Decentralized Matching with Transfers: Experimental and Noncooperative Analyses

Simin He[*] Jiabin Wu[†] Hanzhe Zhang[‡] Xun Zhu[§]

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Abstract

We experimentally examine the Becker-Shapley-Shubik two-sided matching model. In the experiment, the aggregate outcomes of matching and surplus are affected by whether the pairwise Nash-Rubinstein bargaining outcome of equal surplus division is stable and, to a lesser extent, by whether efficient matching is assortative, while the canonical cooperative theory predicts no effect. In balanced markets, that is, markets with equal numbers of participants on both sides, individual payoffs in our and others' experiments cannot be explained by existing refinements of the core, but are consistent with the predictions of our noncooperative model. In imbalanced markets, that is, markets with unequal numbers of participants on the two sides, noncompetitive outcomes, where subjects on the long side do not fully compete, are not captured by the canonical cooperative model, but are included in the set of predictions in our noncooperative model.

Keywords: decentralized matching, matching with transfers, assignment games, bargaining, core
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[*]he.simin@mail.shufe.edu.cn, School of Economics, Shanghai University of Finance and Economics.
[†]jwu5@uoregon.edu, Department of Economics, University of Oregon.
[‡]hanzhe@msu.edu, Department of Economics, Michigan State University.
[§]zhuxun_0609@163.sufe.edu.cn, School of Management, Fudan University.

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1 Introduction

The transferable-utilities (TU) two-sided matching model, developed by Shapley and Shubik (1972) and Becker (1973), has been widely used to study marriage and labor markets, both theoretically and empirically.[1] There is increasing interest in testing the model's predictions on stable/core matching and bargaining outcomes[2] in laboratory experiments, which have the advantage of creating a controlled environment that allows researchers to better understand the scope and limitations of a theory, despite the small number of participants and the low incentives provided (Roth, 2015). This study conducts one of the first comprehensive experiments on the TU matching model and provide a noncooperative model to explain experimental findings that contradict the predictions of the canonical cooperative theory.

Our experimental investigation starts with the smallest *balanced* markets with nontrivial matching possibilities, that is, markets with three subjects on each side, and moves on to study *imbalanced* markets with three subjects on one side and four on the other. To mimic the TU matching market, we reduce frictions by allowing subjects to propose to anyone on the opposite side of the market with any division of the surplus, and no match becomes permanent until the end of the game.[3] To ensure robustness of our main findings, we run two waves of experiments that differ in game-ending rules and payment rules.

According to the canonical theory, different surplus configurations of the market should not affect people's ability to reach efficient matching or stable bargaining outcomes. However, in practice, several factors may impact this. We first investigate how two features affect matching and bargaining outcomes in balanced markets: (i) whether efficient matching is assortative and (ii) whether an equal split of each efficiently matched pair's surplus is stable/in the core. To do so, we use a two-by-two comparison. First, we hypothesize that the configurations that admit an assortative efficient matching are potentially more straightforward and intuitive since sorting has been frequently observed in practice; it is therefore important to investigate whether subjects in a controlled experiment indeed find it easier to match when assortative matching is available. Second, we note that an equal division of every efficiently matched pair's surplus is the pairwise Nash (1950) bargaining outcome, and is also the limit outcome of the pairwise Rubinstein (1982) bargaining when subjects are infinitely patient, so subjects may find it easier and strategically more plausible to reach and maintain such an outcome if it is also in the core.[4]

Our experiment finds that the probability of being matched and the probability of achieving efficient matching are significantly higher in markets with equal splits in the core and, to a lesser extent, in markets

[1]For a comprehensive overview of the TU matching model and its applications, see the following surveys and monographs: Galichon (2016); Chiappori and Salanié (2016); Chade et al. (2017); and Chiappori (2017). The model has been applied to explain observed assortative matching in characteristics such as education, height, race, income, and blood type (Becker, 1973; Siow, 2015; Pollak, 2019; Hou et al., 2022), as well as cross-country differences in income and growth (Kremer, 1993), increases in CEO pay (Gabaix and Landier, 2008), and college and career choices (Chiappori et al., 2009; Zhang, 2020, 2021; Zhang and Zou, 2022).

[2]A matching and bargaining outcome is stable (also known as being in the core) if no pair of agents has an incentive to deviate from their respective partners to form a new pair.

[3]The features of the experiment described capture a labor market in which firms and workers, or a venture capital market in which entrepreneurs and investors, are simultaneously negotiating deals.

[4]There may be additional reasons for equal division, including but not limited to complexity, social preferences, and focal points. When pairwise equal division is not in the core, inequality aversion may prohibit people from forming a pair. For example, in the marriage market, a man and a woman who divide their joint surplus unequally may consider the division unfair and choose to end the relationship, even if they cannot do better by matching with someone else. This phenomenon can be explained by inequality aversion, as first introduced in the economics literature by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000).

with assortative efficient matching. These differences are stronger in wave 1 with time limits compared to wave 2 without time limits. In markets with equal splits in the core, most subjects propose equal division, and most accepted proposals feature equal division. In contrast, in other markets, equal division is neither commonly proposed nor commonly accepted. These results suggest that stable equal splits and assortative efficient matching may be important factors in determining matching and bargaining outcomes in TU matching markets.

To understand the pattern of proposals in all cases, we extend the bilateral bargaining model of Rubinstein (1982) to the matching market (similar to the setup of Rubinstein and Wolinsky (1990), but allowing for more general surplus configurations). This captures the dynamic bargaining process in our experimental design. We find that our noncooperative bargaining-in-matching model features a unique equilibrium when the delay frictions are sufficiently small, in contrast to the large theoretical core according to the canonical theory. Whenever the equal-splits outcome is in the core, it is also our noncooperative model's predicted outcome as frictions vanish, because each pair essentially engages in Rubinstein bargaining with their partner, as outside options do not influence their bargaining outcomes in equilibrium. This result helps explain without behavioral assumptions the widespread observation of equal-splits.[5] When equal-splits is not in the core, outside threats influence players' bargaining power with their partners. Our noncooperative model incorporates these outside options and predicts that the unique equilibrium does not coincide with equal-splits as fictions vanish.

In the experiment, subjects who are efficiently matched tend to arrive at certain bargaining outcomes in the core. Average experimental payoffs largely coincide with the payoffs in the unique equilibrium of our noncooperative model as friction vanishes. In comparison, existing single-valued and set-valued refinements of the core do not systematically match the experimental payoffs.

Finally, we investigate imbalanced matching markets by duplicating the agent with the lowest bargaining power in each of the four balanced markets, resulting in three agents on one side and four agents on the other.[6] According to the canonical theory, competition between the two duplicate agents would be expected to drive down their payoffs, even to zero. However, in the experiment, their payoffs rarely (in less than 1% of instances) reach zero in the experiment. In fact, in wave 1, their payoffs often do not differ much from their payoffs in the balanced markets, as if there was no competition. Even when their payoffs are lower than their payoffs in the balanced markets, they are significantly above zero. Our noncooperative model has a continuum of equilibria that can explain these experimental observations: (i) a class of competitive equilibria in which competitors get (near) zero payoffs, (ii) a class of noncompetitive equilibria in which there is essentially no competition between competitors, and (iii) a class of partially competitive equilibria in which competitors receive positive payoffs between the payoffs in the previous two classes

[5] Recent papers by Elliott and Nava (2019) and Talamàs (2020) take a noncooperative approach to model matching markets but consider different bargaining protocols and agent replenishment in the market. Both papers reach similar conclusions regarding the stability of the equal-splits outcome in markets with it in the core.

[6] A prominent application of imbalanced markets is a marriage market with an imbalanced sex ratio, in which low-income men tend to compete for wives. For example, Wei and Zhang (2011) find that the rising sex ratio in China can explain the increasing saving rates because Chinese parents with sons raise their savings competitively to increase their sons' attractiveness in the marriage market. Another application is the labor market, in which low-skill workers, who are easy substitutes of one another, compete to be employed and receive low wages (Katz and Murphy, 1992).

of equilibria. The noncompetitive and partially competitive equilibria are sustained by the credible threat that agents would fully compete if one deviates from the equilibrium. Such an equilibrium is not sustained in balanced markets, but is sustained in imbalanced markets because the threat to drive a competitor's payoff to zero is credible as part of the stable outcome only in the imbalanced markets. These findings are largely consistent across the two waves of experiments, with slightly more zero payoffs in wave 2.

