modeled, norm compliance is assumed away or held constant, and vice versa. By modeling

preferences and norms separately, we risk misinterpreting laboratory bargaining outcomes if the two in fact interact in meaningful ways to determine bargaining behaviors. In this paper, we model social norms and other-regarding preferences through separate channels in one unifying framework. Social norms are identified by the axioms from the cooperative bargaining theory, and other-regarding preferences are captured using Fehr and Schmidt’s inequity aversion utility function.¹ We discuss the connection between social preferences and the bargaining power when a bargaining norm is present, and how the interaction of preference and norm can undermine our ability to recover the other-regarding preference parameters from laboratory observations.

We are the first to use axioms to describe social norms when other-regarding preferences are present. We reinterpret the axioms coming from cooperative bargaining solutions as identifying bargaining norms. The axioms governing the Nash solution ([30]) and those governing the Kalai-Smorodinsky solution ([23]) identify two distinct social norms, which differ only in their treatment of bargaining opportunities. The Nash norm makes untaken opportunities irrelevant, while the Kalai-Smorodinsky norm allows the bargaining outcome to respond to changes in the best opportunity of each individual.

Our model predicts even splits without having to hypothesize that a large fraction of players would be willing to give away an extra dollar whenever they are ahead. In fact, under the Nash norm, the bargaining outcome is an even split over a wide range of preference parameters. In contrast, even splits are rare under the Kalai-Smorodinsky norm, and they arise from aspects of the bargaining problem. The model also elucidates some challenges in recovering preference parameters from laboratory bargaining data. When other-regarding preferences and social norms interact to determine the bargaining outcome, researchers must be careful when attributing the cause of an outcome change to one or the other. A more equal division does occur when either agent becomes more inequity averse under the Nash social norm. But under the Kalai-Smorodinsky norm, *ceteris paribus*, an agent who is more averse to disadvantageous inequality may not demand a larger share. Agents’ preferences may be unidentifiable if social norms also impact bargaining outcomes.

¹[36] and [25] also incorporate “behavioral” elements into axiomatic bargaining theory. Both papers examine loss-averse preferences, with Shalev using the Nash approach and Kobberling and Peters using the Kalai-Smorodinsky axioms.

The closest paper to ours is [3]. They conduct experiments to study how bargaining outcomes respond to changes in the disagreement payoff and find that subjects respond much less to changes in their own or opponents’ disagreement payoff than what the Nash bargaining solution predicts. Exploring alternative explanations for the findings, they derived results concerning how bargainers with Fehr-Schmidt preferences respond to changes in disagreement payoffs under the Nash solution. While their paper shares with ours an interest in combining axiomatic bargaining solutions with other-regarding preferences, their experimental findings lend credence to the interest in this topic and make further study worthwhile. We complement their paper by studying explicitly an additional axiomatic bargaining solution and by asking new questions related to the preference parameters rather than the disagreement payoffs. Their paper highlights the relevance of the approach, while ours highlights some of the issues raised from pursuing it.

We review the bargaining axioms in Section 2 and presents the model in Section 3. Section 4 discusses the results, and Section 5 offers some conclusions.

1.2 Axiomatic Bargaining Solutions and Social Norms

The cooperative game theoretic approach to bargaining involves specifying “nice” properties that a solution should satisfy. These properties (axioms) are meant to describe a bargaining outcome that a benevolent third party would recommend; therefore, they may embody normative descriptions of fairness.²

The classic two-person bargaining problem consists of a compact convex subset S of the plane representing all feasible utility payoffs achievable through bargaining and a point $d \in S$ representing the fallback payoffs to be received by the bargainers in case of a disagreement. We only consider bargaining problems in which mutual benefits are possible; i.e. problems for which there is some $s \in S$ such that $s > d$.³ Let Ω denote the class of bargaining problems

²Axiomatic bargaining solutions have been interpreted as identifying social norms concerning fairness. [28] characterizes the Nash solution using only the axiom of scale invariance and the Supple-Sen dominance principle (or Supple-Sen Proofness), giving the first ethical interpretation of the Nash solution as representing what constitutes a fair bargain. [4] incorporate the notion of distributive justice in axiomatic bargaining solutions, though fairness considerations are captured by new axioms rather than by preferences.

³We use the following vector notation throughout the paper: $s > d$ represents $s_i > d_i \forall i = \{1, 2\}$.

with disagreement point d and feasible set S , a bargaining problem in Ω is denoted by $\langle d, S \rangle$. A solution $f(d, S)$ is a function defined on Ω which associates with each bargaining problem a single feasible outcome in S that satisfies some prespecified conditions (axioms).

We denote the Nash solution of the bargaining problem as $f^N(d, S)$ and the Kalai-Smorodinsky solution $f^{KS}(d, S)$. Both solutions satisfy four axioms and they have the following three in common.⁴

Axiom 1. INV (Scale Invariance) $\lambda(f(d, S)) = f(\lambda(d, S))$ for $\lambda > 0$.

Axiom 2. SYM (Symmetry) If S is invariant under all exchanges of agents, $f_i(d, S) = f_j(d, S)$ for all i, j .

Axiom 3. PAR (Pareto Efficiency) $f(d, S) \in \{s \in S \mid \nexists s' \in S \text{ with } s' \geq s\}$.

INV suggests that the bargaining power of the bargainers should remain unchanged when we scale the problem up or down. SYM means that identical bargainers should receive identical outcomes. PAR claims that the outcome should achieve Pareto efficiency. The Nash solution also satisfies the axiom of Independence of Irrelevant Alternatives (IIA), which states that the unchosen possible bargaining outcomes are irrelevant, hence removing these alternatives from the feasible set should not change the bargaining outcome.

Axiom 4. IIA (Independence of Irrelevant Alternatives) If $S' \subseteq S$ and $f(d, S) \in S'$, then $f(d, S') = f(d, S)$.

Nash shows that axioms 1-4 hold if and only if the bargaining solution maximizes the product of utility gains from the disagreement point:

$$f^N(d, S) = \arg \max_{(d_1, d_2) \leq (s_1, s_2) \in S} (s_1 - d_1)(s_2 - d_2). \quad (1.1)$$

The Kalai-Smorodinsky solution was proposed in response to the controversy over the IIA axiom. Kalai and Smorodinsky argue that the untaken alternatives represent bargaining opportunities and should matter, especially the highest utility payoff available to each bargainer. Let $b_i(S) \equiv \max\{s_i \mid s \in S\}$ denote the maximal utility level attainable by agent i

⁴The formulation of all axioms is adopted from Thomson (1994, p. 1245-1249).

among all allocations dominating the disagreement point. Kalai and Smorodinsky introduced the following replacement for the IIA axiom:

Axiom 5. (*MON*) Axiom of Monotonicity If $S' \subseteq S$ and $b_i(S') = b_i(S)$, then $f_j(d, S') \leq f_j(d, S)$.

MON states that if S allows agent j but not agent i to achieve a higher maximal utility level than S' does, then the bargaining solution should award more to agent j from S than it does from S' . A sensible bargaining outcome should reflect the improvement of opportunities for agent j . Define the *bliss point* of S as $b(S) = (b_1(S), b_2(S))$.⁵ The Kalai-Smorodinsky solution, $f^{KS}(d, S)$, is a unique solution that satisfies axiom 1-3 and 5. It is the maximal point of S on the line $L(d, b(S))$ connecting d to $b(S)$.

The two social norms, Nash and Kalai-Smorodinsky, differ only in their treatment of bargaining opportunities. When applying the Nash solution, the social norm is identified by IIA, which rules out the impact of unchosen allocations on the bargaining outcome. When applying the Kalai-Smorodinsky solution, the social norm is identified by MON, which claims that the bargaining outcome should reflect changes (deterioration or improvement) in the bargaining opportunities of the bargainers.

1.3 Model

Laboratory bargaining games are phrased in monetary payoffs while axiomatic bargaining problems are defined in utility payoffs. To model laboratory bargaining games as axiomatic bargaining problems, we start with a bargaining problem defined in monetary payoffs, which we refer to as a *monetary bargaining problem*, and transform it to a *bargaining problem* defined in utility payoffs - one as defined in [30] and [23].

We are interested in a two-person bargaining situation where two agents, 1 and 2, bargain over the division of some amount of money normalized to 1. An agreement divides the unit into the allocation $x = (x_1, x_2) \geq 0$ with $x_1 + x_2 \leq 1$. If the two agents fail to reach an agreement, they get their disagreement payoffs $a = (a_1, a_2)$, $a \in A$, where A is the

⁵The bliss point $b(S)$ may not be in set S .

set of possible allocations defined in monetary payoffs. We call the pair $\langle a, A \rangle$ a *monetary bargaining problem*, a term we use to distinguish the problem from the bargaining problem defined in utility payoffs. To incorporate social preferences, we transform the monetary bargaining problem into a bargaining problem defined in utility payoffs using the inequity averse utility function in [17]:⁶

$$U_i(x_i, x_j) = x_i - \alpha_i \max\{x_j - x_i, 0\} - \beta_i \max\{x_i - x_j, 0\}, \quad i \neq j, \quad (1.2)$$

where $0 < \beta_i < 1$ and $\beta_i \leq \alpha_i$.

Let the disagreement point in utility space be $d = (U_1(a), U_2(a))$ and the bargaining set $S = \{(U_1(x), U_2(x)) | x \in A\}$. Then $a \in A$ implies that $d \in S$, hence $\langle d, S \rangle$ is a *bargaining problem* defined in utility payoffs. The class of all possible bargaining problems, Ω , is obtained by transforming all possible monetary bargaining problems by inequity averse utility functions. Therefore, all variations in Ω arise from changing either the disagreement monetary payoffs or the parameters of the Fehr-Schmidt utility function.⁷ The bargaining solution is a mapping $f : \Omega \rightarrow \mathbb{R}^2$ such that $f(d, S) \in S$.

Using the Fehr-Schmidt utility function with positive α_i means that there are monetary allocations in A that player i likes less than the disagreement point. It would be individually irrational to choose these alternatives. The set $\bar{S}$ differs from S by excluding elements that one or both of the players would reject. The following axiom guarantees that such individually-irrational outcomes are not chosen by the bargaining solution.

Axiom 6. Independence of Non-Individually Rational Alternative $f(d, S) = f(d, \bar{S})$ where $\bar{S} \equiv \{s \in S | s \geq d\}$.

Figure 1.1 illustrates the transformation of the bargaining set from the payoff space (the left panel) to the utility space (the right panel). The areas enclosed by the dark lines

⁶Like the bargaining solutions discussed below, the preferences also have an axiomatic foundation. [31] axiomatizes a nonlinear generalization of the Fehr-Schmidt preferences in (1.2), and [35] provides axioms foundation for the exact linear utility function form.

⁷We consider two effects of the parameter changes: one on the shape of feasible set and the other on the location of disagreement point. Similar studies include [23] and [22], where they show how bargaining solutions respond to changes in the feasible set. [39] discusses how bargaining solutions respond when the disagreement point changes.

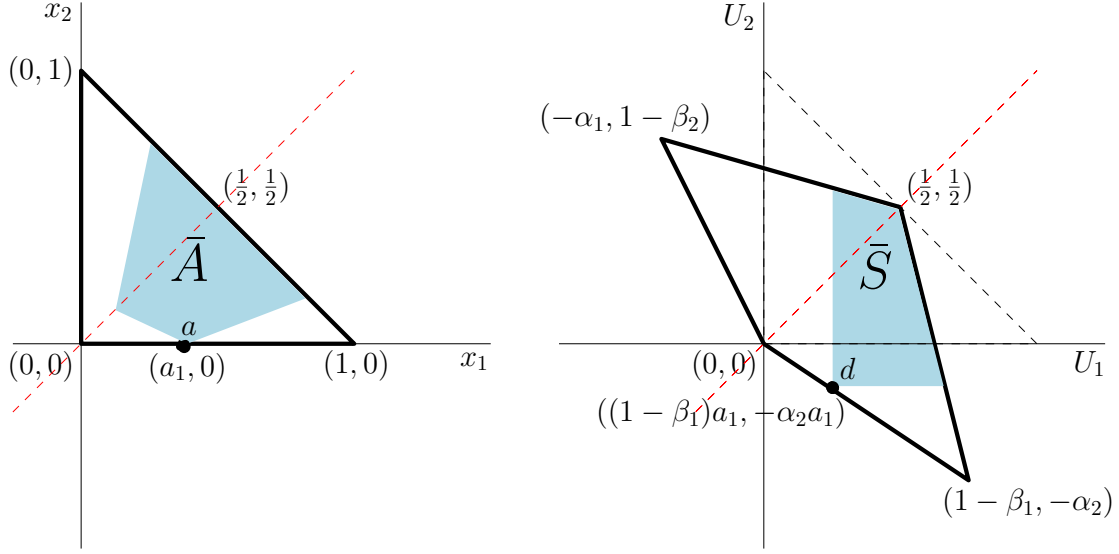


Figure 1.1: Transformation of the Bargaining Set from $\bar{A}$ to $\bar{S}$

represent the set of payoffs from all feasible allocations of the unit between the two players. The monetary payoffs are equitable at $(0,0)$ and $(\frac{1}{2}, \frac{1}{2})$, thus the utility values of these allocations are also $(0,0)$ and $(\frac{1}{2}, \frac{1}{2})$. Comparing the monetary allocation $(1,0)$ to $(0,0)$, player 1's monetary payoff increases by 1 but her utility only increases by $1 - \beta_1$ because she suffers from advantageous inequality, player 2's monetary payoff remains unchanged but his utility decreases by $-\alpha_2$ because he suffers from disadvantageous inequality. Therefore, monetary allocation $(1,0)$ corresponds to $(1 - \beta_1, -\alpha_2)$ in utility space. Similarly, monetary allocation $(0,1)$ corresponds to $(-\alpha_1, 1 - \beta_2)$ in utility space.

Without loss of generality, we normalize the bargaining problem to one with disagreement monetary payoffs $a = (a_1, 0)$. The shaded bargaining set $\bar{A}$ includes all monetary allocations that are preferred to the disagreement monetary payoffs $(a_1, 0)$ by at least one player when the players are inequity averse. The point $d = (a_1(1 - \beta_1), -a_1\alpha_2)$ is the utility value of a , and the shaded bargaining set $\bar{S}$ is the counterpart of $\bar{A}$ in utility space.⁸ Allocations in both $\bar{A}$ and $\bar{S}$ are individually rational for both players, while allocations in the white regions make at least one player worse off than the disagreement point. Lemma 1.1 states that the set $\bar{S}$ is a valid bargaining set.

Lemma 1.1. *The set $\bar{S}$ is convex, compact, and has an element $s \in \bar{S}$ for which $s > d$.*

⁸We provide more details about the transformation in the Appendix B.

Proof in Appendix.

1.4 Results

We solve the bargaining problem defined in utility payoffs following the Nash and Kalai-Smorodinsky solutions and identify how the monetary payoffs, x_1 and x_2 , change in the preference parameters. We say that both agents are *very* averse to advantageous inequality if $\beta_i \geq \frac{1}{2}$ for $i = 1, 2$, and that both agents are *moderately* averse to advantageous inequality if $\beta_i < \frac{1}{2}$ for $i = 1, 2$.

Proposition 1.2. *If both agents are very averse to advantageous inequality, they split the surplus evenly under either the Nash social norm or the Kalai-Smorodinsky social norm.*

Proof in Appendix.

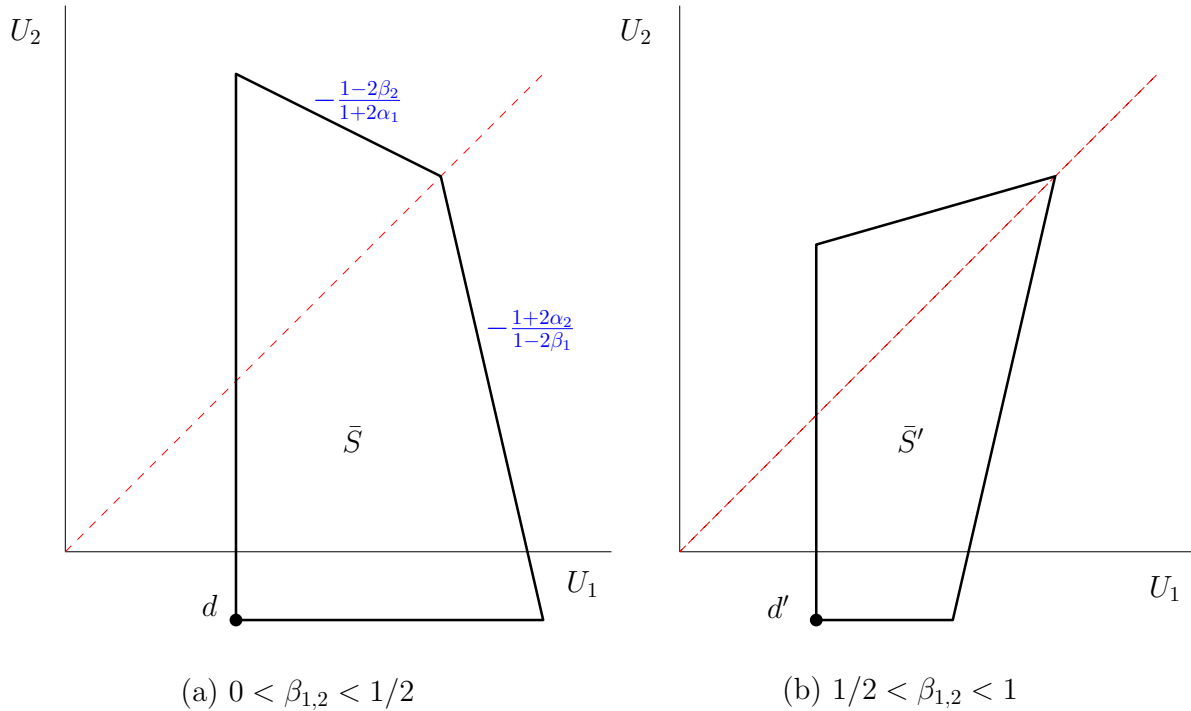


Figure 1.2: Preference Parameters Determine the Slopes of the Bargaining Frontiers

Proposition 1.2 agrees with [17] that even splits happen when agents are very averse to advantageous inequality. The effect of other-regarding attitudes crowds out any impact

that social norms may have on the bargaining outcome in this case. As shown in Figure 1.2, the slopes of the two segments of the bargaining frontier are functions of the preference parameters.⁹ When $\beta_i > \frac{1}{2}$ for $i = 1, 2$, both segments of the bargaining frontier are upward sloping, making point $(\frac{1}{2}, \frac{1}{2})$ the only Pareto efficient allocation in the feasible set. As a result, both the Nash and the Kalai-Smorodinsky outcomes are purely driven by the axiom of Pareto efficiency. Inequality attitudes do not provide bargaining power because the bargaining opportunities do not matter other than the only Pareto efficient outcome. The asymmetry of the disagreement point does not change the outcome for the same reason.

Different from [17], though, in our model the even splits can also arise in cases when agents are moderately averse to advantageous inequality.

Proposition 1.3. *When both agents are moderately averse to advantageous inequality, they split the surplus evenly under the Nash social norm if $a_1 < \bar{a}_1 = (\alpha_2 + \beta_1)/(\alpha_2(1 - 2\beta_1) + (1 + 2\alpha_2)(1 - \beta_1))$, and they split the surplus evenly under the Kalai-Smorodinsky social norm if $(1 - 2d_1)/(b_1 - d_1) = (1 - 2d_2)/(b_2 - d_2)$ and $d_1 < \frac{1}{2}$.*

Proof in Appendix.

Proposition 1.3 suggests that strong aversion to advantageous inequality is no longer a necessary condition for even splits to emerge. Even splits come into place through different mechanisms under different social norms. The Nash solution to bargaining problem $\langle 0, \bar{S} \rangle$ is an even split, and adding inequality attitudes only fixes the solution at that point. Figure 1.3(a) illustrates what happens. The dashed line is the bargaining frontier when neither agents has other-regarding preferences, in which case the Nash solution is found at $(\frac{1}{2}, \frac{1}{2})$. Making agents averse to inequality rotates the two segments of the bargaining frontier inward around the even split, further securing the solution at that point. As long as the disagreement

⁹To see this, first note that the northwest segment corresponds to the case when $x_2 > x_1$. The utilities of the two players are $U_2 = x_2 - \beta_2(x_2 - x_1)$ and $U_1 = x_1 - \alpha_1(x_2 - x_1)$. Also, $x_1 + x_2 = 1$. Solve the three equations simultaneously and write U_2 as a function of U_1 , we have that

$$U_2 = \frac{1 + \alpha_1 - \beta_2}{1 + 2\alpha_1} - \frac{1 - 2\beta_2}{1 + 2\alpha_1} U_1.$$

The slope of the northwest segment is given by $\frac{dU_2}{dU_1} = -\frac{1-2\beta_2}{1+2\alpha_1}$. Similarly, the slope of the southeast segment is given by $\frac{dU_2}{dU_1} = -\frac{1+2\alpha_2}{1-2\beta_1}$.

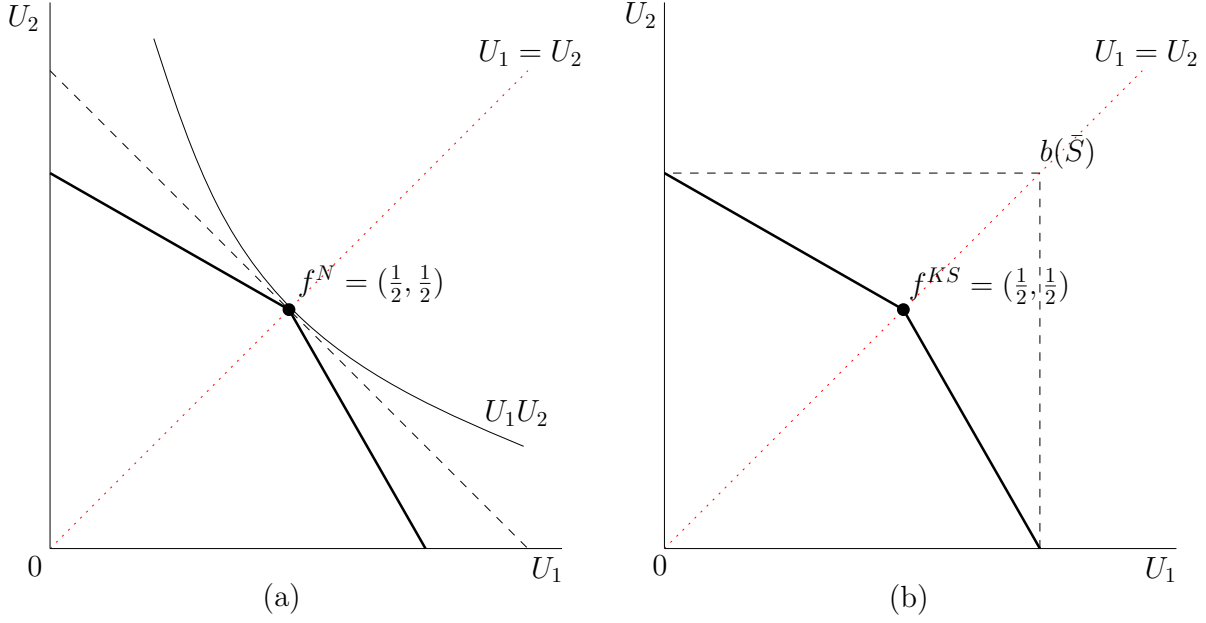


Figure 1.3: Cases of Even Splits when $\beta_{1,2} < \frac{1}{2}$ and $a_1 = 0$

payoffs are equitable, even splits arise whenever the Nash social norm applies regardless of the agents' inequality attitudes. Under the Kalai-Smorodinsky social norm, however, even splits are chosen only under the knife-edge condition that the line connecting the disagreement point and the bliss point, $L(d, \bar{S})$, happens to go through the even split. This requires that $(1 - 2d_1)/(b_1 - d_1) = (1 - 2d_2)/(b_2 - d_2)$ and that $d_1 < \frac{1}{2}$. In the case of a zero disagreement point, the condition reduces to $(1 + 2\alpha_1)(1 - 2\beta_1) = (1 + 2\alpha_2)(1 - 2\beta_2)$.

Figure 1.4 shows the case when the (perceived) fallback position is unequitable ($a_1 > 0$). The bargainers split the surplus evenly under the Nash social norm unless the asymmetry is severe enough (a_1 is large enough). Figure 1.5 illustrates this tension. Each curve identifies combinations of α_2 , β_1 , and a_1 for which (i) the Nash bargaining solution shares the surplus equally, and (ii) any decrease in α_2 , decrease in β_1 , or increase in a_1 results in a movement away from the even split.¹⁰ Fixing a_1 , then, any increase in α_2 or β_1 from a point on the curve keeps the Nash outcome at $(\frac{1}{2}, \frac{1}{2})$. When $a_1 = 0$, the entire (α_2, β_1) space yields the even split, which is consistent with the depiction of the symmetric case in Figure 1.3. As a_1 grows from zero the Nash outcome becomes asymmetric for sufficiently inequity-neutral

¹⁰The contours in Figure 1.5 are the loci of the $\bar{a}_1$ function defined in Proposition 1.3.

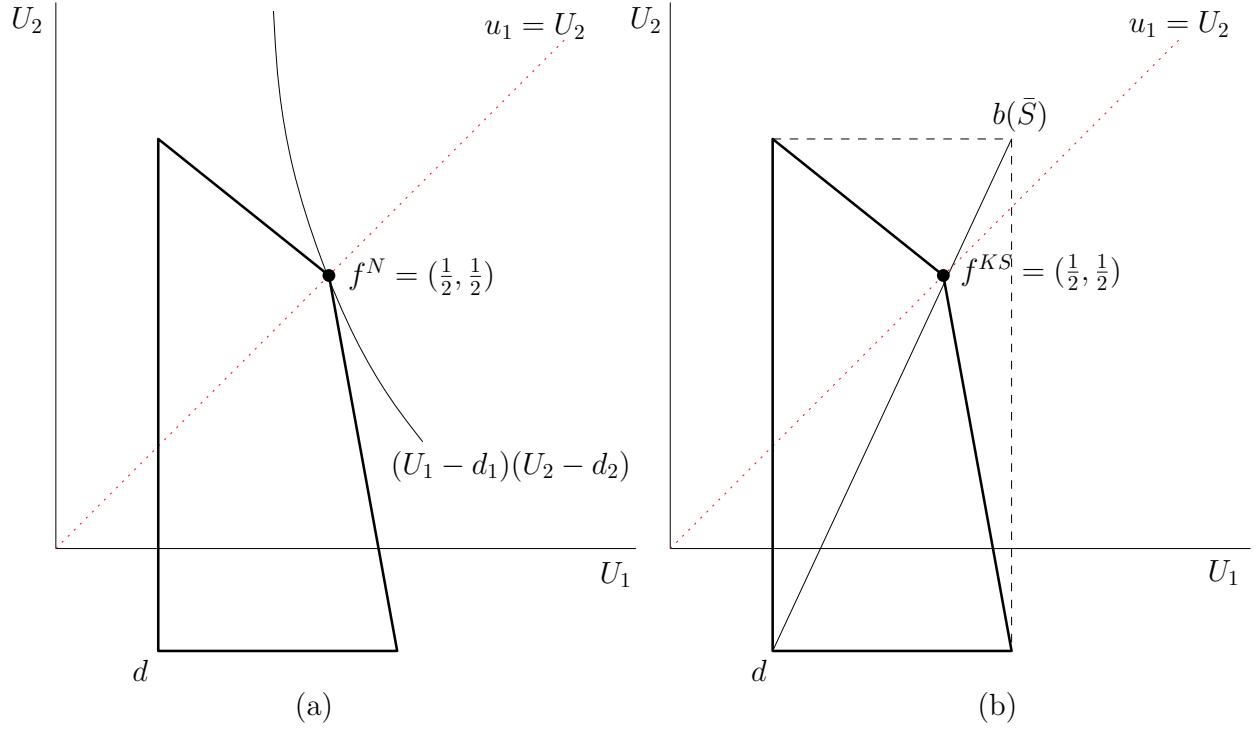


Figure 1.4: Cases of Even Splits when $\beta_{1,2} < \frac{1}{2}$ and $a_1 > 0$

agents, but only as a_1 becomes large does a wide range of parameters support unequitable bargaining outcomes.

Figure 1.4(b) depicts the condition that must hold for a symmetric outcome to emerge from an asymmetric bargaining problem with the Kalai-Smorodinsky solution. Changes in inequity attitudes move both the disagreement point d and the bliss point $b(\bar{S})$, making the condition identified in Proposition 1.3 a knife-edge one. This differs from the Nash solution where large parameter ranges yield an equal division despite asymmetry in the bargaining problem.

Experimentalists have used bargaining games to identify other-regarding attitudes. Figure 1.5 shows that for large regions of the parameter space, small changes in inequity aversion have no impact on the Nash bargaining outcome because it remains at the equal split. Once the outcome gets away from equal division, though, any change in the inequity aversion parameters changes the Nash bargaining outcome. Any change in other-regarding attitudes also moves the Kalai-Smorodinsky outcome. It becomes important to determine the direction the bargaining outcome moves when the underlying preferences change, in part

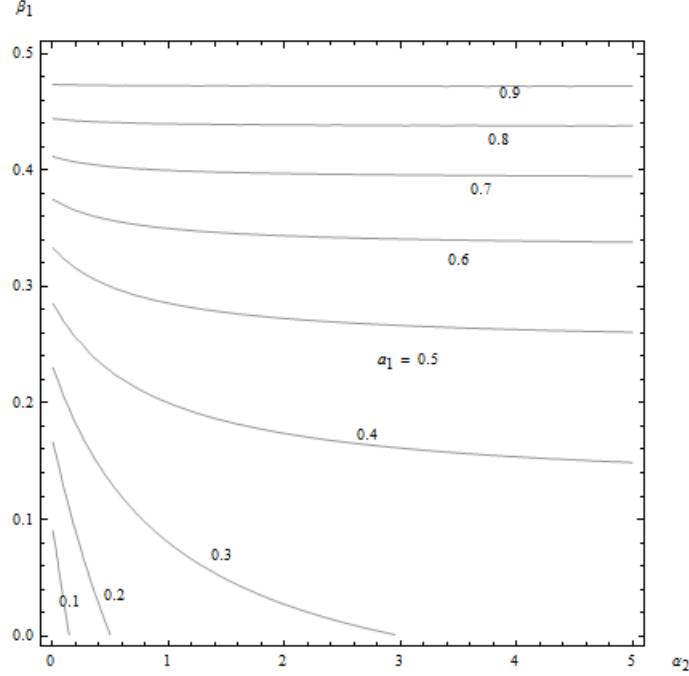


Figure 1.5: Contours of $\bar{a}_1$

to explore whether inequity aversion strengthens bargaining power, and in part to determine whether other-regarding attitudes really can be inferred from laboratory bargaining data.

Denote the share of the surplus of agent i ($i = 1, 2$) as x_i^N according to the Nash solution, and x_i^{KS} according to the Kalai-Smorodinsky solution.

Proposition 1.4. *When both agents are moderately averse to advantageous inequality, under the Nash social norm*

$\partial x_1^N / \partial \beta_2 = 0$, $\partial x_1^N / \partial \alpha_1 = 0$, $\partial x_1^N / \partial \beta_1 < 0$ and $\partial x_1^N / \partial \alpha_2 < 0$ when $a_1 > \bar{a}_1$; under the Kalai-Smorodinsky social norm $\partial x_1^{KS} / \partial \beta_2 \geq 0$, $\partial x_1^{KS} / \partial \alpha_1 \geq 0$, $\partial x_1^{KS} / \partial \beta_1 < 0$, and $\partial x_1^{KS} / \partial \alpha_2 < 0$ when $a_1 = 0$, but its sign is ambiguous when $a_1 > 0$.

Proof in Appendix.

Proposition 1.4 shows when inequality attitudes yield bargaining power. For the Nash social norm, agent 1's bargaining power increases when she becomes less averse to being ahead or when agent 2 becomes less averse to being behind. These results match intuition and are consistent with how experimentalists have interpreted the data. The results for the

Kalai-Smorodinsky social norm are less clear-cut. A decrease in agent 1's aversion to being ahead still provides her with more bargaining power, but a decrease in agent 2's aversion to being behind may not.