Most matching experiments focus on nontransferable-utilities (NTU) matching models, following Gale and Shapley (1962), and take a market-design perspective to understand the stability, efficiency, and strategyproofness of different algorithms implemented by a central clearing house. Roth (2015) and Hakimov and Kübler (2019) provide recent surveys on this topic. A few studies consider decentralized NTU markets in which both sides can make offers, such as Echenique and Yariv (2013); Chen et al. (2015); and Pais et al. (2020). Experimental studies of trading markets (Hatfield et al., 2012, 2016; Plott et al., 2019) have also found that, in the absence of a competitive equilibrium, markets tend to conform to stable outcomes predicted by theory (Kelso and Crawford, 1982; Hatfield et al., 2013).

Several experiments test the TU matching model. Nalbantian and Schotter (1995) set up an experiment mimicking baseball free agency with three "managers" and three "players" negotiating salaries via phone, which effectively creates a decentralized TU matching market with incomplete information. In their experiment, subjects do not have complete information on the matching surpluses, and they negotiate through phone calls to reach permanent agreements. In contrast, our experimental subjects have complete information on the matching surpluses and make offers that are first temporarily accepted, which reduces matching frictions. In addition, the negotiation process in our experiment is more structured than theirs, which allows us to obtain rich information on the details of the subjects' proposals and their decisions to accept or reject. Otto and Bolle (2011) study the final outcome of six different 2-by-2 matching markets with price negotiation and verbal communication. In contrast, we focus on decentralized two-sided matching markets that do not feature verbal negotiation, but allow negotiation through the strategic acceptance/rejection of competing offers from potential matches. This enables us to document subjects' behavior during the negotiation process. Furthermore, the focus on more than two agents on both sides allows us to have nonassortative efficient matching patterns that cannot be captured by 2-by-2 markets. Dolgopolov et al. (2020) study a 3-by-3 assignment matching market and investigate the market outcomes under three institutions (double auctions, posted prices, and decentralized communication), which are different from ours. They find that Nash outcomes are commonly observed under double-auction rules, though efficient outcomes are not always achieved; however, markets with communication achieve higher efficiencies on average. Agranov and Elliott (2021) consider three 2-by-2 markets, but in their decentralized bargaining process, if a pair is matched, both players leave the market (mimicking the theoretical setup of Elliott and Nava (2019)). Hence, the incentives in their setting differ from ours. Agranov et al. (2022) compare matching under complete and incomplete information and find that incomplete information and submodularity jointly hinder the efficiency and stability of matching. However, their comparison is focused on two assortative markets with and without equal-splits in the core. We instead consider eight different markets with complete information, which allows us to examine the role of assortativity, equal-splits in the core, and imbalance on subjects' matching patterns.

The experimental literature on imbalanced markets is scarce. Leng (2020) conducts experiments on 2-by-1 markets using the bargaining protocol of Perry and Reny (1994) that supposedly achieves the core outcome and finds that, contrary to the theoretical prediction but similar to the experimental results of our 3-by-4 markets, the core outcome is not achieved, meaning that agents on the short side of the market do not fully capture the entire surpluses from trade.

In summary, our paper is distinct from other papers in several ways and provides a comprehensive study of balanced and imbalanced matching markets. Overall, our paper contributes to the literature in three ways. First, we manipulate market configurations to investigate the impact of two features—equal-splits in the core and assortativity—on matching and bargaining outcomes. Second, our findings show that agents tend to achieve certain bargaining outcomes in the core in balanced matching markets, and our noncooperative model features a unique equilibrium that aligns with these outcomes. Third and finally, we find that agents can achieve a range of bargaining outcomes both inside and outside the core in imbalanced matching markets, which our noncooperative model helps rationalize such multiplicities.

The remainder of the paper is organized as follows. Section 2 presents definitions and testable implications of the canonical TU matching model. Section 3 introduces the experimental design, procedures, and hypotheses. Section 4 presents experimental results on matching and bargaining outcomes. Section 5 discusses our noncooperative model and its fit with balanced and imbalanced markets in the experiment. Section 6 discusses other experimental results, and Section 7 concludes.

2 Canonical cooperative theory

We briefly go over the canonical cooperative TU matching model based on Shapley and Shubik (1972) and Becker (1973) to define notations and terminologies and to introduce its main testable implications. There are two sides consisting of n_M men, $M = \{m_1, \cdots, m_{n_M}\}$, and n_W women, $W = \{w_1, \cdots, w_{n_W}\}$. The entire set of players is denoted by $I = M \cup W$. We say a market is **balanced** if $n_M = n_W$ and **imbalanced** otherwise. For any man $m \in M$ and woman $w \in W$, they produce a total surplus of s_{mw}. The surpluses of all pairs can be summarized by a surplus matrix $s = \{s_{mw}\}_{m \in M, w \in W}$. Each agent gets zero when unmatched, and gets a payoff that depends on the division of the surplus when matched. Note that the surplus matrix s describes the entire market, so we can refer to a matching market simply by s.

Definition 1 (Stable outcome). *A* **stable outcome** *of market s is described by a* **stable matching** $\mu : I \to I \cup \{\emptyset\}$ *and vectors of* **stable/core payoffs** $u : M \to \mathbb{R}$ *and* $v : W \to \mathbb{R}$ *such that (i) (individual rationality) each person gets at least as much as staying single:* $u_m \geqslant 0$ *for all* $m \in M$ *and* $v_w \geqslant 0$ *for all* $w \in W$*; (ii) (surplus efficiency) each couple exactly divides up the surplus:* $u_m + v_w = s_{mw}$ *if* $m = \mu(w)$ *and* $w = \mu(m)$*; and (iii) (no blocking pair condition) each couple divides the total surplus in such a way that no man and woman pair has an incentive to form a new pair:* $u_m + v_w \geqslant s_{mw}$ *for any* $m \in M$ *and* $w \in W$*.*

There is always a stable outcome in the TU matching model, which serves as a benchmark theoretical prediction for each matching market. Stable matching and payoffs satisfy some easily testable properties, which we summarize below.

Proposition 1 (Stable matching)**.** *A matching is stable if and only if it is efficient; that is, it maximizes the total surplus. Equivalently, a matching μ is stable if and only if it is the solution to the linear programming problem $\max_{\mu \in \mathcal{M}} \sum_{m \in M} s_{m\mu(m)}$, where $\mathcal{M}$ is the set of feasible matching.*

Corollary 1 (Full matching)**.** *If every element in the surplus matrix is positive, a stable matching is a* **full matching***; that is, the number of matched pairs in the stable outcome reaches the maximal possible number.*

Corollary 2 (Efficient matching)**.** *If there is a unique efficient matching, this matching is the unique matching in the stable outcome.*

We say that man m is higher ranked than man m', i.e., $m > m'$, if $s_{mw} \geq s_{m'w}$ for any woman w with a strict inequality for some w; women's ranks are defined similarly. A key observation of Becker (1973) is that if surplus matrix s, after reordering according to rank, satisfies supermodularity, then a stable matching is positive-assortative, in that the highest ranked man is matched with the highest ranked woman, the second highest ranked man is matched with the second highest ranked woman, and the n^{th} highest ranked man is matched with the n^{th} highest ranked woman. To slightly abuse terminology for expositional convenience, we say that the surplus matrix is *assortative* if agents can be ranked and the matrix rearranged according to the ranks satisfies supermodularity. To formally define an assortative surplus matrix, we need to first define a reordered surplus matrix.

Definition 2 (Reordered surplus matrix)**.** *The surplus matrix $\widetilde{s}$ is a* **reordered surplus matrix** *of surplus matrix s if there exists a pair of permutations $\pi_M : M \to M$ and $\pi_W : W \to W$ such that $\widetilde{s}_{\pi_M(m)\pi_W(w)} = s_{mw}$ for any $m \in M$ and any $w \in W$.*

Definition 3 (Assortative surplus)**.** *Consider Condition (A) for a reordered matrix $\widetilde{s}$ of matrix s:*

$$\widetilde{s}_{mw} + \widetilde{s}_{m'w'} > \widetilde{s}_{mw'} + \widetilde{s}_{m'w} \quad \forall m, m' \in M \text{ and } w, w' \in W \text{ s.t. } m > m' \text{ and } w > w'. \tag{A}$$

A reordered matrix $\widetilde{s}$ is **positive-assortative** *(supermodular in Agranov et al. (2022)) if Condition (A) is satisfied and $\forall m, m' \in M, \forall w, w' \in W : m > m' \Rightarrow \widetilde{s}_{mw} \geq (\leq) \widetilde{s}_{m'w}$ and $w > w' \Rightarrow \widetilde{s}_{mw} \geq (\leq) \widetilde{s}_{mw'}$; or* **negative-assortative** *(submodular in Agranov et al. (2022)) if Condition (A) is satisfied and $\forall m, m' \in M, w, w' \in W : m > m' \Rightarrow \widetilde{s}_{mw} \geq (\leq) \widetilde{s}_{m'w}$, and $w > w' \Rightarrow \widetilde{s}_{mw} \leq (\geq) \widetilde{s}_{mw'}$. A matrix s is* **assortative** *if there exists a reordered matrix $\widetilde{s}$ that is positive-assortative or negative-assortative. A matrix s is* **nonassortative** *or* **mixed** *if it is not assortative.*

Proposition 2 (Stable/core payoffs)**.** *The set of stable payoffs (Becker, 1973), or equivalently the core (Shapley and Shubik, 1972), is the set of solutions of the following linear programming problem:*

$$\min \sum_{m \in M} u_m + \sum_{w \in W} v_w \quad \text{s.t. } u_m + v_w \geqslant s_{mw} \, \forall m \in M \text{ and } w \in W.$$

With a finite number of agents, there is always a nonsingleton set of stable payoffs (given a positive surplus matrix). An equal split of the surplus for each pair in the stable matching is not always in the core (as some surplus matrices chosen in the experiment will show).

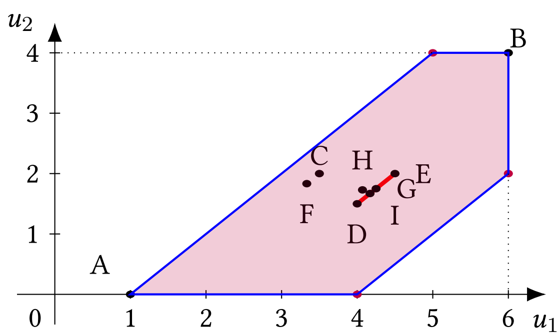
Definition 4 (Equal-splits in the core)**.** ***Equal-splits is in the core*** *(**ESIC**) of game s if there exists efficient matching μ^* such that payoffs $u_m = s_{m\mu^*(m)}/2$ for each matched $m \in M$ and $v_w = s_{\mu^*(w)w}/2$ for each matched $w \in W$. We say that* ***equal-splits is <u>not</u> in the core*** *(**ESNIC**) of game s otherwise.*

The core in general is a nonsingleton set. Many solutions refine the core, but differ in their predictions. See Núñez and Rafels (2015) for a summary of solution concepts. We illustrate with two examples. Consider a balanced market with two men $\{m_1, m_2\}$ and two women $\{w_1, w_2\}$ and an imbalanced market with three men $\{m_1, m_2, m_3\}$ and three women $\{w_1, w_2\}$. The surplus matrices are given by

$$s: \begin{array}{ccc} & w_1 & w_2 \\ m_1 & \underline{\underline{6}} & 5 \\ m_2 & 2 & \underline{\underline{4}} \end{array} \quad \text{and } s': \begin{array}{ccc} & w_1 & w_2 \\ m_1 & \underline{\underline{6}} & 5 \\ m_2 & 2 & \underline{4} \\ m_3 & 2 & \underline{4} \end{array}$$

By our definition, s is not an assortative surplus matrix because the two women are unranked. In this market, the unique stable matching μ^* is $\mu^*(m_1) = w_1$ and $\mu^*(m_2) = w_2$. The core satisfies $u_1 + v_1 = 6$, $u_1 + v_2 \geq 5$, $u_2 + v_2 = 4$, and $u_2 + v_1 \geq 2$, which is equivalent to two expressions containing only u_1 and u_2: $4 \geq u_1 - u_2$ and $u_1 - u_2 \geq 1$. Taking the individual rationality conditions together, we can depict the core on a graph with u_1 on the x-axis and u_2 on the y-axis. As shown in Figure 1, the entire shaded area is the core. Equal-splits of $u_1 = v_1 = 3$ and $u_2 = v_2 = 2$ is in the core. Refined solutions differ in this market.

Figure 1: Cooperative solutions for market $s = (6, 5; 2, 4)$



Note. All solutions predict efficient matching. The five points on the boundary are its extreme points (Shapley and Shubik, 1972). A at $(1, 0)$ is column-optimal allocation; B at $(6, 4)$ is row-optimal allocation; C at $(3.5, 2)$ is the fair division point (Thompson, 1980); line segment DE from $(4, 1.5)$ to $(4.5, 2)$ is the kernel (Rochford, 1984); F at $(10/3, 11/6)$ is Shapley (1953) value; G at $(17/4, 7/4)$ is the nucleolus (Schmeidler, 1969); H at $(61/15, 26/15)$ is the centroid of the core; and I at $(25/6, 5/3)$ is median stable matching (Schwarz and Yenmez, 2011).

The imbalanced market s' is generated by adding m_3, a replica of m_2, to the previous balanced market s. In this new market, there is no unique stable matching because w_2 matches with either m_2 or m_3 in efficient matching. Consider the stable matching $\widetilde{\mu}$ that retains the unique stable matching μ^* of the balanced market s in the previous example: $\widetilde{\mu}(m_1) = w_1$ and $\widetilde{\mu}(m_2) = w_2$, $\widetilde{\mu}(m_3) = \emptyset$. The core of the imbalanced market satisfies $u_1 + v_1 = 6$, $u_1 + v_2 \geq 5$, $u_2 + v_2 = 4$, $u_2 + v_1 \geq 2$ and three new conditions: $u_3 + v_1 \geq 2$, $u_3 + v_2 \geq 4$, and $u_3 = 0$. These conditions pin down $u_1 \in [1, 4]$ and $u_2 = 0$, which correspond to the bottom line of the shaded area (the core of the balanced market) in Figure 1. In general, introducing an additional player to the market shrinks the core. Competition between m_2 and m_3 not only drives m_2's core payoff to 0, but also restricts the set of core payoffs for m_1.

3 Experiment

In this section, we present the experimental design and procedures for the first wave of the experiment. The second wave will be introduced in Section 4.1.2.

3.1 Treatment design

We use eight surplus configurations, as shown in Table 1. Each surplus configuration represents a different matching market. The four markets shown on the left-hand side of Table 1 are balanced, and the four on the right-hand side are imbalanced. The row players are represented by cold color squares and the column players are represented by warm color circles. In the experiment, we use squares and circles of different colors and do not index the subjects. In the exposition, we refer the row players as men and the column players as women. For example, m_1 represents the first square.