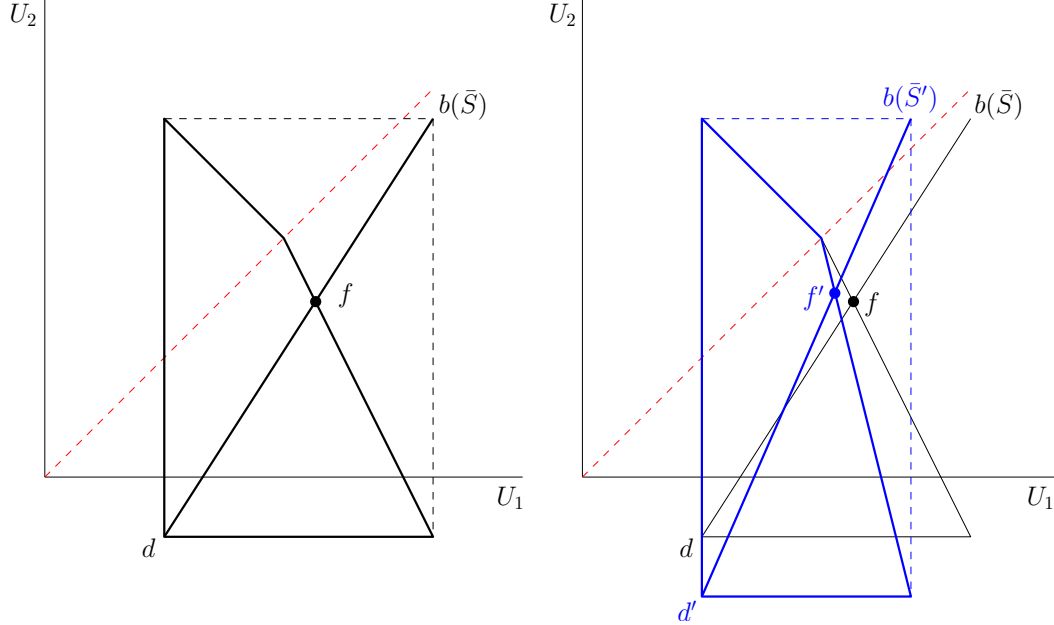


Figure 1.6: A Change in the Kalai-Smorodinsky Bargaining Outcome when α_2 Increases

Figure 1.6 shows what happens. The left panel shows the Kalai-Smorodinsky outcome before α_2 changes. The right panel shows what happens when player 2 becomes more averse to disadvantageous inequality (α_2 increases). On one hand, player 2 dislikes the disagreement payoff combination more after the change. This moves the disagreement point d downward to d' . This change makes player 2 more agreeable, hence increases the bargaining power of player 1. On the other hand, when α_2 increases player 2 suffers more disutility from allocations that assign more than half to player 1. This rotates the segment of the bargaining frontier below the 45-degree line clockwise around the even split. As a result, the new feasible set excludes many allocations that favor player 1, making player 2 less agreeable and decreasing the bargaining power of player 1. The change of the bargaining outcome depends on which one of the two forces dominates the other. If the Kalai-Smorodinsky social norm governs bargaining behavior, then, experimentalists can no longer infer the disadvantaged agents' attitudes toward being behind from the outcomes of the game.

1.5 Conclusion

This paper separates social norms from other-regarding preferences in bargaining situations by using axiomatic, rather than non-cooperative, solutions. We present a framework where inequality attitudes and social norms interact to determine bargaining outcomes. We argue that their interaction changes how we rationalize laboratory data and poses challenges to the inference of preference parameters using laboratory observations. Since social norms and asymmetries in bargaining power both play important roles in decision-making, experimentalists must take care when making sense of laboratory data. Different procedural designs or framing may activate different social norms or introduce asymmetries in bargaining power that are not immediately obvious, and both could affect bargaining outcomes.

We realize that in taking the cooperative approach our model loses several useful features of non-cooperative solution concepts, and also requires an unusual way of thinking about the game. For example, strategic interactions and beliefs are absent in our framework. These aspects of the bargaining games are especially relevant in the research on intentionality and the theories of reciprocity, though they are not the concern of this paper. We also realize the assumption that agents use axiomatic bargaining solutions requires that they know all of the individual preference parameters, which runs counter to the non-cooperative approach and is also questionable in bargaining situations where the interactions occur among strangers. Despite these weaknesses, our framework still provides useful lessons as well as possibilities for future research identifying axiomatic approaches to other social norms in the presence of social preferences.

Chapter 2

Gender-biased task assignment: Evidence from a laboratory experiment

2.1 Introduction

A rich literature has documented a converging yet persistent gender pay gap in the U.S. labor market (e.g., [2]; [20]; [19]; [9]), especially at the top of the wage distribution. Among many other explanations, labor economists have linked the gender earnings differential to male-female differences in task characteristics and performance. In particular, surveys and experimental studies have emphasized the contribution of a gender difference in preferences towards risks, competition, negotiation, prosocial behaviors, and personality traits ([7]; [14]; [16]; [32]).¹ The role of managerial decisions is less investigated and understood. Several notable exceptions (e.g. [34] and [33]) revealed that managers are rarely gender-blind. More recently, [21] studied the interaction between the gender difference in risk attitudes and the performance-rewarding behavior of managerial roles. The participants in their experiment rewarded the performance of male and female workers equally given that the workers had chosen competitive remuneration (tournaments), but they rewarded

¹[9] offers a summary of recent studies on these gender differences using survey data.

the performance of females significantly less than that of males given that the workers had chosen non-competitive remuneration (piece-rates). [11] found that managers show a gender bias against women, but the bias was overcome by evaluating two workers jointly rather than individually. These studies highlight the importance of the demand-side factors and their interactions with the labor supply in explaining differential outcomes within a company.

Drawing insights from the management science, we consider performance multidimensional and a function of the capacity, willingness and opportunity to perform.² Gender-biased task allocation creates gender inequality in on-the-job opportunities, which may subsequently lead to performance and earnings gaps. We examine, in a laboratory experiment, whether men receive lucrative tasks more often than equally capable women, leading to a gender pay gap attributable to a gender difference in earnings potential. Observing a workplace where the managerial roles are predominantly male, we hypothesize in-group favoritism the main driver of managerial biases and design the experiment to differentiate it from other possibilities.³

In the experiment, subjects earn money by both allocating to others and correctly answering verbal analogy questions. Questions differ in the levels of difficulty and profitability. As in [29], easy questions are taken from the past versions of the Scholastic Aptitude Test (SAT) and hard ones from the past versions of the Graduate Record Exam (GRE). Each correctly answered SAT question is worth 2 tokens. Each correctly answered GRE question is worth 5 tokens. We choose these piece rates so that almost all our potential subjects will find the GRE questions lucrative.⁴ Each subject plays the role of a manager and allocates question types between two matched other subjects (the “workers”) in the same

²[10] argues that the missing opportunity is often the missing dimension of existing theories of individual performance. They propose a model where three dimensions - the capacity, willingness and opportunity to perform - interact to determine work performance.

³Studies in social sciences suggest several possible sources of gender biases in task allocation. Research in social psychology and economics, for example, [40], [1] and [13], find strong evidence of ingroup favoritism in reward or resource allocation. Management scientists find that women compared to men are more often assigned to dull rather than challenging tasks (e.g. [15], [41], and [38]), though the manager’s gender mediates the decisions ([27]). These studies conclude that the results are likely driven by managers’ stereotypical beliefs, discrimination, or perceptions of the relative capability of men compared to women.

⁴[29] estimate the distributions of the success rates on the SAT and GRE questions of our potential subjects - the undergraduate students at the University of Tennessee at Knoxville. We choose the piece rates for our experiment based on the estimated distributions to make sure that the GRE questions, despite challenging, are lucrative comparing to the SAT questions for almost all of our potential subjects.

session. Managers allocate an SAT question to one worker and a GRE question to the other. The money-maximizing strategy suggests an allocation based on the comparative advantages of the workers. For simplicity, we call a worker “deserving” (of receiving the lucrative task) if the worker has the comparative advantage in answering the GRE questions in a matched pair. We examine how the sex composition of the three-person group (a manager and two workers) cause deviations from the money-maximizing strategy. Deviations reduce social surplus and harm the more capable worker to benefit the less capable. Managers suffer financially but to a lesser extent than the harmed worker. These features depart from existing experiments on discrimination, where discriminatory actions are often costless to the initiating parties and harmless to social welfare (e.g. [18]; [5]).

We find that men receive the lucrative task more often than women, but the difference can largely be explained by past performance and a gender difference in task preference. A large fraction of workers shies away from the lucrative tasks, suggesting that the subjects may incur a psychic cost when the tasks are challenging. The managers respond to the task preferences of the workers. Hence the gender difference in task preference leads to a gender difference in the earnings potential. Having a partner who wants the GRE question lower the deserving worker’s chance of receiving the GRE question, especially when the deserving worker is female. The managers who prefer the SAT to the GRE questions are more susceptible to the influence of the task preferences of the workers than the managers who prefer the GRE to the SAT questions. Our subjects allocate tasks efficiently most often when workers’ preferences go with their monetary incentives and least often when workers’ preferences go against their monetary incentives. Moreover, the managers choose the efficient task allocation less often when two workers both want the lucrative task than when two workers both want the standard task. Our findings suggest that at least *some* managers have concerns for the subjective utilities of their employees. These concerns are relieved if the workers who were denied opportunity to work on their preferred tasks are compensated financially and liberated if the workers happen to show interests in tasks accord to their comparative advantages.

We present our experimental design and procedures in Section 2.2 and characterize the rational choices of risk-neutral agents based on a simple Roy selection model in Section 2.3.

Section 2.4 discusses our identification strategies and reports main findings. Section 2.5 concludes.

2.2 Experimental Design and Procedures

We wish to create a situation where a manager allocates two tasks of the same nature but differ in profitability between two workers with similar past performance. The tasks employed are verbal analogy questions taken from the past versions of the Scholastic Aptitude Test (SAT) and the Graduate Record Exam (GRE). The GRE questions are more challenging than the SAT questions by construct.⁵ We make the challenging tasks lucrative by choosing a pair of piece rates such that most of our potential subjects would find the GRE questions more profitable than the SAT questions given their success rates on each test.⁶

The experiment has three stages of play. Each subject plays the role of a manager in stage two and the role of a worker in stage one and three. In stage one, each subject answers ten SAT and ten GRE questions in 15 minutes. They learn about their success rates and earnings on each exam, and then indicate which type of questions, the SAT or the GRE, that they would prefer to answer in stage three (see Figure B4 in the appendix). In stage two, each subject plays the role of a manager and allocates question types between two matched workers for ten rounds. The managers assign task types to a new pair of workers in each round. For each pair of workers, they allocate a GRE question to one worker and an SAT question to the other, knowing each worker’s success rates, task preference, and sex. We inform the managers about the sex of the workers by referring to a worker as a “he” or “she” when describing their first stage performance and task preferences. The managers do not know the specifics of the questions that they assign; they simply determine the type of the questions (see Figure B5 in the appendix). In stage three, each subject receives 20 questions to answer in 15 minutes. A subject may receive fewer or more than ten SAT (or GRE) questions, and the mix of question types solely depends on the decisions made by the

⁵The SAT is an *undergraduate* entrance exam while the GRE a *graduate* entrance exam.

⁶Different from [29], which set the piece rates for the GRE questions to be weakly higher than those for the SAT questions, we set the piece rate for the GRE questions to be significantly higher than that of the SAT questions so that the challenging GRE questions are money-maximizing for more than 90% of our subjects.

managers who received the subject’s information in stage two. In both stages one and two, both types of questions are presented in the same format without labeling explicitly which ones are drawn from the SAT and which are from the GRE (see Figure B3 in the appendix). We adopt this feature of the design in hope to minimize possible effects that psychological factors such as confidence or motivation may have on the performance of the subjects.

We conduct a short questionnaire before stage one to collect information on, among other things, the sexes of the participants. A longer questionnaire after stage three asks the participants about their thoughts on the experiment. The participants in all but the first session of the experiment also select a gamble before the experiment starts.⁷ The gamble selected by each subject was recorded during the first questionnaire. The outcome of the gamble is determined by a computerized coin-flip by the end of the experiment for each subject. The earnings from the gamble are reported to the subjects by the end of the second questionnaire and added to their earnings from the experiment.

Each participant as a worker receives 2 tokens for every SAT question that they answer correctly and 5 tokens for every GRE question that they answer correctly. Each participant as a manager receives 2 tokens (5 tokens) if a worker to whom they assigned an SAT (a GRE) question answers it correctly. The payment scheme makes sure that almost all subjects find the GRE questions lucrative and that managers maximize their expected earnings choosing a task allocation which aligns with the workers’ comparative advantages. Deviations from this strategy are Pareto-damaging. They help the less capable worker at the costs of both the manager and the more capable worker. Managers suffer financially but to a lesser extent than the harmed worker. These features depart from existing experiments on discrimination, where discriminatory actions are often costless to the initiating parties and harmless to social welfare ([18]; [5]). The earnings in tokens were converted into dollars at a conversion rate of five tokens to one dollar.

We ran six sessions of the experiment with a total of 106 subjects in the Experimental Economics Laboratory at the University of Tennessee at Knoxville. To ensure a gender-balanced sample, we scheduled two studies using the Online Recruitment System for

⁷The gamble selection was added to elicit the risk attitudes of the subjects when we noticed a gender difference in task preference after the first session of the experiment.

Economic Experiments (ORSEE) system to recruit male and female subjects separately for any session of the experiment. We carried out a scheduled session as long as at least 16 subjects signed up.⁸

The subjects were seated in the waiting area outside of the computer lab upon their arrival. Five minutes before the scheduled starting time of the experiment, we checked the subjects in and in the order of their arrival time. Each of the subjects was given a card and told to sit at the computer station corresponding to the letter printed on the card. The last subject to arrive for a session where an odd number of subjects showed up did not participate in the experiment and was given a \$5 show-up fee.

Each participant had a copy of the information sheet and experiment instructions. The participants in the last five sessions also received a copy of the game selection.⁹ The instructions were read out loud, and the participants were asked if they have questions about the experiments. Once the program was initiated, the experiment proceeded without further communication between the experimenter and the participants. The participants made decisions in private following the instructions shown on the computer screens until the experiment concluded and the earnings reported. Subjects were paid with cash in an envelope.

2.3 Conceptual Framework

The success rates of a subject in stage one should determine the subject's money-maximizing choice of the preferred exam for stage three. Let G denote the number of correctly answered GRE questions and S the number of correctly answered SAT questions in stage one. A risk-neutral individual is expected to prefer the GRE to the SAT questions if $5G > 2S$ and the SAT to the GRE questions if $5G < 2S$. Risk-neutral participants should be indifferent between the two exams if $5G = 2S$. Taking the log of both sides of the equation, we can rewrite the condition for being indifferent between the two exams as

$$\log(G) = \log\left(\frac{2}{5}\right) + \log(S). \quad (2.1)$$

⁸The design and structure of the codes require an even number and a minimum of 12 participants.

⁹The handouts given to the participants are attached to this paper as part of the appendix.

As shown in Figure 2.1(a), the graph of $\log(G)$ as a function of $\log(S)$ is a line with a y-intercept $\log(2/5)$ and a slope of one. Under risk neutrality, money-maximizing individuals should prefer answering the GRE questions if the locus of their $(\log(S), \log(G))$ fall above the line defined by Equation (2.1), and they should prefer answering the SAT questions if the locus of their $(\log(S), \log(G))$ fall below the line.