Table 1: Surplus configurations in the experiment

Market	Core	Efficient matching	Configuration		w_1	w_2	w_3	w_4
Balanced markets (6 players)	ESIC	Assortative	EA6	m_1	$\underline{\underline{30}}$	40	50	
				m_2	40	$\underline{\underline{60}}$	80	
				m_3	50	80	$\underline{\underline{110}}$	
Balanced markets (6 players)	ESNIC	Assortative	NA6	m_1	90	80	$\underline{\underline{70}}$	
				m_2	80	$\underline{\underline{60}}$	40	
				m_3	$\underline{\underline{70}}$	40	10	
Balanced markets (6 players)	ESIC	Mixed	EM6	m_1	30	$\underline{\underline{60}}$	80	
				m_2	60	70	$\underline{\underline{100}}$	
				m_3	$\underline{\underline{40}}$	40	60	
Balanced markets (6 players)	ESNIC	Mixed	NM6	m_1	90	$\underline{\underline{60}}$	30	
				m_2	$\underline{\underline{100}}$	50	30	
				m_3	80	60	$\underline{\underline{40}}$	
Unbalanced markets (7 players)	ESNIC	Assortative	EA7	m_1	$\underline{30}$	40	50	$\underline{30}$
				m_2	40	$\underline{\underline{60}}$	80	40
				m_3	50	80	$\underline{\underline{110}}$	50
Unbalanced markets (7 players)	ESNIC	Assortative	NA7	m_1	90	80	$\underline{70}$	$\underline{70}$
				m_2	80	$\underline{\underline{60}}$	40	40
				m_3	$\underline{\underline{70}}$	40	10	10
Unbalanced markets (7 players)	ESNIC	Mixed	EM7	m_1	30	$\underline{\underline{60}}$	80	30
				m_2	60	70	$\underline{\underline{100}}$	60
				m_3	$\underline{40}$	40	60	$\underline{40}$
Unbalanced markets (7 players)	ESNIC	Mixed	NM7	m_1	90	$\underline{\underline{60}}$	30	30
				m_2	$\underline{\underline{100}}$	50	30	30
				m_3	80	60	$\underline{40}$	$\underline{40}$

Assortative: Efficient matching is assortative; Mixed: Efficient matching is not assortative; ESIC: equal-splits in the core; ESNIC: equal-splits not in the core. In the balanced markets, the double-underlined surpluses in each configuration show the pairings in the unique efficient matching. In the unbalanced markets, the double-underlined surpluses in each configuration show the pairings that are for sure part of efficient matching, and each of the two single-underlined surpluses in each configuration constitutes the last pair of efficient matching.

In the balanced markets, the double-underlined surpluses in each configuration show the pairings in the unique efficient matching. We vary the configurations in two dimensions: (i) whether efficient matching is assortative, as defined in Definition 3, and (ii) whether equal-splits is in the core, as defined in Definition 4. Hence, each market (i) has equal-splits in the core (ESIC, or simply E) or equal-splits not in the core (ESNIC, or simply N) and (ii) is assortative (A) or mixed (M). We refer to the four configurations by EA6, EM6, NA6, and NM6. We also design the surpluses to provide consistency across markets: The maximum total surplus that all agents can obtain is 200, the average total surplus that all agents can obtain is 180 if they are matched fully and randomly, and the minimum total surplus they can obtain if they are all matched is 160.

The only difference between imbalanced and balanced markets is that there is one more warm color (circle) player in each imbalanced market. Specifically, each of the four surplus matrices replicates the column player that yields the lowest surplus in the corresponding balanced market setting. Though equal-splits is no longer in the core (because the duplicate players would get zero in the core), we refer to the four markets by EA7, NA7, EM7, and NM7, to clarify the connection with their balanced market counterpart.

We employ a between-subject design for the balanced and imbalanced markets, and a within-subject design for the four different configurations of each market type. That is, subjects play either the four balanced markets or the four imbalanced markets, but they play the four markets in different orders. Using the Latin square method,[7] for balanced and imbalanced markets, we each have four treatment orders:

	1	2	3	4
Treatment 1	EA	NA	EM	NM
Treatment 2	NM	EA	NA	EM
Treatment 3	EM	NM	EA	NA
Treatment 4	NA	EM	NM	EA

At the beginning of the experiment, subjects are randomly selected to form a group (of six or seven), and this grouping remains fixed throughout the experiment. They stay anonymous, and their roles can change from round to round. Subjects within a group play the four markets in the order corresponding to their assigned treatment. Each market is played for 7 rounds, so they play 28 rounds in total.[8] At the beginning of each round, each subject is randomly assigned a color that represents their role. A cold color (square) can only be matched with a warm color (circle). Each market lasts at least 3 minutes. Within the 3-minute interval, anyone can propose to anyone on the opposite side. To propose, a subject clicks the color they wish to propose to, and decides the division of surplus. The receiver of a proposal has 30 seconds to accept or reject. When the proposer is waiting for the response, the proposer cannot make a new proposal to anyone. If a proposal is rejected, both sides are free to make and receive new offers.

If a proposal is accepted, a temporary match is reached; information on the temporary match and division of the surplus is shown to everyone in the market. When a temporary match is reached, both subjects can still make and receive proposals. One can always break their current temporary match by reaching a new temporary match (either by proposing to a new person and being accepted, or by accepting another proposal). A market ends at the 3-minute mark and all temporary matches become permanent, unless someone gets released from a temporary match in the last 15 seconds; in that case, they have 15 additional seconds to make a new proposal. If another subject is bumped from their temporary match as a result of the new proposal, the bumped subject gets a chance to make a proposal. This process of adding 15 additional seconds continues until no new proposal is accepted. Subjects can see the history of final matches in previous rounds.[9]

[7] We thank Yan Chen for this suggestion.

[8] One reason we choose 7 rounds for each market is to ensure an ex ante equal opportunity for subjects in the imbalanced-markets setting, as one of 7 subjects is for sure unmatched and gets zero payoff in each round.

[9] To be clear, historical information is based on roles (squares and circles) but not on individual experimental subjects, so there is no way to establish a bargaining style or reputation across periods. Subjects may learn better the overall structure of the game over time and consequently perform better (as suggested by the experimental results), but they cannot learn about any particular individual over time.

3.2 Procedures

The experiment was conducted at the Shanghai University of Finance and Economics. Chinese subjects were recruited from the subject pool of the Economics Lab through Ancademy, a platform for social sciences experiments; most subjects installed and used the app on their phones. In the first wave of our experiment, 296 subjects participated: 156 in the balanced markets and 140 in the imbalanced markets. Each subject participated only once. We ran 8 sessions for the balanced markets and 6 sessions for the imbalanced markets. In each session we ran 3–6 independent markets. For the balanced markets, the number of times each treatment order is used is 7, 7, 6, and 6, respectively, yielding 728 individual rounds of games. For the imbalanced markets, we used each treatment order 5 times, yielding 560 individual rounds of games. Subjects were mostly undergraduate students from various fields of studies.

The experiment was computerized using z-Tree (Fischbacher, 2007) and conducted in Chinese. Upon arrival, each subject was randomly assigned a card with their table number, and seated in the corresponding cubicle. Prior to the start of the experiment, subjects read and signed a consent form agreeing to their participation. All instructions were displayed on their computer screens. Control questions were conducted to check their understanding of the instructions. English translations of the instructions and screenshots are provided in Appendix A.

Subjects were paid the sum of their payoffs in 28 rounds at an exchange rate of 12 units of payoffs to 1 CNY in balanced markets. To keep the average earnings comparable between balanced and imbalanced markets, we lowered the exchange rate of the experimental currency from 12 to 10 in imbalanced markets. Everything else is kept the same as in the balanced market. After finishing the experiment, subjects received their earnings in cash. Average earnings were 85 CNY (equivalent to about 12 USD, or about 20 PPP-adjusted USD) for the balanced markets, and 93 CNY for the imbalanced markets (equivalent to about 14 USD, or about 23 PPP-adjusted USD). Each session lasted around 2 hours.

3.3 Discussion

We briefly discuss the rationale behind some elements of our design for the first wave of the experiment. First, we impose the 3-minute soft deadline primarily for practical purpose. In each experimental session, to ensure ex ante equal opportunity for subjects in imbalanced markets, each market type is played 7 rounds for a total of 28 rounds. If the average duration of each round is 3 minutes, we can control the entire duration of the experiment within 2 hours (including the time explaining the instruction and paying the subjects). Imposing a soft deadline inevitably creates some frictions. We change the game-ending rule in the second wave of the experiment to a 30-second inactivity rule, consistent with Agranov et al. (2022).

Second, we pay the subjects for every round for the fairness concern in the imbalanced markets. If we instead pay one random round, it would result in a zero payoff for at least one subject. Paying the sum of payoffs for all rounds with the feedback on earnings can potentially lead to income effects, which may push for equal-splits. Nevertheless, the problem is mitigated by varying the order of the games and we do see significant differences in how often the subjects end up with equal-splits in different markets. In the second wave of the experiment, we change the payment rule to paying randomly one round for each of the four configurations.