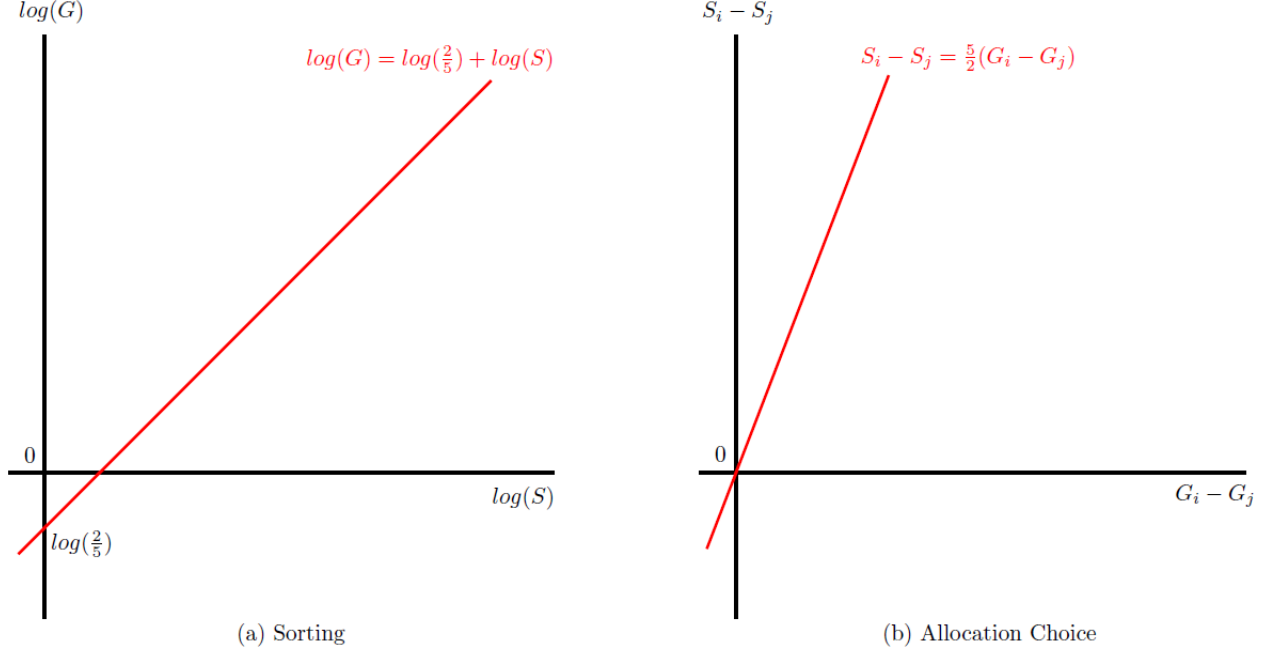


Figure 2.1: Money-Maximizing Sorting and Managerial Decisions Under Risk Neutrality

When risk-neutral managers (m) allocate an SAT question and a GRE question between two workers (i and j), they maximize their expected earnings by assigning the GRE question to worker i if $5G_i + 2S_j > 5G_j + 2S_i$ and to worker j if $5G_i + 2S_j < 5G_j + 2S_i$. They should assign the question types at random if $5G_i + 2S_j = 5G_j + 2S_i$, when the two alternatives generate the same expected payoff. We can rewrite the condition for being indifferent between the two allocations as

$$S_i - S_j = \frac{5}{2}(G_i - G_j). \quad (2.2)$$

Without the loss of generality, we label the worker with an absolute advantage (AA) in answering the GRE in a matched pair as i so that $G_i > G_j$. Managers maximize their expected earnings from task allocations by assigning the GRE to i and the SAT to j when

$(S_i - S_j)/(G_i - G_j) < 5/2$, that is, when the worker with an absolute advantage in answering the GRE also has a comparative advantage (CA) in answering the GRE. Figure 2.1(b) prescribes the money-maximizing choices of risk-neutral managers. For two matched workers whose $(G_i - G_j, S_i - S_j)$ lies below the line of $S_i - S_j = \frac{5}{2}(G_i - G_j)$, the managers should assign the GRE to i , and for those whose $(G_i - G_j, S_i - S_j)$ lies above the line, they should assign the GRE to j .

2.4 Results

2.4.1 Task Performance and Preferences

We observe the success rates, task preferences, the numbers of GRE and SAT questions received, and the earnings from answering and allocating questions for all 106 subjects. For the 86 subjects of the last five sessions, we also observe their gamble choices and payoffs. Table (2.1) summarizes the key variables of our subjects by their sex. We have an equal number of female and male participants. In our sample, men perform better than women on both the SAT and the GRE questions in stage one. On average, males answered 8.17 SAT and 5.25 GRE questions correctly, while women answered 7.66 SAT and 4.91 GRE correctly. Men on average also receive more GRE questions in stage three and earn slightly more than women in all three stages of the experiment, but none of these gender mean differences are statistically significant.

The majority of our subjects indeed find the GRE questions lucrative: all but nine subjects earn more money on the GRE than on the SAT in stage one. We observe a positive self-selection into task types, but the sorting based on performance is far from perfect. Figure 2.2 plots the log-transformed success rates of the participants by their stated task preference. It shows that the participants who prefer the GRE indeed earn no less money from the GRE than from the SAT in stage one, but many participants prefer the SAT even when the GRE is financially rewarding for them. In fact, despite that more than 90% of all subjects earn more money on the GRE than on the SAT in stage one, only half of them prefer to answer the GRE in stage three.

Table 2.1: Summary Statistics, Each Observation is a Participant

Variable	Female					Male				
	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
S	53	7.66	1.73	4	10	53	8.17	1.98	0	10
G	53	4.91	1.58	1	8	53	5.25	1.52	1	10
GRE lucrative	53	0.91	0.30	0	1	53	0.92	0.27	0	1
Prefer GRE	53	0.40	0.49	0	1	53	0.62	0.50	0	1
No. SAT received	53	10.23	6.44	0	20	53	9.77	7.08	0	20
No. GRE received	53	9.77	6.44	0	20	53	10.23	7.08	0	20
Earnings (\$)										
Stage 1	53	7.97	1.98	3.8	12	53	8.51	1.97	3.4	14
Stage 2	53	8.30	1.53	4.8	11.2	53	8.40	1.85	2.6	12.2
Stage 3	53	8.18	2.88	2	17	53	8.51	3.44	1.2	16
Total	53	24.45	4.60	12	37	53	25.41	5.89	12.8	39.2
Gamble choice	41	3.24	1.30	1	6	45	4.18	1.47	1	6
Gamble payoff	41	5.33	3.25	0.8	12.4	45	5.54	4.43	-1.2	12.4

Note: Men perform better and earn more than women, but the differences are statistically insignificant. The gender differences in task preferences and risk attitudes are statistically significant. A larger fraction of men than women prefer the GRE to the SAT questions. The two sample test of proportions yields a z statistic with an absolute value of 2.33. Men are more risk averse than women ($|t| = 3.13$), but the gender difference in risk attitudes does not explain the gender gap in task preferences.

Moreover, there is a statistically significant gender difference in task preference. An equal percentage of women (91%) and men (92%) find the GRE questions lucrative, but a larger percentage of men (62%) than women (40%) state to prefer answering the GRE questions in stage three. Positive sorting based on past performance is more pronounced for male than female participants. Figure 2.3 compares the sorting patterns of women and men. The graph on the left shows that more high-ability women than high-ability men self-select into answering the SAT questions, and the one on the right shows that more high-ability men than high-ability women self-select into answering the GRE questions.

The gender difference in task preference has the potential to create a gender gap in earnings because task preference has a sizable effect on the opportunity to earn, which we measure using the number of GRE questions a participant receives in stage three. We examine the determinants of the earnings potential and the actual earnings in stage three with the following regression:

$$Y = \alpha_0 + \alpha_1 \cdot \text{male} + \alpha_2 \cdot \text{askG} + \alpha_3 \cdot S + \alpha_4 \cdot G + \epsilon, \quad (2.3)$$

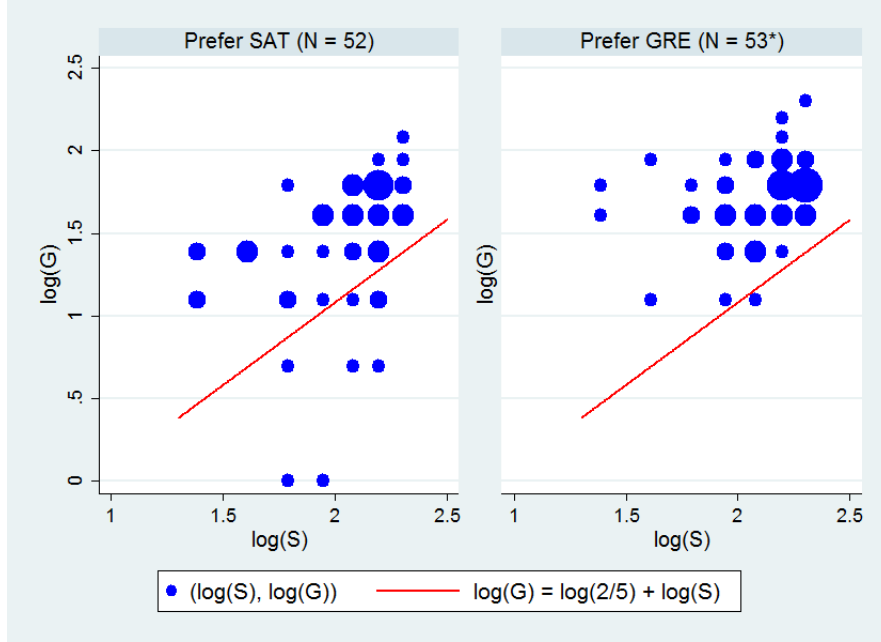


Figure 2.2: Positive Sorting

* 54 subjects prefer the GRE, but $\log(S)$ is undefined for one subject because he answers none of the first ten SAT question correctly.

where $male$ is an indicator variable equal to one if the subject is male, $askG$ is an indicator variable equal to one if subject prefers to answer the GRE questions, S and G are the stage-one success rates, and ϵ is an idiosyncratic error. We run the regression using $NumG$, the number of GRE questions received in stage three, and the actual earnings in stage three, $EarningSt3$, as the dependent variable Y , respectively.

Table (2.2) shows that, conditional on stage-one success rates, the GRE-preferring participants on average receive between one and two more GRE questions in stage three than the SAT-preferring participants. Plus, their mean earnings is about \$1.31 higher than that of the SAT-preferring participants.

2.4.2 Task Allocations

Each subject as a manager allocates question types between two different matched workers for ten rounds in stage two. Hence we observe the task allocation decision in 1060 unique three-person groups. For each group, we can identify the efficient allocation because the past success rates of all workers are observed. Figure 2.4 plots the relative performance

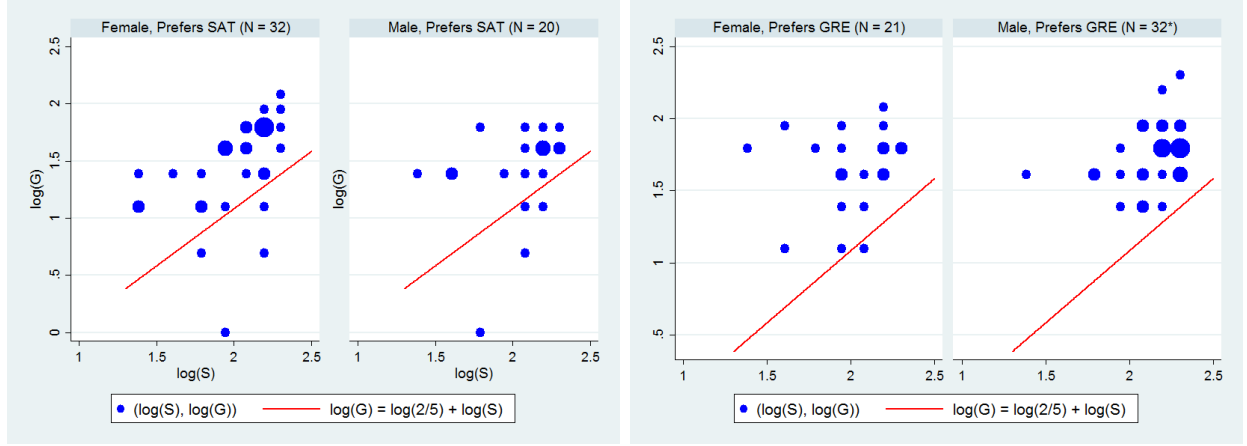


Figure 2.3: Gender Difference in Sorting

* 33 male subjects prefer the GRE, but $\log(S)$ is undefined for one man because he answers none of the first ten SAT question correctly.

$(G_i - G_j, S_i - S_j)$ of the matched workers, with i being the worker who has an absolute advantage in answering the GRE. Figure 2.4 has several notable features due to aspects of our experiment design. First, because the GRE is a harder exam than the SAT, two matched workers differ more in their GRE success rates than in their SAT success rates. Second, high-ability individuals tend to have high success rates on both exams because both exams are aptitude tests. As a result, a worker with an absolute advantage in answering the GRE often has a comparative advantage in answering the GRE as well. Lastly, a large share of the observations locates at $S_i - S_j = 0$ because we match the workers based on their SAT success rates.

In 80 groups, two alternative task allocations yield identical expected payoff for the manager (i.e. $S_i - S_j = 2.5(G_i - G_j)$),¹⁰ in which case the managers choose either allocation about half of the time (44%).¹¹ The two matched workers in all remaining 980 groups have comparative advantages in different question types, and the managers can maximize their expected payoffs by allocating the GRE to the worker with a comparative advantage in answering the GRE questions. An allocation based on comparative advantages is “efficient” in the sense that it maximizes the total expected payoff of the three persons in a group. For simplicity, we refer to the worker who has a comparative advantage in answering the

¹⁰In fact, the two matched workers in these groups have identical first stage-one performance. They are the observations at point (0, 0) in Figure 2.4.

¹¹The two-tailed test for the proportion equaling 0.5 has a p-value of 0.26.

Table 2.2: Determinants of Earnings Potential and Earnings

Dependent Var:	NumG	NumG	EarningSt3	EarningSt3
Coef. (std. error in parentheses)				
<i>male</i>	-0.54 (0.91)	-0.78 (1.30)	-0.54 (0.38)	-0.96 (0.55)
<i>askG</i>	1.62 (0.97)	1.39 (1.31)	1.31** (0.41)	0.92 (0.55)
<i>male * askG</i>		1.39 (1.31)		0.92 (0.55)
<i>S</i>	-0.99*** (0.26)	-1.00*** (0.26)	0.23* (0.11)	0.23* (0.11)
<i>G</i>	3.34*** (0.34)	3.33*** (0.34)	1.33*** (0.14)	1.31*** (0.14)
<i>constant</i>	0.36 (2.07)	0.50 (2.15)	-0.61 (0.87)	-0.36 (0.90)
N	106	106	106	106
Adj R^2	0.5472	0.5430	0.6338	0.6343

GRE the “deserving worker” and the other worker the “partner.” Table (2.3) summarizes the characteristics of the deserving workers by their sex for all 980 groups in which a deserving worker can be defined.

The average deserving worker has a lower success rate on the SAT and a higher success rate on the GRE than the average participant. The GRE questions are lucrative for 96% of deserving females, but only 50% of them wants to answer the GRE question in stage three. All deserving males find the GRE lucrative, and 76% of them wants the GRE for stage three. Despite the gender difference in their interests in the GRE, about the same percentage of deserving men and women receive the GRE questions. Roughly 85% of deserving women and 87% of deserving men receive the GRE. Because men on average perform better on the SAT questions than do women in stage one, a larger fraction of deserving men than deserving women have an absolute advantage in answering the SAT. About ten percentage of deserving women have an absolute advantage in answering the SAT - compared to 16% of deserving men. The majority of deserving workers (90% of women and 88% of men) has an absolute advantage in answering the GRE.

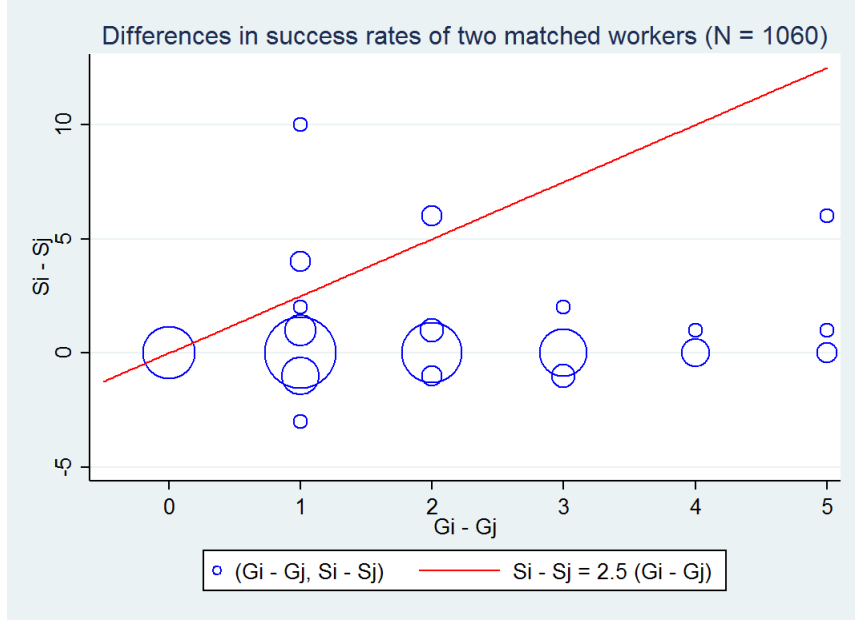


Figure 2.4: Relative Performance of Matched Workers

When two matched workers differ in their comparative advantages, our participants allocate the tasks efficiently about 86% of the time, but the percentage of efficient allocations varies across groups with different sex and preference compositions. We assign each participant one of the four types based on their sex and task preference: females who prefer GRE (*FG*), males who prefer GRE (*MG*), females who prefer SAT (*FS*), and males who prefer SAT (*MS*). Table 2.4 summarizes the number of observations and the percentage of efficient task allocations in each possible combination of the types of deserving workers and their partners.

The most notable pattern shown by Table 2.4 is that task preference influences managerial decisions. The percentages in the first two columns are on average lower than those in the last two columns, which means that the deserving workers receive the GRE less often when their partners want the GRE rather than the SAT. The managers choose efficient allocations least frequently when the preferences of the workers go against their monetary incentives and most frequently when the preferences go with their monetary incentives. When the deserving worker wants the SAT questions while the partner wants the GRE questions, the managers allocate tasks efficiently only 40-80% of the time. In comparison, when the

Table 2.3: Summary Statistics, Each Observation is a Three-Person Group

Variable	Female Deserving Worker					Male Deserving Worker				
	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
S	490	7.61	1.83	4	10	490	7.73	2.29	0	10
G	490	5.73	1.38	2	8	490	6.04	1.43	4	10
GRE lucrative	490	0.96	0.20	0	1	490	1.00	0.00	0	1
Prefer GRE	490	0.50	0.50	0	1	490	0.76	0.43	0	1
Receive GRE	490	0.85	0.36	0	1	490	0.87	0.34	0	1
AA in SAT	490	0.10	0.30	0	1	490	0.16	0.37	0	1
AA in GRE	490	0.90	0.30	0	1	490	0.88	0.33	0	1
$EP(A^*)$	490	4.46	0.82	2.4	5.8	490	4.64	0.93	2.8	7

Note: The expected payoff from the efficient allocation, $EP(A^*)$, is equal to $5G_i + 2S_j$ if i is the deserving worker and $5G_j + 2S_i$ if j is the deserving worker.

Table 2.4: Numbers of Observations and Percentages of Efficient Allocation, by Observation Type

		Partner			
		FG	MG	FS	MS
Deserving Worker	FG	40 (78%)	60 (83%)	40 (100%)	90 (91%)
	MG	70 (81%)	120 (94%)	100 (95%)	80 (90%)
	FS	50 (64%)	50 (64%)	130 (93%)	30 (97%)
	MS	10 (80%)	30 (40%)	40 (95%)	40 (80%)

deserving worker prefers the GRE questions while the partner prefers the SAT questions, the managers allocate tasks efficiently 90-100% of the time. When two workers prefer the same exam, the managers allocate tasks efficiently more often when both workers prefer the SAT to the GRE. On average, 84% of the allocations are efficient when workers both prefer the GRE, while 91% are when workers both prefer the SAT. Our data suggest that the managers may have concerns about the subjective utility of the workers. They are burdened and error prone when their decision denies the workers of their desirable tasks, though part of the burden seems to be relieved when the decision compensates the aggrieved worker financially.

Table 2.4 also suggests that the consequences of reporting the same task preference may differ for men and women. When both workers want the GRE, having a male partner seems to improve the chance of receiving the GRE for a deserving female, but having a female partner seems to hurt the chance of receiving the GRE for a deserving male. When both workers prefer the GRE, a deserving female receives the GRE 78% of the time when her partner is another female and 83% of the time when her partner is a male. In contrast, a deserving male receives the GRE 94% of the time when his partner is another male and 81% of the time when his partner is a female. Moreover, stating to prefer the SAT seems to lower the chance of receiving the GRE questions by a greater extent for women than it is for men.

The patterns we see in Table 2.4 could be driven by differences in performance because success rates and task preferences are correlated. Now we turn to regression analyses to examine them in detail. We begin by asking how having a partner who wants the GRE affects the deserving worker's chance of receiving the GRE. We run pooled OLS regression

$$getG = \beta_0 + \beta_1 \cdot p_askG + \beta_2 \cdot p_male + \beta_3 \cdot p_male_askG + \beta_4 \cdot EP(A^*) + \beta_5 \cdot AAS + \beta_6 \cdot AAG + \epsilon_\beta, \quad (2.4)$$

where $getG$ is an indicator variable equal to one if the worker with a comparative advantage in the GRE (i.e. the deserving worker) receives the GRE, p_askG is an indicator variable equal to one if the deserving worker's partner prefers the GRE, p_male equals one if the partner is male and zero if the partner is female, p_male_askG is the interaction of p_male and p_askG , $EP(A^*)$ is the expected social surplus generated by the efficient allocation and captures the opportunity cost of allocating inefficiently, AAS is an indicator variable equal to

one when the worker with comparative advantage in the GRE has an absolute advantage in the SAT, while AAG is an indicator variable equal to one when the worker with comparative advantage in the GRE also has an absolute advantage in the GRE.

We run regression (2.4) with the full sample and for different types of deserving workers and managers. Table 2.5 reports the results from this set of regressions. Overall, having an absolute advantage in answering the GRE significantly increase the probability of receiving the GRE, while having an absolute advantage in answering the SAT significantly decrease the probability of receiving the GRE. Once the information on absolute advantages is controlled for, the opportunity cost of choosing the inefficient allocation has a marginally positive effect on the probability of receiving the GRE.

Table 2.5: Probability of Receiving the GRE Question (Pooled OLS), by Deserving Worker Type and Manager Type

Variable	Deserving Worker's Type					Manager's Type			
	All	FG	MG	FS	MS	FG	MG	FS	MS
p_askG	-0.19*** (0.04)	-0.22*** (0.07)	-0.13* (0.06)	-0.24*** (0.07)	-0.13 (0.14)	-0.06 (0.07)	-0.12* (0.05)	-0.20** (0.07)	-0.41** (0.14)
p_male	-0.04* (0.02)	-0.08* (0.04)	-0.05 (0.04)	-0.01 (0.03)	0.01 (0.07)	-0.03 (0.03)	0.01 (0.03)	-0.04 (0.04)	-0.17 (0.09)
p_male_askG	0.09* (0.04)	0.17* (0.07)	0.13 (0.07)	0.02 (0.07)	-0.12 (0.18)	-0.06 (0.04)	0.01 (0.05)	0.15* (0.07)	0.37* (0.16)
$EP(A^*)$	0.03* (0.01)	0.00 (0.04)	0.03* (0.02)	-0.01 (0.02)	-0.07 (0.06)	0.01 (0.02)	0.01 (0.02)	0.02 (0.02)	0.04 (0.04)
AAS	-0.11*** (0.03)	-0.18 (0.10)	-0.02 (0.04)	-0.04 (0.05)	-0.16 (0.12)	-0.11 (0.06)	0.02 (0.03)	-0.17** (0.06)	-0.20* (0.08)
AAG	0.49*** (0.06)	0.42*** (0.12)	0.38*** (0.10)	0.52*** (0.09)	0.64*** (0.16)	0.33* (0.13)	0.70*** (0.07)	0.48*** (0.11)	0.33* (0.13)
Adj. R^2	0.2623	0.1867	0.2417	0.3102	0.3675	0.1554	0.5087	0.2284	0.2016
N	980	230	370	260	120	196	302	300	182

Note: The full sample includes all three-person observations for which the deserving worker can be defined (i.e. two matched workers had comparative advantages in different exams). Columns 2 - 5 report the regression results for each type of deserving workers. Columns 6 - 9 report the regression results for each type of managers. (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

The coefficients on p_askG suggest that having a partner who wants the GRE significantly decrease the deserving worker's chance of receiving the GRE. The effect is stronger for deserving females than for deserving males. Having a partner who wants the GRE lowers the chance of receiving the GRE by 22-24% for a deserving woman but only by 13% for a deserving man. Plus, the effect on deserving men is less statistically significant than that on deserving women. Having a male partner decreases the chance of receiving the GRE for the deserving worker unless the male partner wants the GRE, but these effects are statistically

significant only for deserving women who prefer the GRE. Male managers are more responsive to the preferences of the workers than female managers, and managers who prefer the SAT are more responsive to the preferences of the workers than the managers who prefer the GRE.

We then examine how the preference-composition of a three-person group affects the allocation choices with the following regression:

$$getG = \eta_0 + \eta_1 \cdot SS + \eta_2 \cdot GG + \eta_3 \cdot SG + \eta_4 \cdot EP(A^*) + \eta_5 \cdot AAS + \eta_6 \cdot AAG + \epsilon_\eta, \quad (2.5)$$

where SS equals one when the two matched workers both prefer the SAT and zero otherwise, GG equals one when the two matched workers both prefer the GRE and zero otherwise, and SG equals one when the deserving worker prefers the SAT and the partner prefers the GRE and zero otherwise. The groups in which the deserving worker prefers the GRE and the partner prefers the SAT (GS) are the reference groups. Other regressors are as previously defined. We run regression (2.5) with the full sample, and then for different sex compositions of the two matched workers and types of managers. Table 2.6 reports the results from this set of regressions.

All coefficients reported in Table 2.6 are either close to zero or negative: the managers choose money-maximizing allocations less frequently as long as the workers' preferences fail to align with their monetary incentives. The percentage of efficient allocations is the highest in groups GS - when the deserving worker prefers the GRE and the partner prefers the SAT. Having two workers who both prefer the SAT does not lead to significantly more managerial errors, but having two workers who both prefer the GRE does. The managers choose the efficient allocation least frequently when the deserving worker prefers the SAT and the partner prefers the GRE. Compared to the case where the asks go with money (GS), the error rate of the managers is 19-37% higher when the asks go against money (SG).

The results from the regressions confirm most of our conclusions drawn from the patterns observed in Table 2.4. Managers allocate 86% of the tasks efficiently and show mild gender-based bias. Deserving women are more likely than deserving men to lose the lucrative task to partners who want the lucrative tasks. Compared to gender, task preference plays a much

Table 2.6: Probability of Receiving the GRE Question (Pooled OLS), by the Sex Composition of Matched Workers and Manager Type

Variable	Workers' Sex Composition					Manager's Type			
	All	FF	FM	MM	MF	FG	MG	FS	MS
<i>SS</i>	-0.01 (0.02)	-0.04 (0.02)	0.00 (0.05)	-0.04 (0.06)	-0.01 (0.05)	-0.05 (0.04)	-0.02 (0.03)	-0.03 (0.06)	0.09 (0.06)
<i>GG</i>	-0.08** 0.03	-0.23*** (0.07)	-0.06 (0.05)	0.01 (0.03)	-0.13* (0.06)	-0.06 (0.04)	0.08* (0.04)	-0.06 (0.05)	-0.11 (0.09)
<i>SG</i>	-0.28*** (0.04)	-0.30*** (0.07)	-0.23*** (0.06)	-0.37*** (0.10)	-0.19 (0.13)	-0.25** (0.09)	-0.21* (0.08)	-0.29*** (0.07)	-0.30* (0.11)
<i>EP(A*)</i>	0.02 (0.01)	-0.01 (0.02)	0.01 (0.03)	0.02 (0.01)	0.03 (0.03)	-0.01 (0.03)	0.01 (0.02)	0.01 (0.02)	0.05 (0.04)
<i>AAS</i>	-0.09** (0.03)	-0.09* (0.04)		-0.03 (0.06)	-0.03 (0.06)	-0.09 (0.05)	0.03 (0.04)	-0.16* (0.06)	-0.15* (0.08)
<i>AAG</i>	0.48*** (0.06)	0.45*** (0.12)	0.50*** (0.10)	0.50*** (0.11)	0.31** (0.12)	0.34* (0.13)	0.68*** (0.07)	0.44*** (0.11)	0.32* (0.14)
Adj. R^2	0.2892	0.2400	0.2905	0.4434	0.1236	0.1858	0.5214	0.2601	0.1880
N	980	260	230	270	220	196	302	300	182

Note: The full sample includes all three-person observations for which the two matched workers had comparative advantages in different exams, hence risk-neutral managers could maximize their expected payoffs by assigning the GRE to the deserving worker. Columns 2-5 report the regression results by the sex composition of the two matched workers. *FF* represents the groups with two female workers, *MM* two males, *FM* represents the groups where a deserving female has a male partner, and *MF* those where a deserving male has a female partner. Variable *AAS* was omitted from the regression for the sample of deserving females with male partners (*FM*) because it has the value zero for all observations. Columns 6-9 report the regression results by the type of the manager. (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

greater role in task allocations. Managers deviate from efficient allocation mostly when the money-maximizing strategies would deny one or both workers their desired tasks.

2.4.3 Earnings

The participants earn between \$12 and \$39.2, which include the earnings from the experiment and, for the participants in the last five sessions, the payment for the risk-attitude assessment task. As shown in Figure 2.5, earnings are more dispersed in stage three than in stage one, reflecting the increase in earnings inequality when individuals specialize in the tasks for which they have comparative advantages. In both stages one and three, men who prefer the GRE earn more than women who prefer the GRE, and men who prefer the SAT earn less than women who prefer the SAT, but none of the gender differences in earnings is statistically significant. From stage one to stage three, the earnings of both GRE-preferring men and women improve while the earnings of SAT-preferring men and women shrink. As can be seen in Table 2.7, the changes in earnings from stage one to stage three are statistically significant for all types except for the women who prefer the SAT. A gender earnings gap

did not arise in our experiment due to aspects of our experimental design. For example, in our experiment, no worker is *persistently* met with another worker who has a higher ability, prefers the GRE questions, or of the opposite sex. Subjects who prefer the GRE questions to the SAT questions earn significantly more than those who prefer the SAT questions to the GRE questions. Considering the gender difference in task preferences and its influence on managerial decisions, we suspect that a gender earnings gap may arise if the sample is not as gender-balanced as ours, but neither our current experimental design nor the number of observations from 106 subjects can allow a powerful test of the speculation.

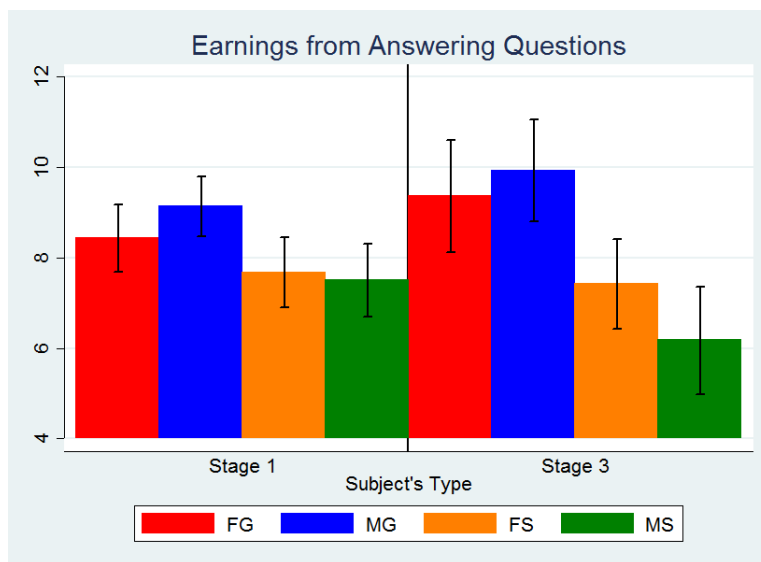


Figure 2.5: Compare Earnings Across Stage, by Subject Type

Table 2.7: Mean Earnings Comparison, by Subject Type

Stage	<i>FG</i>	<i>MG</i>	<i>FG – MG</i>	<i>FS</i>	<i>MS</i>	<i>FS – MS</i>
Stage 1	42.14	45.67	-3.52	38.34	37.45	0.89
Stage 3	46.76	49.61	-2.84	37.06	30.85	6.21
Stage 1 – 3	-4.62*	-3.94*	-0.7	1.28	6.60**	-5.32

2.5 Conclusion

We examine, in a controlled laboratory experiment, whether men receive lucrative tasks more often than equally capable women, leading to a gender pay gap in the opportunity

to earn. Our subjects allocate a standard task and a lucrative task between two workers, knowing their past performances, task preferences, and sexes. We find that men receive the lucrative task more often than women, but the difference can largely be explained by past performance as well as a gender difference in task preference. Half of our subjects shy away from the lucrative tasks, suggesting that they may incur a psychic cost when working on tasks that are challenging. More women than men prefer the standard to the lucrative tasks. The gender difference in task preference is significant, but it does not cause a gender gap in earnings to arise due to aspects of our experimental design. Task preferences have significant effects on managerial decisions. Managers choose the efficient task allocation less often when the workers' preferences go against rather than with their money-incentive. Overall, the evidence points to a concern of the managers for the subjective utilities of the workers.

Our research echoes the message of [11] that performance does trump biases, especially when the workers are evaluated side-by-side, and agrees with [21], which highlights the need to study the interaction between the demand and supply sides to better understand the gender wage gap phenomenon. We find it encouraging that the majority of task allocations are efficient when performance can be accurately measured and evaluated jointly. Employers and managers may mitigate or overcome potential prejudices or biases by adopting well-designed performance evaluation practices. Additionally, our results strongly suggest that the presence of non-performance related information has non-trivial effects on managerial decisions. While [21] informs us that managers may respond to the same choice (choosing piece-rates) of male and female workers differently, our study suggests that, when men and women differ in their preferences in task characteristics, a gender difference in labor market outcomes may arise even when managers suffer no gender bias.