4 Results

In this section, we focus on the two most important aspects of the model: (i) the aggregate outcomes of matching and surplus and (ii) individual payoffs. We discuss other experimental findings in Section 6.

4.1 Aggregate outcomes: matching and surplus

4.1.1 Wave 1

Table 2a presents the raw distributions of matches and singles, where in each matrix, each cell not in the last row or column indicates the percentage (rounded to the nearest integer) of rounds with such a pair in the final matching outcome. The last row and column of each matrix show the percentage of rounds a player is single. We observe significant instances of singles and inefficient matches.

The canonical theory predicts (1) full matching (Corollary 1), (2) efficient matching and efficient surplus (Corollary 2), and (3) a stable matching and bargaining outcome (Proposition 1). We test these predictions in a few different ways with different measures of these outcomes. We state the hypotheses below.

Hypothesis 1 (Full matching)**.** *(a) The number of matched pairs is the maximum feasible number; (b) Full matching is always achieved.*

Row 1a of Table 2b shows the average number of matched pairs by market type. It ranges from 2.43 in NM6 to 2.93 in EA7. For each of the eight market types, we can reject the hypothesis that the maximal number of matched pairs is reached. We observe comparable results in previous experiments. Nalbantian and Schotter (1995) consider a 3-by-3 market with equal-splits in the core and nonassortative efficient matching (i.e., a market of type EM6). In their experiment, 9.3% (14 of 150 potential matches) fail to match, which translates to 2.79 pairs, compared with 2.76 pairs in our experiment's EM6 market.

Nonetheless, the market does not completely break down. Row 1b of Table 2b shows the proportion of full matching by market type. It ranges from 45% in NM6 to 94% in EA7. For every market type except NM6, three pairs are matched in over 60% of the rounds. In almost all games, there are more than two matched pairs. There is one matched pair in three of the 1,288 games (less than 0.3% of all games): two NM6 games of the 728 balanced market games and one EA7 game of the 560 imbalanced market games. The existence of unmatched individuals suggests that there are still frictions present in our experimental design that prevent people from being fully matched. In our further discussion section, we take a detailed look at the behavior of unmatched individuals in the experiment and break down the possible reasons that they remain unmatched.

In a frictionless setting, we should expect that efficient matching—even if it is not unique—is reached 100% of the time. It goes without saying that this prediction is rejected with the observation that some subjects do not match. Hence, we also test a more restrictive hypothesis: Some subjects may remain unmatched—and we remain agnostic about the reason—but when the maximum feasible number of matches is reached, the cooperative model predicts efficient matching.

Hypothesis 2. *(a) The number of efficiently matched pairs is the maximum feasible; (b) Efficient matching is always achieved; (c) Efficient surplus is achieved. These hypotheses also hold conditional on full matching.*

Table 2: Aggregate outcomes: wave 1

(a) Frequency of being matched and unmatched in the experiment: wave 1

EA6

	w_1	w_2	w_3	$\emptyset$
m_1	86%	5%	3%	6%
m_2	8%	82%	4%	5%
m_3	3%	7%	86%	4%
$\emptyset$	3%	5%	8%	

NA6

	w_1	w_2	w_3	$\emptyset$
m_1	4%	22%	68%	6%
m_2	26%	51%	8%	15%
m_3	66%	10%	5%	18%
$\emptyset$	3%	17%	19%	

EA7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	53%	1%	1%	44%	1%
m_2	8%	72%	6%	9%	4%
m_3	0%	11%	88	0%	1%
$\emptyset$	39%	16%	5%	47%	

NA7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	1%	9%	46%	42%	1%
m_2	16%	59%	8%	9%	8%
m_3	76%	9%	0%	1%	14%
$\emptyset$	6%	23%	46%	47%	

EM6

	w_1	w_2	w_3	$\emptyset$
m_1	1%	80%	9%	11%
m_2	6%	9%	80%	5%
m_3	87%	3%	2%	8%
$\emptyset$	7%	8%	9%	

NM6

	w_1	w_2	w_3	$\emptyset$
m_1	23%	41%	9%	27%
m_2	69%	6%	8%	17%
m_3	7%	43%	38%	12%
$\emptyset$	2%	10%	45%	

EM7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	0%	83%	11%	0%	6%
m_2	9%	4%	74%	8%	4%
m_3	51%	1%	0%	44%	3%
$\emptyset$	39%	11%	15%	48%	

NM7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	23%	56%	6%	4%	11%
m_2	71%	2%	3%	4%	20%
m_3	1%	23%	32%	39%	5%
$\emptyset$	4%	19%	59%	54%	

Note. In each table, each cell not in the last row or column indicates the percentage of markets in which a pair has formed between the row player and column player. The last row contains the percentage of markets in which each respective column player is unmatched, and the last column contains the percentage for each row player.

(b) Tests of hypotheses on aggregate outcomes: wave 1

	EA6	EM6	NA6	NM6	EA7	EM7	NA7	NM7
1a: # matched pairs=3	2.84***	2.76***	2.61***	2.43***	2.93*	2.86***	2.78***	2.64***
	(4.00)	(5.59)	(8.03)	(14.74)	(2.52)	(4.79)	(4.61)	(8.18)
1b: full matching=1	0.84***	0.76***	0.61***	0.45***	0.94*	0.86***	0.78***	0.64***
	(4.00)	(5.59)	(8.03)	(14.82)	(2.65)	(4.79)	(4.61)	(8.18)
2a: # efficiently matched pairs=3	2.54**	2.47***	1.85***	1.48***	2.56***	2.53***	2.23***	1.99***
	(3.44)	(4.73)	(10.57)	(20.03)	(5.36)	(5.64)	(7.92)	(11.97)
2b: efficient matching=1	0.76***	0.69***	0.41***	0.25***	0.71***	0.69***	0.55***	0.46***
	(4.14)	(5.81)	(11.14)	(22.05)	(5.51)	(6.01)	(8.64)	(10.81)
2c: % surplus achieved=1	0.95***	0.92***	0.88***	0.85***	0.95***	0.92***	0.91***	0.87***
	(4.53)	(5.69)	(8.50)	(14.17)	(3.94)	(5.42)	(5.85)	(8.57)
2a': # efficiently matched pairs=3	2.67*	2.77*	2.32***	2.01***	2.64***	2.71***	2.48***	2.39***
given full matching	(2.39)	(2.46)	(5.60)	(6.23)	(5.10)	(4.43)	(5.95)	(5.73)
2b': efficient matching=1	0.86*	0.88*	0.68***	0.58***	0.75***	0.80***	0.69***	0.66***
given full matching	(2.62)	(2.46)	(5.69)	(6.17)	(5.60)	(3.90)	(6.80)	(5.33)
2c': % surplus achieved=1	0.99*	1.00**	0.98***	0.97***	0.97***	0.97**	0.96***	0.96***
given full matching	(2.46)	(3.23)	(4.51)	(5.43)	(5.78)	(2.93)	(4.38)	(4.60)
3a: stable outcome=1	0.71***	0.52***	0.07***	0.05***	0.00	0.00	0.00	0.00
	(5.17)	(9.21)	(47.22)	(53.96)	(.)	(.)	(.)	(.)
3b: stable10 outcome=1	0.76***	0.69***	0.39***	0.22***	0.40***	0.09***	0.13***	0.35***
	(4.14)	(5.64)	(11.28)	(24.44)	(11.02)	(34.94)	(28.18)	(13.23)
3a': stable outcome=1	0.80***	0.66***	0.10***	0.12***	0.00	0.00	0.00	0.00
given full matching	(3.77)	(6.12)	(31.59)	(22.23)	(.)	(.)	(.)	(.)
3b': stable10 outcome=1	0.86*	0.87*	0.64***	0.53***	0.41***	0.10***	0.15***	0.50***
given full matching	(2.62)	(2.37)	(5.76)	(7.02)	(10.92)	(31.83)	(23.48)	(7.10)
3a": stable outcome=1	0.93**	0.73***	0.14***	0.22***	0.00	0.00	0.00	0.00
given efficient matching	(3.12)	(5.26)	(20.08)	(10.16)	(.)	(.)	(.)	(.)
3b": stable10 outcome=1	1.00	0.96	0.90	0.90*	0.54***	0.13***	0.22***	0.73**
given efficient matching	(.)	(1.00)	(1.70)	(2.43)	(6.98)	(24.48)	(14.99)	(3.62)
clusters	26	26	26	26	20	20	20	20

Stars indicate statistically significant differences between canonical theoretical predictions and experimental observations: * $p<0.05$, ** $p<0.01$, *** $p<0.001$; t statistics in parentheses; standard errors clustered at the group level

Rows 2a-2c and 2a'-2c' of Table 2b test these hypotheses. Row 2a shows that the number of efficiently matched pairs ranges from 1.48 in NM6 to 2.56 in EA7, far from the maximum number of 3. Row 2b provides a breakdown of the types of matching with respect to the number of efficiently matched and inefficiently mismatched pairs. In all market types except NA6 (41.2%), NM6 (24.7%) and NM7 (46.4%), efficient matching is achieved in the majority of rounds. Row 2c shows that the efficiency loss due to inefficient matches is statistically significant: The total surplus achieved is 92% (EM6 and EM7) to 95% (in EA6 and EA7) in markets with equal-splits in the core, and 85% (in NM6) to 91% (NA7) in markets without equal-splits in the core.

We then study efficient matching conditional on full matching. Not all matched pairs in full matching are efficiently matched (Row 2a'): The number is between 2.01 in NM6 and 2.77 in EM6, still significantly lower than 3. Given full matching, efficient matching is achieved in 75% to 88% of rounds in markets with equal-splits in the core, and in 58% to 69% of rounds in markets without equal-splits in the core. The average surplus in these markets given full matching is high: 96% to 99%. Recall that in balanced markets, when the maximum number of pairs is achieved, the minimum surplus is 80% and a random full matching generates 90% of the maximum surplus. Despite a high total surplus as long as matched, the inequality in individual outcomes is large, so that agents continue to have large incentives to negotiate.

An outcome is stable when not only the matching is efficient, but also the combination of individual payoffs derived from pairwise surplus division is in the core. Hence, reaching a stable outcome—efficient matching along with a stable division of surpluses—is more stringent than achieving efficient matching. Because the payoffs are transferable, the matching in any stable outcome is necessarily efficient.

Hypothesis 3. *A stable outcome is achieved (a) unconditionally, (a') conditional on full matching, and (a") conditional on efficient matching. A stableX outcome—an outcome in which no pair of agents can improve their joint payoffs by more than X units—is achieved (b) unconditionally, (b') conditional on full matching, and (b") conditional on efficient matching.*

Row 3a" of Table 2b shows the probability that an outcome is stable, given efficient matching. In EA6 and EM6—the balanced ESIC markets—in the vast majority of cases, when subjects match efficiently, they also divide up the surplus in a way that cannot be improved upon by any blocking pair (93% and 73%, respectively). However, in NA6 and NM6—the balanced ESNIC markets—efficient matching is achieved less frequently, and even when it is achieved, blocking pairs are more likely to exist. Strictly speaking, only 14% of NA6 markets and 22% of NM6 markets do not have any blocking pair. These markets have blocking pairs that can modestly improve their payoffs (Row 3b"): 90%-14%=76% of NA6 markets and 90%-22%=68% of NM6 markets have blocking pairs that can improve by fewer than 10 units of payoff.

In our imbalanced markets, stable outcomes always involve a matched subject and an unmatched subject who get zero payoff. Strictly speaking, a stable outcome is not reached in any imbalanced markets in wave 1 of our experiment, because no matched subject receives zero. Even with a looser definition of stability, a significant portion of imbalanced markets have blocking pairs that can improve by more than 10 units of payoff, but they do not form a match by the end of the game. This significant discrepancy between theory and experiment in stable payoffs suggests that players are behaving in a way that is systematically different from what the cooperative theory predicts.

4.1.2 Wave 2

The results in Section 4.1.1 show that the matching rate and the efficiency rate are significantly different from 100%. One plausible reason for this could be that some subjects may not have enough time to react and form new matches after they are released by the end of the three minutes, even with the additional 15 seconds provided. To make sure that frictions created by the ending rule do not drive our main findings on matching patterns and surplus divisions, we run an additional wave of experiment with an alternative ending rule as a robustness check.

In wave 2 of the experiment, we use the same eight surplus configurations as in wave 1. We again employ a between-subject design for the balanced and imbalanced markets, and a within-subject design for the four different configurations of each market type. The main design difference lies in the ending rule: In wave 2, the market ends when there are no new proposals made within 30 seconds.[10] This means that the market continues as long as it is active, and ends when there are no activities for a certain period of time. To adjust for the change in the ending rule, we make another change in the design: In wave 1, the receiver of a proposal has 30 seconds to accept or reject the proposal; in wave 2, we shorten the time to 15 seconds. This change is made to avoid a scenario where the market may end immediately if the receiver does not respond within the 30 seconds, leaving the proposer no time to make a new proposal. This scenario would create additional frictions in the market, so we aim to avoid it.

In addition to changing the ending rule, we also reduce the number of rounds for which subjects are paid in order to minimize the influence of income effects and coordination on surplus division. In wave 1, we pay the sum of payoffs for all rounds, but in wave 2, we only pay subjects four randomly selected rounds, one for each configuration. This helps to ensure that the results are not influenced by these factors.

The experiment was again conducted at the Shanghai University of Finance and Economics. In total, 130 subjects participated: 60 in the balanced markets and 70 in the imbalanced markets. Therefore, there were exactly 10 independent groups for each market type. Each subject participated only once, and have never participated in the wave 1 experiment. We ran 2 sessions for the balanced markets and 3 sessions for the imbalanced markets. Because markets tended to last longer in wave 2, we let subjects play 5 rounds instead of 7 rounds for each configuration, amounting to 20 rounds in total.[11] At the end of the experiment, subjects were paid four randomly selected rounds out of the total rounds they played at the exchange rate of 1 unit of payoff to 1 CNY. Average earnings were 140 CNY (equivalent to about 19 USD, or about 32 PPP-adjusted USD). On average, the sessions lasted two and half hours. The balanced markets took 3.5 minutes per market, and the imbalanced markets took 5.1 minutes per market.

Overall, the results of wave 2 confirm the main findings of wave 1, although the matching rate and efficiency rate are higher in wave 2. This is likely due to the change in the ending rule, which allows more time for subjects to react and form new matches after being released by the end of the three minutes. Despite this, the results of wave 2 show that the efficiency rate is still significantly lower than what is

[10]In the imbalanced market, to potentially shorten the market length, we added a “Move to the next round” button. If at least six out of seven players in the market press this button, the market also ends.

[11]In the balanced markets, initially we planned to let subjects play 28 rounds (7 rounds for each configuration). However, due to a technical mistake, subjects ended up playing 5 rounds for each of the four configurations, followed by 8 rounds of the fourth configuration. We dropped the observations of these last 8 rounds in our experimental analysis.