Our results also draw attention to the importance of distinguishing between monetary outcomes and subjective welfare when discussing the gender gap in labor market outcomes.¹² In light of voluminous experimental evidence on gender differences in their preferences regarding task characteristics, the decisions that fail to maximize monetary payoffs might, in fact, be utility-maximizing. Conditional on preferences, a gender earnings gap might be more begin than we usually consider. However, questions remain regarding the formation

¹²[37] documents the paradox of declining female happiness.

of preferences. It is hard to argue whether certain preferences are better than others. The gender wage gap may truly represent the gender welfare gap only when the factors shaped our norms and perceptions of gender roles catch up with the converging monetary measures.

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Appendices

A Appendix A

Appendix A

1. Proof of Lemma 1.1

- (1) Given the monetary disagreement point (a_1, a_2) , consider the allocation $z = (\frac{1}{2}(1 + a_1 - a_2), \frac{1}{2}(1 - a_1 + a_2))$. Note that $z_1 + z_2 = 1$ and $z_1, z_2 > 0$ because $a_i - a_j > -1$. Therefore $z \in A$. It remains to show that $U_i(z) > U_i(a)$ for $i = 1, 2$. Assume, without loss of generality, that $a_1 \leq a_2$. Then $z_1 < z_2$ by construction. We have

$$U_1(z) = z_1 - \alpha_1(z_2 - z_1) = \frac{1}{2}(1 + a_1 - a_2) - \alpha_1(a_2 - a_1)$$

and

$$U_1(a) = a_1 - \alpha_1(a_2 - a_1).$$

Therefore,

$$U_1(z) - U_1(a) = \frac{1}{2}(1 + a_1 - a_2) - a_1 = \frac{1}{2}(1 - a_1 - a_2) > 0.$$

Similarly,

$$U_2(z) - U_2(a) = \frac{1}{2}(1 - a_1 - a_2) > 0.$$

Therefore $(U_1(z), U_2(z)) \in \bar{S}$.

- (2) The set $\bar{S}$ is a quadrilateral (refer to Figure A2). Two of the sides are vertical and horizontal segments extending from the disagreement point d . If $\beta_1 \neq \frac{1}{2}$, then $\bar{S}$ can be described by the equation:

$$0 \leq s_2 \leq \begin{cases} \frac{1+\alpha_1-\beta_2}{1+2\alpha_1} - \frac{1-2\beta_2}{1+2\alpha_1} s_1 & 0 \leq s_1 \leq \frac{1}{2} \\ \frac{1+\alpha_2-\beta_1}{1-2\beta_1} - \frac{1+2\alpha_2}{1-2\beta_1} s_1 & \frac{1}{2} < s_1 \leq 1 \end{cases} \quad \text{if}$$

The set $\bar{S}$ fails to be convex if both boundary segments are downward sloping and the segment corresponding to $s_1 < \frac{1}{2}$ is steeper than the one corresponding to $s_1 > \frac{1}{2}$. They are both downward sloping if $\beta_1, \beta_2 < \frac{1}{2}$. Writing out the condition on the slopes, one sees that

$$\frac{1 - 2\beta_2}{1 + 2\alpha_1} \leq 1 \leq \frac{1 + 2\alpha_2}{1 - 2\beta_1}$$

and so $\bar{S}$ must be convex.

2. Proof of Proposition 1.2

Let $f^N(d, \bar{S})$ and $f^{KS}(d, \bar{S})$ represent the Nash solution and the Kalai-Smorodinsky solution to bargaining problems defined in utility payoffs, and $f^N(a, \bar{A})$ and $f^{KS}(a, \bar{A})$ represent those to monetary bargaining problems. When $\beta_i > \frac{1}{2}$ for $i = 1, 2$, U_1 and U_2 are strictly increasing as the allocation moves toward the even split and they are maximized at the even split. The objective function $(U_1 - (1 - \beta_1)a_1)(U_2 + \alpha_2 a_1)$ is also maximized at the even split because it is strictly increasing in U_1 and U_2 . Therefore, $f^N(d, \bar{S}) = (\frac{1}{2}, \frac{1}{2})$ when $\beta_i > \frac{1}{2}$ for $i = 1, 2$. When $\beta_i > \frac{1}{2}$ for $i = 1, 2$, $(\frac{1}{2}, \frac{1}{2})$ is the bliss point and the maximal point on $L(d, b(\bar{S}))$. Therefore, $f^{KS}(d, \bar{S}) = (\frac{1}{2}, \frac{1}{2})$. At the equal split, the agents do not suffer from disutility, hence $f^N(a, \bar{A}) = f^{KS}(a, \bar{A}) = (\frac{1}{2}, \frac{1}{2})$.

3. Proof of Proposition 1.3

The Nash solution selects a point in the bargaining set that maximizes the product of the utility increases from the disagreement point:

$$f^N(d, \bar{S}) = \arg \max_{U_1, U_2} (U_1 - d_1)(U_2 - d_2).$$

For a monetary bargaining problem with disagreement point $a = (a_1, 0)$, the disagreement point is $d = ((1 - \beta_1)a_1, -\alpha_2 a_1)$. The Nash solution is found at where the isoquant $(U_1 - (1 - \beta_1)a_1)(U_2 + \alpha_2 a_1) = C$ (C is a constant) is tangent to the bargaining frontier.

We first solve the bargaining problem $\langle d, \bar{S} \rangle$ using the Nash solution. The slope of the isoquant $(U_1 - (1 - \beta_1)a_1)(U_2 + \alpha_2 a_1) = C$ is given by

$$\frac{dU_2}{dU_1} = -\frac{U_2 + \alpha_2 a_1}{U_1 - (1 - \beta_1)a_1}. \quad (6)$$

When evaluated at point $(\frac{1}{2}, \frac{1}{2})$, it becomes

$$\left. \frac{dU_2}{dU_1} \right|_{(\frac{1}{2}, \frac{1}{2})} = -\frac{1 + 2\alpha_2 a_1}{1 - 2(1 - \beta_1)a_1}. \quad (7)$$

When both β_1 and β_2 are smaller than $\frac{1}{2}$, as shown in Figure 1.2(a), both segments of the bargaining frontier are downward sloping. The tangency would happen at a point on the segment of the bargaining frontier above the 45° line if the slope of the isoquant at $(\frac{1}{2}, \frac{1}{2})$ is flatter than the slope of the segment of the bargaining frontier above the 45° line. i.e.

$$\left. \frac{dU_2}{dU_1} \right|_{(\frac{1}{2}, \frac{1}{2})} = -\frac{1 + 2\alpha_2 a_1}{1 - 2(1 - \beta_1)a_1} > -\frac{1 - 2\beta_2}{1 + 2\alpha_1} \quad (8)$$

The tangency would happen at a point on the segment of the bargaining frontier below the 45° line if the slope of the isoquant at $(\frac{1}{2}, \frac{1}{2})$ is steeper than the slope of the segment of the bargaining frontier below the 45° line. i.e.

$$\left. \frac{dU_2}{dU_1} \right|_{(\frac{1}{2}, \frac{1}{2})} = -\frac{1 + 2\alpha_2 a_1}{1 - 2(1 - \beta_1)a_1} < -\frac{1 + 2\alpha_2}{1 - 2\beta_1} \quad (9)$$

Otherwise the Nash solution is $(\frac{1}{2}, \frac{1}{2})$.

First note that inequality (8) never hold for the parameter values in the range restricted by our assumptions. Solving inequality (9), we obtain the range of parameter values for which the Nash solution yields an allocation where agent 1 gets higher utility level than agent 2 does. The condition is given by

$$a_1 > \frac{\alpha_2 + \beta_1}{\alpha_2(1 - 2\beta_1) + (1 + 2\alpha_2)(1 - \beta_1)} \equiv \bar{a}_1, \quad (10)$$

where $\bar{a}_1$ is the lower bound of values of a_1 for which the Nash solution assigns more utility to agent 1 than to agent 2. For $a_1 \leq \bar{a}_1$, the Nash solution remains at the even split $(\frac{1}{2}, \frac{1}{2})$.

Kalai-Smorodinsky solution is found at the intersection of the bargaining frontier and the line connecting the disagreement point and the bliss point, $L(d, \bar{S})$. For a given disagreement point $d = (d_1, d_2)$ and a given bliss point $b = (b_1, b_2)$, $L(d, \bar{S})$ can be written as

$$\frac{U_1 - d_1}{b_1 - d_1} = \frac{U_2 - d_2}{b_2 - d_2} \quad (11)$$

Kalai-Smorodinsky solution is $(\frac{1}{2}, \frac{1}{2})$ when $L(d, \bar{S})$ happens to go through that point, meaning that equation (11) holds when $U_1 = U_2 = \frac{1}{2}$. Therefore, Kalai-Smorodinsky solution is an even split when $(1 - 2d_1)/(b_1 - d_1) = (1 - 2d_2)/(b_2 - d_2)$. We need $d_1 < \frac{1}{2}$ to make sure that the even split is Pareto dominating d to begin with.

4. Proof of Proposition 1.4

To show that $\partial x_1^N / \partial \beta_2 = 0$, $\partial x_1^N / \partial \alpha_1 = 0$, $\partial x_1^N / \partial \alpha_2 < 0$ and $\partial x_1^N / \partial \beta_1 < 0$ when $a_1 > \bar{a}_1$ (i.e. when condition (10) holds), first recall that the Nash solution is found at a point on the segment of the bargaining frontier that is below the 45° line in this case. We obtain the Nash solution by solving equation (34) and the following equation (the tangency condition) together for U_1^N and U_2^N .

$$\begin{aligned} -\frac{U_2 + \alpha_2 a_1}{U_1 - (1 - \beta_1)a_1} &= -\frac{1 + 2\alpha_2}{1 - 2\beta_1} \\ \Rightarrow (1 + 2\alpha_2)U_1 - (1 - 2\beta_1)U_2 &= a_1[\alpha_2(1 - 2\beta_1) + (1 - \beta_1)(1 + 2\alpha_2)] \end{aligned} \quad (12)$$

Solving the system

$$\begin{bmatrix} (1 + 2\alpha_2) & (1 - 2\beta_1) \\ (1 + 2\alpha_2) & -(1 - 2\beta_1) \end{bmatrix} \times \begin{bmatrix} U_1^N \\ U_2^N \end{bmatrix} = \begin{bmatrix} 1 + \alpha_2 - \beta_1 \\ c \end{bmatrix}$$

where $c = a_1[\alpha_2(1 - 2\beta_1) + (1 - \beta_1)(1 + 2\alpha_2)]$, we get that the Nash solution when $\beta_1, \beta_2 < \frac{1}{2}$ and $a_1 > \bar{a}_1$ is given by

$$U_1^N = \frac{1}{2(1 + 2\alpha_2)}[(1 + \alpha_2 - \beta_1) + c], \quad (13)$$

and

$$U_2^N = \frac{1}{2(1 - 2\beta_1)}[(1 + \alpha_2 - \beta_1) - c]. \quad (14)$$

Note that $U_1^N > U_2^N$ because the tangency happens at the segment of the bargaining frontier below the 45° line. Using equations (29) and (30), we can transform the Nash solutions (13) and (14) back into monetary terms, which are given by

$$x_1^N = \frac{1 + \alpha_2}{2(1 + 2\alpha_2)} - \frac{\beta_1}{2(1 - 2\beta_1)} + \frac{c}{2(1 + 2\alpha_2)(1 - 2\beta_1)}, \quad (15)$$

and

$$x_2^N = \frac{\alpha_2}{2(1 + 2\alpha_2)} + \frac{1 - \beta_1}{2(1 - 2\beta_1)} - \frac{c}{2(1 + 2\alpha_2)(1 - 2\beta_1)}. \quad (16)$$

It is easy to see that $\partial x_1^N / \partial \beta_2 = 0$, $\partial x_1^N / \partial \alpha_1 = 0$ because x_1 is not a function of β_2 or α_1 . Taking the partial derivatives of x_1^N as given by equation 13 with respect to α_2 and β_1 , we have that

$$\frac{\partial x_1^N}{\partial \alpha_2} = -\frac{(1 - a_1)}{2(1 + 2\alpha_2)^2} < 0,$$

and

$$\frac{\partial x_1^N}{\partial \beta_1} = -\frac{(1 - a_1)}{2(1 - 2\beta_1)^2} < 0.$$

To show that $\partial x_1^{KS} / \partial \beta_2 \geq 0$, $\partial x_1^{KS} / \partial \alpha_1 \geq 0$, $\partial x_1^{KS} / \partial \beta_1 < 0$, and that $\partial x_1^{KS} / \partial \alpha_2 < 0$ when $a_1 = 0$, but the sign of $\partial x_1^{KS} / \partial \alpha_2$ is ambiguous when $a_1 > 0$, we need to show how points d and $b(\bar{S})$, and line $L(d, \bar{S})$ move as a result of changes in the preference parameters.

First, we study the movement of d when $\alpha_1, \beta_1, \beta_2$ changes. Recall that

$$d = (d_1, d_2) = ((1 - \beta_1)a_1, -\alpha_2 a_1).$$

Taking the derivative of d_1 and the derivative of d_2 with respect to α_1, β_1 , and β_2 , we have that

$$\frac{\partial d_1}{\partial \alpha_1} = 0 \quad \text{and} \quad \frac{\partial d_2}{\partial \alpha_1} = 0 \quad (17)$$

$$\frac{\partial d_1}{\partial \beta_1} = -a_1 < 0 \quad \text{and} \quad \frac{\partial d_2}{\partial \beta_1} = 0 \quad (18)$$

$$\frac{\partial d_1}{\partial \beta_2} = 0 \quad \text{and} \quad \frac{\partial d_2}{\partial \beta_2} = 0 \quad (19)$$

Second, we study the movement of $b(\bar{S})$. When $\beta_1, \beta_2 < \frac{1}{2}$ and $d_1 < \frac{1}{2}$, the bliss point $b(\bar{S})$ is given by

$$(b_1, b_2) = \left(\frac{(1 + \alpha_2 - \beta_1) + \alpha_2(1 - 2\beta_1)a_1}{(1 + 2\alpha_2)}, \frac{(1 + \alpha_1 - \beta_2) - (1 - \beta_1)(1 - 2\beta_2)a_1}{(1 + 2\alpha_1)} \right)$$

When $\beta_1, \beta_2 < \frac{1}{2}$ and $d_1 > \frac{1}{2}$, the bliss point $b'(\bar{S})$ is given by

$$(b_1, b'_2) = \left(\frac{(1 + \alpha_2 - \beta_1) + \alpha_2(1 - 2\beta_1)a_1}{(1 + 2\alpha_2)}, \frac{(1 + \alpha_2 - \beta_1) - (1 + 2\alpha_2)(1 - \beta_1)a_1}{(1 - 2\beta_1)} \right)$$

The derivatives of b_1, b_2 and b'_2 with respect to the preference parameters are given by

$$\frac{\partial b_1}{\partial \alpha_1} = 0 \quad \frac{\partial b_2}{\partial \alpha_1} = -\frac{(1 - 2\beta_2)(1 - (1 - \beta_1)a_1)}{(1 + 2\alpha_1)^2} < 0 \quad \text{and} \quad \frac{\partial b'_2}{\partial \alpha_1} = 0 \quad (20)$$

$$\frac{\partial b_1}{\partial \beta_1} = -\frac{1 + 2\alpha_2 a_1}{1 + 2\alpha_2} < 0 \quad \frac{\partial b_2}{\partial \beta_1} = \frac{(1 - 2\beta_2)a_1}{1 + 2\alpha_1} > 0$$

and

$$\frac{\partial b'_2}{\partial \beta_1} = \frac{(1 + 2\alpha_2)(1 - (1 - \beta_1)a_1)}{(1 - 2\beta_1)^2} > 0 \quad (21)$$

$$\frac{\partial b_1}{\partial \beta_2} = 0 \quad \frac{\partial b_2}{\partial \beta_2} = -\frac{(1 - 2(1 - \beta_1)a_1)}{1 + 2\alpha_1} < 0 \quad \text{and} \quad \frac{\partial b'_2}{\partial \beta_2} = 0 \quad (22)$$

From (17) and (20) or (19) and (22), we know that d does not move, $b(\bar{S})$ moves downward, and $b'(\bar{S})$ does not move when α_1 or β_2 increases. A downward movement of $b(\bar{S})$ means that $L(d, b(\bar{S}))$ intersects the bargaining frontier at a lower point, leading to an increase in U_1 and a decrease in U_2 , which also implies an increase in x_1 and a decrease in x_2 when $x_1 + x_2 = 1$.

From (18) and (21), we know that d moves to the left, both $b(\bar{S})$ and $b'(\bar{S})$ move to the left and upward when α_1 increases. This means that both $L(d, b(\bar{S}))$ and $L(d, b'(\bar{S}))$ intersect the bargaining frontier at a higher point, leading to an increase in U_2 and a decrease in U_1 , implying an increase in x_2 and a decrease in x_1 .

Therefore, $\partial x_1^{KS}/\partial \alpha_1 \geq 0$, $\partial x_1^{KS}/\partial \beta_1 < 0$, and $\partial x_1^{KS}/\partial \beta_2 \geq 0$.

Now we show that $\partial x_1^{KS}/\partial \alpha_2 < 0$ when $a_1 = 0$. The disagreement point is $d = (0, 0)$.

The bliss point in this case is given by

$$(b_1, b_2) = \left(\frac{1 + \alpha_2 - \beta_1}{1 + 2\alpha_2}, \frac{1 + \alpha_1 - \beta_2}{1 + 2\alpha_1} \right)$$

The slope of $L(d, \bar{S})$ is given by

$$\frac{(1 + 2\alpha_2)(1 + \alpha_1 - \beta_2)}{(1 + 2\alpha_1)(1 + 2\alpha_1)} \quad (23)$$

Take the derivative of the above slope with respect to α_2 we have that

$$\frac{2(1 + \alpha_1 - \beta_2)}{(1 + 2\alpha_1)(1 + 2\alpha_1)} > 0,$$

which implies that $L(d, \bar{S})$ becomes steeper when α_2 increases. This change allows $L(d, \bar{S})$ to intersect the bargaining frontier at a higher point, increasing U_2 and decreasing U_1 . x_1 decreases as a result.

Lastly, we show that the sign of $\partial x_1^{KS}/\partial \alpha_2$ is ambiguous when $a_1 > 0$. When $a_1 > 0$,

$$\frac{\partial d_1}{\partial \alpha_2} = 0 \quad \text{and} \quad \frac{\partial d_2}{\partial \alpha_2} = -a_1 < 0 \quad (24)$$

$$\frac{\partial b_1}{\partial \alpha_2} = -\frac{(1 - 2\beta_1)(1 - a_1)}{(1 + 2\alpha_2)^2} < 0 \quad \frac{\partial b_2}{\partial \alpha_2} = 0$$

and

$$\frac{\partial b'_2}{\partial \alpha_2} = \frac{1 - 2(1 - \beta_1)a_1}{1 - 2\beta_1} \text{ (its sign is ambiguous)} \quad (25)$$

From 24 and 25, we know that $L(d, b(\bar{S}))$ and $L(d, b'(\bar{S}))$ rotates in a manner that may allow them to intersect the bargaining frontier at a lower or higher point. We cannot unambiguously sign the derivative $\partial x_1^{KS}/\partial \alpha_2$ when $a_1 > 0$. Here we provide two numerical examples, the first shows that increasing α_2 increases U_1 , which implies an increase in x_1 ; the second example shows the opposite.

Example 1:

$$a_1 = 0.1, \beta_1 = \beta_2 = 0.1, \alpha_1 = 1, \alpha_2 = 1.2 \quad \Rightarrow \quad U_1^{KS} \approx 0.512.$$

$$a_1 = 0.1, \beta_1 = \beta_2 = 0.1, \alpha_1 = 1, \alpha_2 = 10 \quad \Rightarrow \quad U_1^{KS} \approx 0.509.$$

In this example, agent 1 gets less when agent 2 becomes more averse to disadvantageous inequality.

Example 2:

$$a_1 = 0.3, \beta_1 = \beta_2 = 0.1, \alpha_1 = 1, \alpha_2 = 1.2 \quad \Rightarrow \quad U_1^{KS} \approx 0.526.$$

$$a_1 = 0.3, \beta_1 = \beta_2 = 0.1, \alpha_1 = 1, \alpha_2 = 10 \quad \Rightarrow \quad U_1^{KS} \approx 0.529.$$

In this example, agent 1 gets more when agent 2 becomes more averse to disadvantageous inequality.

Appendix B

Transformation of the bargaining set:

The feasible set defined in monetary payoffs, A , is the subset of the $x_1 \times x_2$ plane shown in the left panel of Figure A1 that is enclosed by lines

$$x_1 = 0, \tag{26}$$

$$x_2 = 0, \tag{27}$$

and

$$x_1 + x_2 = 1. \tag{28}$$

We transform set A and represent it on the $U_1 \times U_2$ plane using Fehr-Schmidt preferences. When the agents are inequity averse, their utility functions are given by $U_1 = x_1$ and $U_2 = x_2$ when $x_1 = x_2$. When $x_1 > x_2$, they are given by

$$U_1 = x_1 - \beta_1(x_1 - x_2) = (1 - \beta_1)x_1 + \beta_1x_2, \tag{29}$$

and

$$U_2 = x_2 - \alpha_2(x_1 - x_2) = (1 + \alpha_2)x_2 - \alpha_2x_1. \tag{30}$$

When $x_1 < x_2$, they are given by

$$U_1 = x_1 - \alpha_1(x_2 - x_1) = (1 + \alpha_1)x_1 - \alpha_1x_2, \tag{31}$$

and

$$U_2 = x_2 - \beta_2(x_2 - x_1) = (1 - \beta_2)x_2 + \beta_2x_1. \tag{32}$$

Taking the difference of U_i and U_{3-i} where $i = 1, 2$, we notice that $U_i - U_{3-i} = (1 + \alpha_{3-i} - \beta_i)(x_i - x_{3-i}) > 0$ whenever $x_i > x_{3-i}$, which means that whichever agent has the higher monetary payoff should also have the higher Fehr-Schmidt utility level.

Figure A1 shows the transformation of the feasible monetary bargaining set A to its counterpart S in utility space. To transform the segment of the monetary bargaining frontier

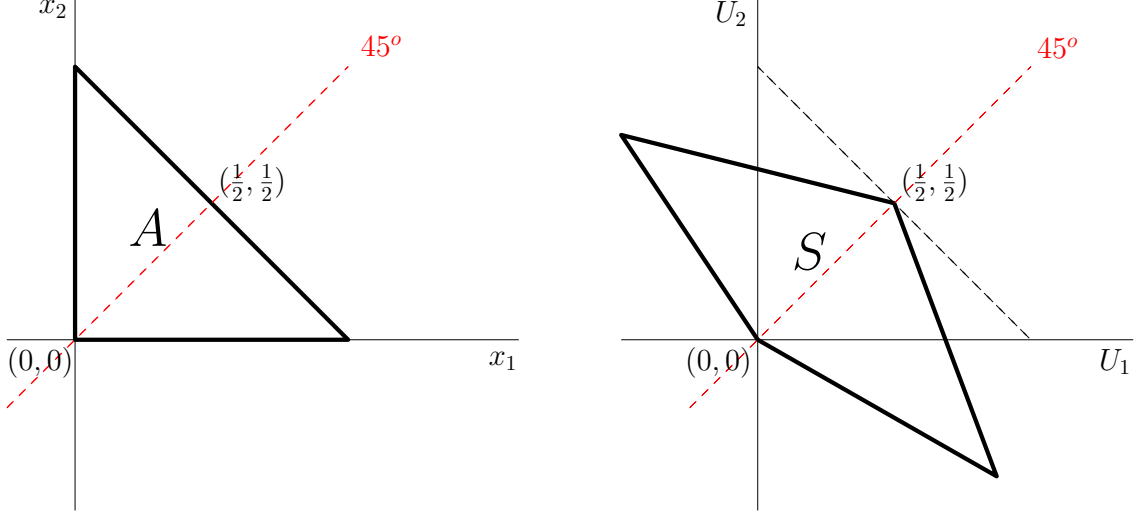


Figure A1: Transformation of the Feasible Set

above the 45° line to its counterpart in utility space, we solve equations (28), (31), and (32) jointly to write U_2 as a function of U_1 :

$$U_2 = -\frac{1 - 2\beta_2}{1 + 2\alpha_1}U_1 + \frac{1 + \alpha_1 - \beta_2}{1 + 2\alpha_1}. \quad (33)$$

To transform the segment of the monetary bargaining frontier below the 45° line, we solve equations (28), (29), and (30) jointly to write U_2 as a function of U_1 :

$$U_2 = -\frac{1 + 2\alpha_2}{1 - 2\beta_1}U_1 + \frac{1 + \alpha_2 - \beta_1}{1 - 2\beta_1}. \quad (34)$$

To transform the vertical boundary of set A , we solve equations (26), (31), and (32) jointly to write U_2 as a function of U_1 :

$$U_2 = -\frac{1 - \beta_2}{\alpha_1}U_1. \quad (35)$$

To transform the horizontal boundary of set A , we solve equations (27), (29), and (30) jointly to write U_2 as a function of U_1 :

$$U_2 = -\frac{\alpha_2}{1 - \beta_1}U_1. \quad (36)$$

The feasible set defined in utility space, S , is the subset of the $U_1 \times U_2$ plane that is enclosed by lines (33), (34), (35), and (36).

Figure A2 shows the transformation from bargaining set $\bar{A}$ to $\bar{S}$. The boundaries of $\bar{A}$ are traced out by segments of the agents' indifference curves going through the monetary disagreement point $a = (a_1, 0)$. Sets $\bar{A}$ and $\bar{S}$ differ from sets A and S by excluding allocations that are individually irrational for inequity averse agents to choose. At $a = (a_1, 0)$, the utility

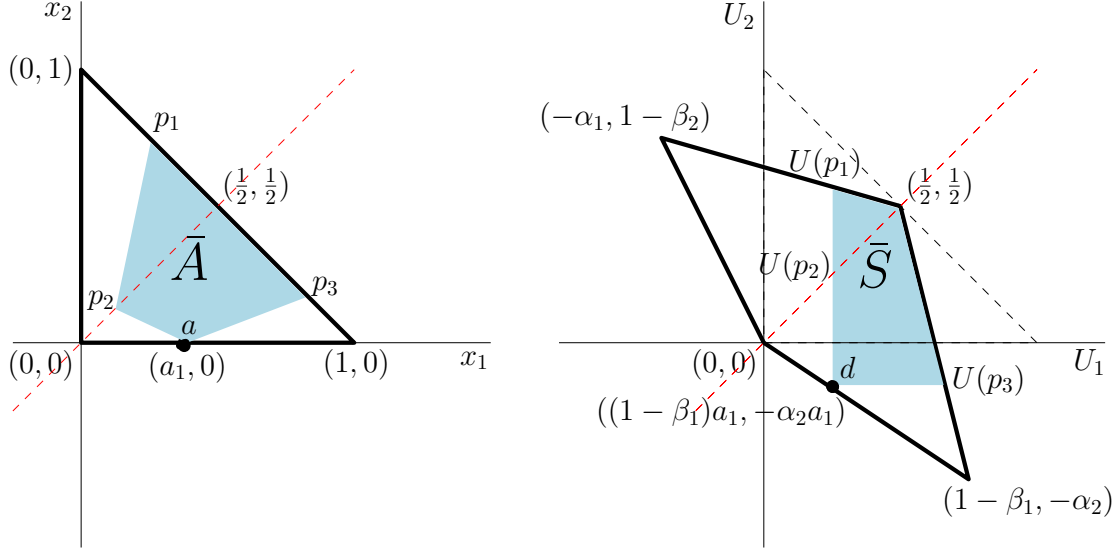


Figure A2: Transformation of the Bargaining Set from $\bar{A}$ to $\bar{S}$

of agent 1 is given by

$$U_1 \Big|_{(a_1, 0)} = (1 - \beta_1)a_1. \quad (37)$$

To get the indifference curve of agent 1 that goes through point a , we solve

$$(1 - \beta_1)x_1 + \beta_1x_2 = (1 - \beta_1)a_1,$$

and

$$(1 + \alpha_1)x_1 - \alpha_1x_2 = (1 - \beta_1)a_1.$$

At the 45° line, the indifference curve of agent 1 is $x_1 = x_2$. Its segment below the 45° line is given by

$$x_2 = -\frac{1 - \beta_1}{\beta_1}x_1 + \frac{1 - \beta_1}{\beta_1}a_1, \quad (38)$$

and its segment above the 45° line is given by

$$x_2 = \frac{1 + \alpha_1}{\alpha_1} x_1 - \frac{1 - \beta_1}{\alpha_1} a_1. \quad (39)$$

Following similar steps, we can obtain the indifference curve of agent 2. At the monetary disagreement point a , the utility of agent 2 is given by

$$U_2 \Big|_{(a_1, 0)} = -\alpha_2 a_1 \quad (40)$$

At the 45° line, the indifference curve of agent 2 is $x_1 = x_2$. Its segment below the 45° line is given by

$$x_2 = \frac{\alpha_2}{1 + \alpha_2} x_1 - \frac{\alpha_2}{1 + \alpha_2} a_1, \quad (41)$$

and its segment above the 45° line is given by

$$x_2 = -\frac{\beta_2}{1 - \beta_2} x_1 - \frac{\alpha_2}{1 - \beta_2} a_1. \quad (42)$$

The bargaining set $\bar{A}$ is the subset of the $x_1 \times x_2$ plane enclosed by lines (28), (38), (39), and (41). The counterpart of $\bar{A}$ in utility space, $\bar{S}$, is the subset of the $U_1 \times U_2$ plane enclosed by lines (33), (34), (37), and (40). Alternatively, $\bar{A}$ is the convex hull of points a, p_1, p_2 , and p_3 , and $\bar{S}$ is the convex hull of points $d, U(p_1), U(p_2)$, and $U(p_3)$, where

$$\begin{aligned} a &= (a_1, 0), \\ p_1 &= \left(\frac{\alpha_1}{1 + 2\alpha_1} + \frac{1 - \beta_1}{1 + 2\alpha_1} a_1, \frac{1 + \alpha_1}{1 + 2\alpha_1} - \frac{1 - \beta_1}{1 + 2\alpha_1} a_1 \right), \\ p_2 &= ((1 - \beta_1)a_1, (1 - \beta_1)a_1), \\ p_3 &= \left(\frac{1 + \alpha_2}{1 + 2\alpha_2} + \frac{\alpha_2}{1 + 2\alpha_2} a_1, \frac{\alpha_2}{1 + 2\alpha_2} - \frac{\alpha_2}{1 + 2\alpha_2} a_1 \right), \end{aligned}$$

and

$$\begin{aligned} d &= (a_1(1 - \beta_1), -a_1\alpha_2), \\ U(p_1) &= \left((1 - \beta_1)a_1, \frac{(1 + \alpha_1 - \beta_2) - (1 - \beta_1)(1 - 2\beta_2)a_1}{1 + 2\alpha_1} \right), \\ U(p_2) &= ((1 - \beta_1)a_1, (1 - \beta_1)a_1), \\ U(p_3) &= \left(\frac{(1 + \alpha_2 - \beta_1) - \alpha_2(1 - 2\beta_1)a_1}{1 + 2\alpha_2}, -\alpha_2 a_1 \right). \end{aligned}$$