Table 2': Aggregate outcomes: wave 2

(a) Frequency of being matched and unmatched in the experiment: wave 2

EA6

	w_1	w_2	w_3	$\emptyset$
m_1	98%	0%	0%	2%
m_2	0%	96%	2%	2%
m_3	0%	2%	98%	0%
$\emptyset$	2%	2%	0%	

NA6

	w_1	w_2	w_3	$\emptyset$
m_1	6%	26%	68%	0%
m_2	30%	54%	16%	0%
m_3	64%	14%	10%	12%
$\emptyset$	0%	6%	6%	

EA7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	66%	6%	0%	26%	2%
m_2	6%	68%	16%	10%	0%
m_3	0%	16%	84%	0%	0%
$\emptyset$	28%	10%	0%	64%	

NA7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	0%	10%	48%	42%	0%
m_2	12%	66%	10%	12%	0%
m_3	86%	12%	2%	0%	0%
$\emptyset$	2%	12%	40%	46%	

EM6

	w_1	w_2	w_3	$\emptyset$
m_1	0%	96%	2%	2%
m_2	0%	2%	98%	0%
m_3	100%	0%	0%	0%
$\emptyset$	0%	2%	0%	

NM6

	w_1	w_2	w_3	$\emptyset$
m_1	16%	50%	22%	12%
m_2	82%	0%	8%	10%
m_3	0%	46%	48%	6%
$\emptyset$	2%	4%	22%	

EM7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	2%	82%	16%	0%	0%
m_2	10%	10%	73%	6%	0%
m_3	47%	0%	0%	53%	0%
$\emptyset$	41%	8%	10%	41%	

NM7

	w_1	w_2	w_3	w_4	$\emptyset$
m_1	2%	92%	2%	4%	0%
m_2	98%	0%	0%	0%	2%
m_3	0%	6%	50%	44%	0%
$\emptyset$	0%	2%	48%	52%	

Note. In each table, each cell not in the last row or column indicates the percentage of markets in which a pair has formed between the row player and column player. The last row contains the percentage of markets in which each respective column player is unmatched, and the last column contains the percentage for each row player.

(b) Tests of hypotheses on aggregate outcomes: wave 2

	EA6	EM6	NA6	NM6	EA7	EM7	NA7	NM7
1a: # matched pairs=3	2.96	2.98	2.88**	2.72**	2.98	3.00	3.00	2.98
	(1.00)	(1.00)	(3.67)	(3.77)	(1.00)	(.)	(.)	(1.00)
1b: full matching=1	0.98	0.98	0.88**	0.74**	0.98	1.00	1.00	0.98
	(1.00)	(1.00)	(3.67)	(3.88)	(1.00)	(.)	(.)	(1.00)
2a: # efficiently matched pairs=3	2.92	2.94	1.86***	1.80***	2.44**	2.54***	2.42***	2.84*
	(1.50)	(1.41)	(5.40)	(6.80)	(4.73)	(5.92)	(5.30)	(2.45)
2b: efficient matching=1	0.96	0.96	0.50***	0.44***	0.68**	0.71***	0.66***	0.92*
	(1.50)	(1.50)	(5.51)	(7.80)	(4.71)	(7.66)	(5.67)	(2.45)
2c: % surplus achieved=1	0.99	0.99	0.94***	0.91***	0.98**	0.96***	0.97**	0.99
	(1.12)	(1.17)	(5.93)	(4.90)	(3.50)	(5.59)	(3.58)	(1.46)
2a': # efficiently matched pairs=3	2.96	2.96	2.06**	2.16*	2.50**	2.54***	2.42***	2.88
given full matching	(1.00)	(1.00)	(4.19)	(2.92)	(4.25)	(5.92)	(5.30)	(1.96)
2b': efficient matching=1	0.98	0.98	0.57**	0.64*	0.70**	0.71***	0.66***	0.94
given full matching	(1.00)	(1.00)	(4.22)	(3.15)	(4.51)	(7.66)	(5.67)	(1.96)
2c': % surplus achieved=1	1.00	1.00	0.96*	0.98*	0.98**	0.96***	0.97**	1.00
given full matching	(1.00)	(1.00)	(3.19)	(2.73)	(3.66)	(5.59)	(3.58)	(1.96)
3a: stable outcome=1	0.86	0.74**	0.16***	0.02***	0.02***	0.00	0.04***	0.04***
	(2.09)	(3.88)	(11.70)	(49.00)	(49.00)	(.)	(24.00)	(36.00)
3b: stable10 outcome=1	0.96	0.96	0.42***	0.34***	0.58***	0.38***	0.40***	0.78*
	(1.50)	(1.50)	(6.33)	(8.34)	(6.68)	(6.15)	(7.61)	(3.16)
3a': stable outcome=1	0.88	0.76**	0.18***	0.05***	0.02***	0.00	0.04***	0.04***
given full matching	(1.77)	(3.76)	(9.87)	(19.00)	(49.00)	(.)	(24.00)	(36.00)
3b': stable10 outcome=1	0.98	0.98	0.48***	0.50**	0.60***	0.38***	0.40***	0.80*
given full matching	(1.00)	(1.00)	(5.34)	(4.39)	(6.21)	(6.15)	(7.61)	(2.74)
3a": stable outcome=1	0.90	0.77**	0.24***	0.06***	0.05***	0.00	0.04***	0.04***
given efficient matching	(1.46)	(3.66)	(7.39)	(17.00)	(19.00)	(.)	(24.00)	(36.00)
3b": stable10 outcome=1	1.00	1.00	0.82*	0.72	0.86*	0.51**	0.59**	0.85*
given efficient matching	(.)	(.)	(2.37)	(2.24)	(2.28)	(3.82)	(4.15)	(2.35)
clusters	10	10	10	10	10	10	10	10

Stars indicate statistically significant differences between canonical theoretical predictions and experimental observations: * p<0.05, ** p<0.01, *** p<0.001; t statistics in parentheses; standard errors clustered at the group level predicted by the cooperative theory. In addition, the results for stable outcomes are similar to those in wave 1, with a significant discrepancy between theory and experiment in the proportion of stable outcomes reached. These findings suggest that subjects are behaving in a way that is systematically different from what the cooperative theory predicts, regardless of the ending rule used.

The results of the second wave of the experiment are summarized in Table 2'. As shown in rows 1a and 1b, the number of matched pairs and the matching rate in most markets were not significantly different from 3 and 100%, respectively. However, in NA6 and NM6, the number of matched pairs and the matching rate were significantly lower than the predictions of the cooperative theory. In comparison, the number of matched pairs and the matching rate in NA6 and NM6 improved from wave 1 to wave 2 (from 2.61 pairs and 61% to 2.88 pairs and 88% in NA6, and from 2.43 pairs and 45% to 2.72 pairs and 74% in NM6). This improvement may be due to the change in the ending rule, which allowed more time for subjects to react and form new matches. Row 2c shows that the percentage of efficient surplus achieved ranged from 91% in NM6 to 99% in EA6 and EM6 in the balanced markets, and from 96% in EM7 to 99% in NM7 in the imbalanced markets. The percentage of efficient matching was not significantly different from 100% in EA6 and EM6 markets. However, inefficient matching was still prevalent in other markets, even when full matching was achieved. Overall, by imposing an indefinite ending rule and a higher stake per market, both the number of matched pairs and the percentage of efficient surplus achieved improved compared to wave 1. However, inefficient matching was not eliminated in ESNIC markets.

Rows 3a-3b" provide summary statistics on stable outcomes. Balanced ESIC markets (EA6 and EM6) have high frequencies of stable outcomes, but other markets do not (row 3a), and this pattern remains when we restrict our attention to full or efficient matching (rows 3a' and 3a"). When we consider a relaxation of stable outcomes to stable10 outcomes, most blocking pairs cannot improve their payoffs by more than 10 units, but there remains a significant portion of blocking pairs who could have jointly improved their payoffs more than 10 units. In the imbalanced markets, there are some occurrences (0-4%) of stable outcomes, meaning that some matched players get zero payoffs; in comparison, there was zero instance that matched players get zero in wave 1. However, matched players getting zero payoff, the unique core prediction, remains a rare occasion. The experimental finding that the two duplicate players on the longer side of the market do not have their payoffs driven to zero remains.

4.1.3 Determinants of aggregate outcomes

We vary the surplus configurations in the dimensions of whether stable matching is assortative and whether equal-splits is in the core, because we conjecture that in reality, the two dimensions may influence people's actual decisions in matching. Several papers report how strategic complexity affects plays in games. Bednar et al. (2012) demonstrate that the prevalent strategies in games that are less cognitively demanding are more likely to be used in games that are more cognitively demanding. Luhan et al. (2017) and He and Wu (2020) show that subjects may not use a certain efficient strategy due to its complexity, but instead settle on a simpler but inefficient strategy. Under nonassortative efficient matching, the stable matching pattern is less obvious. Hence, nonassortative matching—even when equal-splits is in the core—may be perceived as more complex to subjects and more cognitively demanding. Consequently, subjects may settle on inefficient matching patterns such as the ones on the diagonals or accept payoffs that are not supported in the core.