B Appendix B

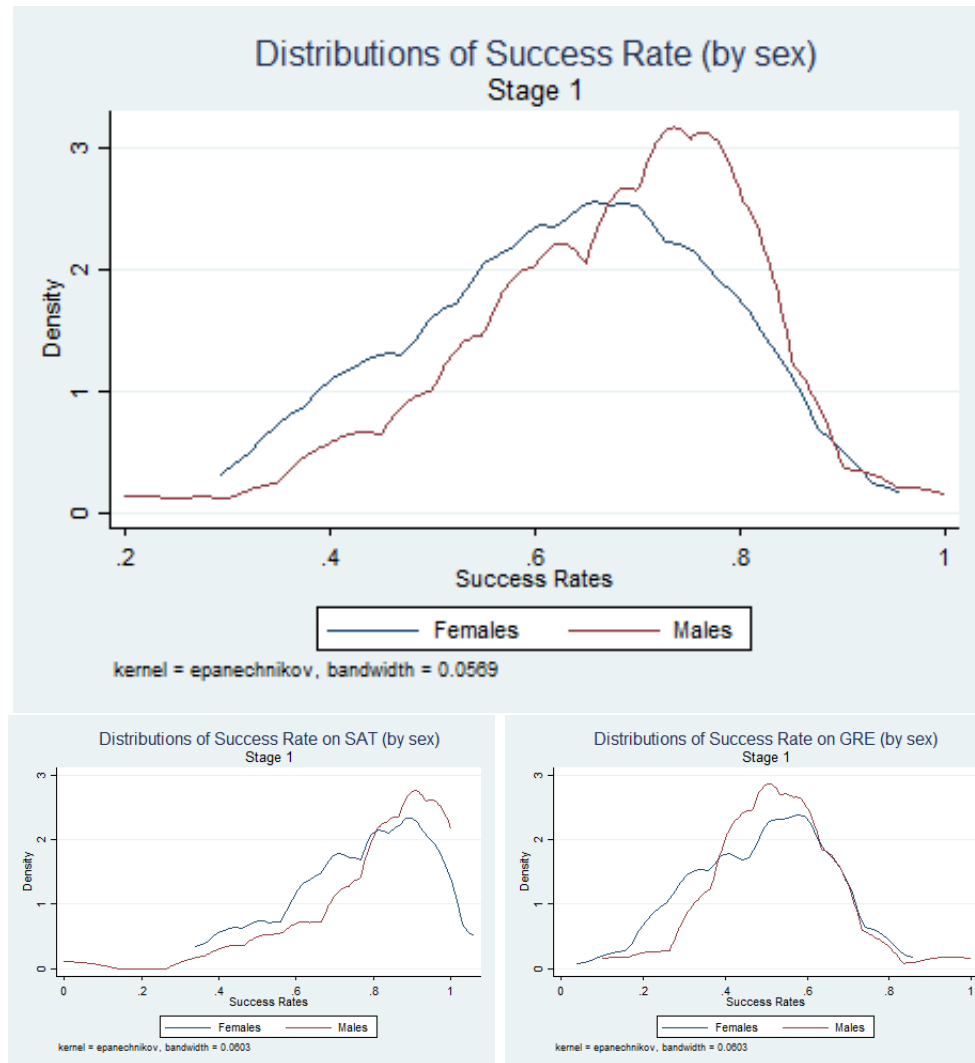


Figure B1: Success Rates in Stage One, by Sex

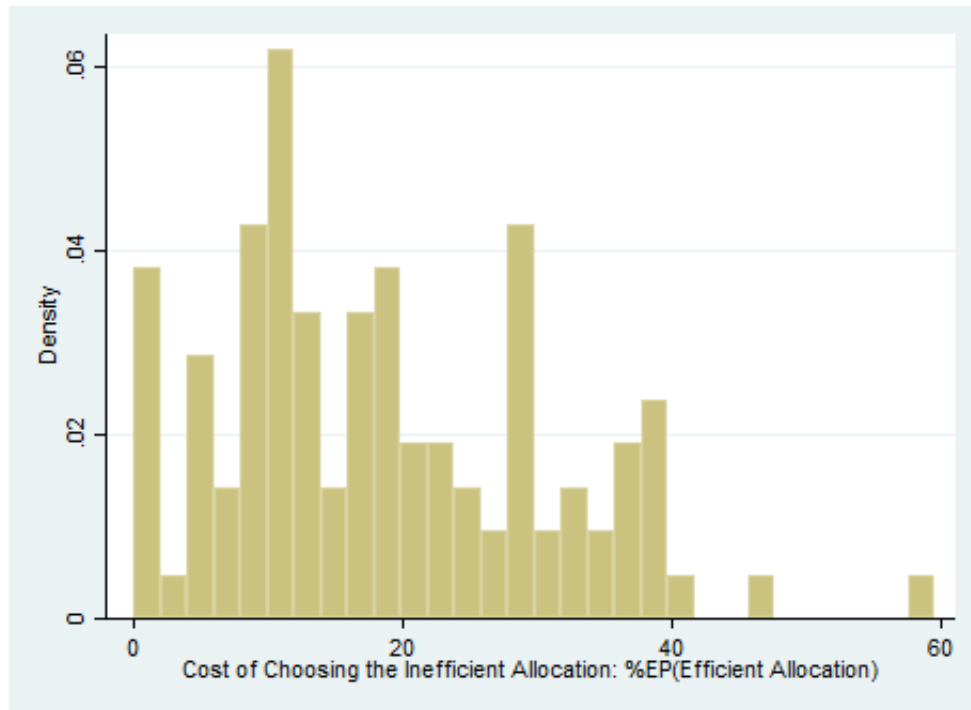


Figure B2: Cost of Choosing the Inefficient Task Allocation as a Percentage of the Expected Payoff from Choosing the Efficient Task Allocation

Period

1 out of 10

Remaining time [sec]: 845

Question 1

Answer Choices

Make your selection...

MUSICIAN : ORCHESTRA :

A) worker : product

B) composer : score

C) soloist : accompanist

D) player : team

E) dancer : stage

☐ A

☐ B

☐ C

☐ D

☐ E

Figure B3: No Explicit Label of the Question Type

Period 1 out of 10	Remaining time [sec]: 85
-----------------------	--------------------------

Your Player ID: 1

In Stage 1:

You correctly answered:

7 out of 10 SAT questions;
5 out of 10 GRE questions.

Thus, you have earned:

14 tokens form answering the SAT questions;
25 tokens form answering the GRE questions.

Which type of questions would you prefer to answer in Stage 3
of the experiment, SAT questions or GRE questions?

☐ I prefer to answer SAT questions.

☐ I prefer to answer GRE questions

Save and Continue

Figure B4: Indicating Task Preference

Period 1 out of 10	
-----------------------	--

Your Player ID: 12

Round 1

Information about Player #5 and Player #10:

Player #5 prefers to answer SAT questions.
He answered 3 SAT and 1 GRE questions correctly in Stage 1.

Player #10 prefers to answer GRE questions.
He answered 3 SAT and 4 GRE questions correctly in Stage 1.

Please choose one of the two alternative assignments below:

☐ Assign Player #5 a GRE question and Player #10 an SAT question.

☐ Assign Player #10 a GRE question and Player #5 an SAT question.

Save and Continue

Figure B5: Task Allocation Decision

Experiment Instructions

We invite you to participate in a research of economic decision-making. We ask you to read these instructions and to ask questions that you may have before we start the experiment.

Experiment Overview

In this experiment, you will be asked a series of verbal analogy questions that have appeared in past versions of an undergraduate entrance exam (SAT) and a graduate school entrance exam (GRE). The bulk of your earnings will depend on your ability to answer these questions correctly. You will also be asked to assign questions to some other participants currently in the lab, and the remaining part of your earnings will depend on whether or not *they* correctly answer the questions assigned by you.

The experiment consists of two questionnaires and three stages of play (see Experiment Timeline). You will fill out a questionnaire before Stage 1 and after Stage 3 of the experiment.

In **Stage 1**, you will have 15 minutes to answer 20 verbal analogy questions taken from past versions of SAT and GRE exams. 10 of these questions will be SAT questions, and 10 of them will be GRE questions. However, the questions will be presented to you in a random order and in the same format. So, you will not be able to tell the two apart. Your answer choices will be saved automatically by the computer. After you have completed all 20 questions, you can review and change your answers until you reach the time limit of the stage. After all participants have submitted their answers (or when the timer expires), you will learn about your success rates and the number of tokens earned on both tests. Then, you will indicate which type of questions, SAT or GRE, you would like to answer in *Stage 3* of the experiment.

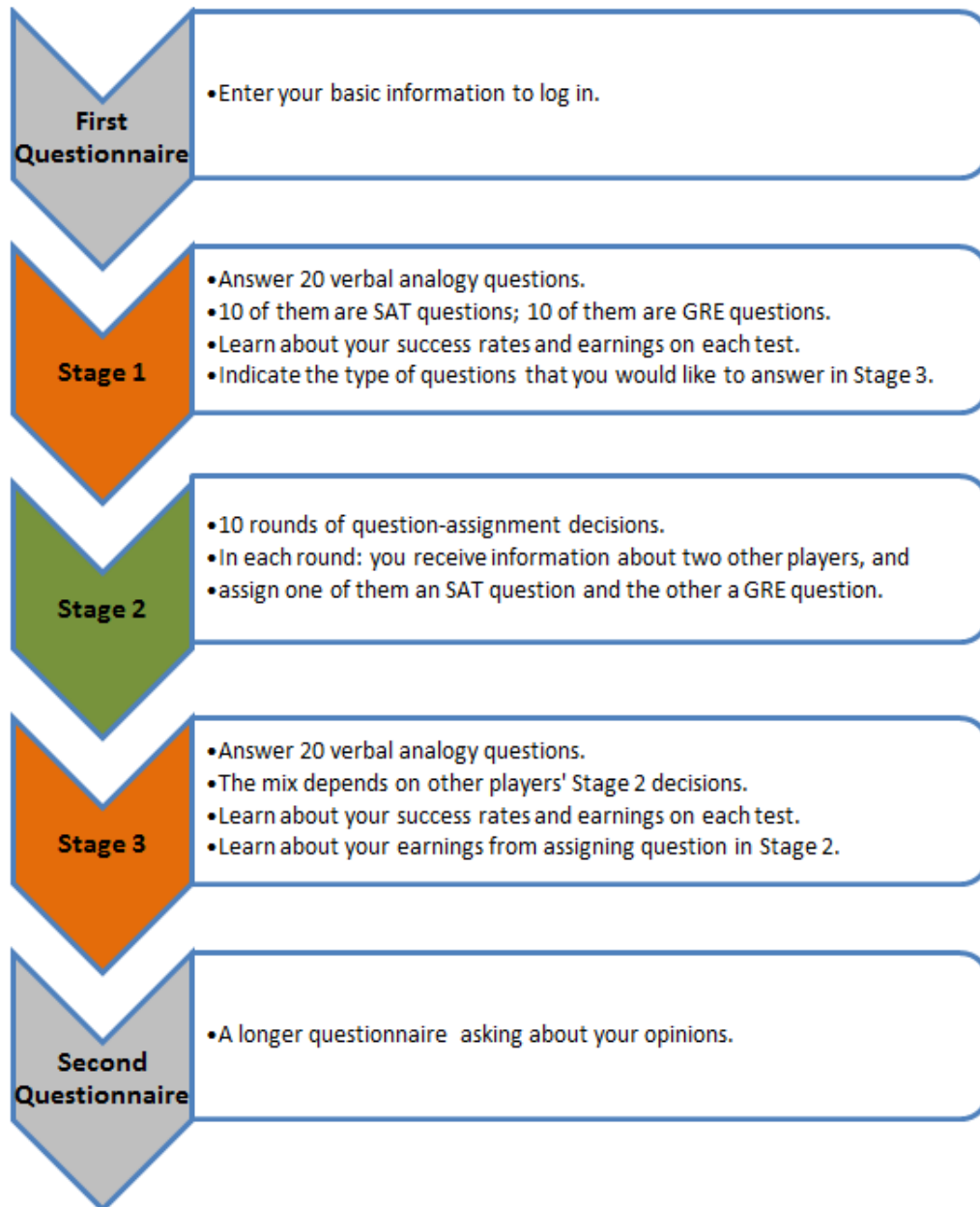
In **Stage 2**, each participant will make 10 rounds of question-assignment decisions. *In each round*, you will allocate an SAT question and a GRE question between two other players currently in the lab. You will receive information about their preferred question-type and their Stage 1 success rates, and you will assign an SAT question to one of them and a GRE question to the other. You will not know the specifics of any question you assign. You are simply determining the type of question assigned to each player.

Once everyone has made their decision, assignments will be recorded in our computer system and a new round of question-assignment will begin. Each round of question-assignment will follow the same structure described above. The only thing that will change from round to round is the pair of players you will assign questions to. By the end of the stage, you will have assigned 10 SAT questions and 10 GRE questions to different players currently in the lab.

In **Stage 3**, all players will receive 20 questions to complete as a result of Stage 2. The number of SAT and/or GRE questions you are given will depend only on the assignment decisions of your fellow players. You will have 15 minutes to answer all 20 questions. Like in Stage 1, the questions will be presented in the same format, and your answer choices will be saved automatically by the computer. Once you have submitted your responses, you will learn about your own success rates, the success rates of the players you allocated questions to, and your total earnings from this experiment.

You can use the handout titled “Experiment Timeline” to keep track of the progress of the experiment.

Experiment Timeline



Earnings Determination

Each correctly answered SAT question is worth 2 tokens. Each correctly answered GRE question is worth 5 tokens.

Your total number of tokens earned in the experiment will be the sum of the tokens earned in the three stages of the experiment. Your earnings in tokens will be converted to dollars at the rate **5 tokens = \$1**.

Your earnings in Stage 1 and 3 will be the total number of tokens you earned for correctly answering the verbal analogy questions. You will earn nothing if you answer a question incorrectly.

- For example, if you correctly answer four SAT questions and three GRE questions in Stage 1, you would earn a total of 23 tokens (calculated as $2 \times \text{four} + 5 \times \text{three} = 23$).

Your earnings in Stage 2 will depend on the Stage 3 performance of the players you allocated questions to. You will earn 2 tokens if a player correctly answers an SAT question assigned by you and 5 tokens if a player correctly answers a GRE question assigned by you. You will earn nothing if the player answers the question incorrectly.

- For example, if six of the ten players you assigned an SAT question in Stage 2 answer the question correctly in Stage 3, you will receive 12 tokens ($2 \times \text{six} = 12$) from the SAT questions you assigned. If six of the ten players you assigned a GRE question in Stage 2 answer the question correctly in Stage 3, you will receive 30 tokens ($5 \times \text{six} = 30$) from the GRE questions you assigned.

In general, you will earn more tokens if you answer more questions correctly and/or if the players you assigned questions to answer more questions correctly.

Payment Method

All payments will be done by a third party to ensure that all participants' earnings are known neither by any other participant nor by the experimenter. A third party in a separate room will arrive with envelopes and distribute them by station letter. Before you leave, make sure you have received the proper amount and signed the receipt. You will hand in your receipt and envelope as you exit the lab. (These final instructions will be read again at the conclusion of the experiment.)

Now, before we begin ...

In case any of you are not familiar with the SAT or GRE exams, let's review an example of verbal analogy questions before we start the experiment:

Question

ASPRIN : HEADACHE ::

Correct Answer: A.)

Answer Choices

A.) nap : fatigue

B.) light : dark

C.) rubber : mat

D.) teammate : friendship

E.) clash : titan

The analogy, "ASPRIN : HEADACHE :: nap : fatigue," should be read "aspirin is to headache as nap is to fatigue." Analogy questions ask you to select the pair of words among the answer choices that most closely reflects the relationship between the pair of words in capital letters.

Now, you can open and run the Z-leaf application. A computer program will guide you through each stage of the experiment. Please follow the instructions that will appear on the screen closely and make sure that you complete the decisions within the time limit of each stage. You will be able to see the remaining time (in seconds) at the upper-right corner of the screen.

Gamble Selection

You will select **one** from the six gambles listed below to play.

Each gamble has two possible outcomes (LOW or HIGH). Each outcome has a 50% chance of occurring. Your earnings from playing the gamble will be determined by

- Which one of the six gambles you select; and
- Which one of the two possible outcomes occurs.

For example, if you select Gamble 4, you will receive

- 8 tokens if the LOW outcome occurs; and
- 44 tokens if the HIGH outcome occurs.

You must select one and only one gamble.

You will be asked to enter your gamble choice during the first questionnaire. The outcome (LOW or HIGH) of the gamble will be determined by a computerized coin-flip in the background program. The outcome and the associated payoff will be revealed to you by the end of the second questionnaire. You will learn which outcome had occurred. Your payoff from playing the gamble will be converted to dollars (5 tokens = \$1) and added to your earnings from the experiment.

List of Gambles

	Outcomes	Payoffs	Chances
Gamble 1	LOW	20 tokens	50%
	HIGH	20 tokens	50%
Gamble 2	LOW	16 tokens	50%
	HIGH	28 tokens	50%
Gamble 3	LOW	12 tokens	50%
	HIGH	36 tokens	50%
Gamble 4	LOW	8 tokens	50%
	HIGH	44 tokens	50%
Gamble 5	LOW	4 tokens	50%
	HIGH	52 tokens	50%
Gamble 6	LOW	- 6 tokens	50%
	HIGH	62 tokens	50%

Vita

Jing Li was born in Yunnan, China on July 6, 1986. She grew up in Lufeng, Chuxiong, and graduated from Chuxiong No. 1 High School in 2004. She attended Qingdao University in Qingdao, Shandong, where she received a Bachelor of Science Degree in Economics in June 2009. She then pursued the study of Economics at the University of Illinois and received a Master of Science degree in Policy Economics in December 2010. She moved to Knoxville, Tennessee the following July to study at the University of Tennessee. She received her Doctorate of Philosophy degree in Economics in December 2017.