Equal-splits has been widely supported in the literature on bargaining experiments, especially when it is coupled with efficiency. Two arguments are commonly used to support equal-splits observed in the data: the focal point theory of Schelling (1960) and distributional social preferences (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000). When equal-splits is at odds with efficiency, there is mixed evidence on the trade-offs between the two; see Roth and Malouf (1979); Hoffman and Spitzer (1982); Roth and Murnighan (1982); Roth et al. (1989); Ochs and Roth (1989), Herreiner and Puppe (2010); Roth (1995); Camerer (2003); Anbarci and Feltovich (2013, 2018); Isoni et al. (2014); and Galeotti et al. (2018), among many others, on reporting and understanding equal-splits in bargaining experiments. In our experiment, efficiency is aligned with stable matching. Hence, when equal-splits is in the core, it does not conflict with efficiency. However, when it is not in the core, subjects will face trade-offs between equality and efficiency, which may negatively affect the rate of matching, the rate of stable matching, and overall efficiency.

Hypothesis 4. *For balanced markets, (i) the number of matched pairs, (ii) the number of efficiently matched pairs, and (iii) the percentage of efficient surplus achieved are the same (i) in assortative markets as in nonassortative markets, and (ii) in ESIC markets as in ESNIC markets.*

Tables 2b and 2'b provide the following comparisons of balanced markets that contradict the hypothesis. First, assortative markets (EA6 and NA6) have a higher number of matched pairs, a higher number of efficiently matched pairs, and a higher aggregate surplus than the nonassortative markets (EM6 and NM6). Second, ESIC markets (EA6 and EM6) have a higher number of matched pairs, a higher number of efficiently matched pairs, and a higher surplus than ESNIC markets (NA6 and NM6). We confirm the statistical significance of these comparisons for balanced markets by running the OLS regression:

$$y_i = \beta_1 \cdot \text{assortative}_i + \beta_2 \cdot \text{ESIC}_i + \beta_3 \cdot \text{assortative}_i \cdot \text{ESIC}_i + \beta_4 \cdot \text{round}_i + \beta_5 \cdot \text{order}_i + c + \varepsilon_g, \qquad (1)$$

where i indicates the index of the game (out of 728 balanced markets), y_i is the dependent variable ((log) number of matched pairs in game i, (log) number of efficiently matched pairs in game i, or (log) surplus in game i), assortative_i is an indicator of whether game i is assortative, ESIC_i is an indicator of whether game i has equal-splits in the core, round_i is the round (out of 7) the same market has been played, and order_i is the order (out of 4) the game is played in. The standard errors are clustered at the group level (recall 26 and 10 groups of subjects played balanced markets and 20 and 10 groups of subjects played imbalanced markets in waves 1 and 2, respectively).

Table 3 reports the regression results. Compared with other markets, ESIC markets have 9.56% (8.03%) more matched pairs, 38.7% (45.1%) more efficiently matched pairs, 7.78% (10.4%) more surplus in wave 1 (wave 2). In addition, ESIC markets are 31.7 percentage points (pp) (24.9 pp) more likely for full matching, 41.1 pp (52.9 pp) more likely for efficient matching, and 47.6 pp (72.3 pp) more likely for stable outcome in wave 1 (wave 2). The effects of ESIC are comparable across the two waves. The statistical significance is weaker in wave 2 partially due to a smaller sample size. Assortativity has a modest effect on matching and efficiency. Compared with nonassortative markets, assortative markets have 5.40% (4.84%) more matched

Table 3: Determinants of aggregate outcomes in balanced markets

(a) Determinants of outcomes in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	log (# matched pairs+1)	log (# efficiently matched pairs+1)	log surplus	whether full matching	whether efficient matching	whether stable outcome
ESIC	0.0956^{***}	0.387^{***}	0.0778^{**}	0.317^{***}	0.411^{***}	0.476^{***}
	(4.72)	(7.55)	(3.29)	(4.44)	(5.63)	(10.42)
assortative	0.0540^{***}	0.148^{**}	0.0411^{*}	0.172^{**}	0.162^{*}	0.0232
	(3.88)	(2.82)	(2.51)	(3.48)	(2.65)	(0.95)
ESIC*assortative	-0.0303	-0.135^{*}	-0.00706	-0.0893	-0.107	0.164^{*}
	(-1.48)	(-2.32)	(-0.31)	(-1.21)	(-1.32)	(2.51)
round	0.00490^{*}	0.0160^{*}	0.00847^{***}	0.0151^{*}	0.0285^{***}	0.0223^{**}
	(2.64)	(2.56)	(3.75)	(2.36)	(4.23)	(3.59)
order	0.0139^{*}	0.0257	0.0218^{**}	0.0450^{*}	0.0519^{*}	0.0438^{**}
	(2.66)	(1.77)	(3.23)	(2.56)	(2.24)	(2.87)
constant	1.167^{***}	0.682^{***}	5.032^{***}	0.269^{***}	0.0598	-0.153^{**}
	(66.68)	(12.22)	(201.44)	(4.86)	(0.81)	(-2.92)
observations	728	728	728	728	728	728
clusters	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Determinants of outcomes in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	log (# matched pairs+1)	log (# efficiently matched pairs+1)	log surplus	whether full matching	whether efficient matching	whether stable outcome
ESIC	0.0803^{**}	0.451^{***}	0.104^{**}	0.249^{**}	0.529^{***}	0.723^{***}
	(3.40)	(6.53)	(3.66)	(3.73)	(7.37)	(8.99)
assortative	0.0484^{*}	0.0157	0.0421	0.140^{*}	0.0600	0.140
	(2.70)	(0.17)	(1.64)	(2.33)	(0.58)	(2.02)
ESIC*assortative	-0.0629^{*}	-0.0441	-0.0549	-0.157	-0.0771	-0.0254
	(-2.61)	(-0.43)	(-1.68)	(-2.23)	(-0.65)	(-0.20)
round	0.00935	0.0291	0.00743	0.0325	0.0500^{*}	0.0400^{*}
	(1.60)	(1.80)	(1.04)	(2.03)	(3.12)	(2.81)
order	0.0159^{*}	0.0779	0.0199^{*}	0.0427^{*}	0.0427	0.0134
	(2.28)	(2.00)	(2.97)	(2.49)	(1.51)	(0.40)
constant	1.236^{***}	0.687^{***}	5.118^{***}	0.536^{***}	0.183	-0.134
	(37.69)	(7.76)	(208.98)	(5.50)	(1.62)	(-2.20)
observations	200	200	200	200	200	200
clusters	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

pairs, 14.8% (1.57%) more efficiently matched pairs, 4.11% (4.21%) more surplus, and 17.2 pp (14.0 pp) more full matching in wave 1 (wave 2). The instances of efficient matching and stable outcome modestly increase in assortative markets. Overall, effects of assortativity are weaker in wave 2, partially due to a smaller sample size and partially due to an increase in overall efficiency.

Learning mildly improves matching outcome. Each additional round of play of the same game is associated with 0.49% (0.94%) more matched pairs, 1.6% (2.91%) more efficiently matched pairs, and 0.85% (0.74%) more surplus, and each 7 rounds of play of other games ahead of the current game are associated with 1.99% (1.59%) more matched pairs and 2.18% (1.99%) more surplus in wave 1 (wave 2). These results are statistically significant at at least the 95% level in wave 1 (* in the tables), but are mostly not significant in wave 2. In the appendix, we provide robustness checks with alternative specifications of the regressions regarding the dependent variables (no log), rounds of plays, treatment effects, heterogeneous order effects. The results are consistent with those under our current specifications. We also test to see if having played any particular market would influence the subsequent outcomes of other markets. We find that there is no market that systematically influences the subsequent outcomes of other markets. In addition, we limit the analysis to only the first periods of the experiment or the first rounds of the markets, and the results for the first rounds are consistent with the full results.

Overall, for balanced markets, equal-splits in the core is a crucial determinant of efficient matches and surpluses; in comparison, assortativity plays a less important role. To a much less extent but at a statistically significant level, experience with the negotiation process slightly increases matching rate and efficiency, but the increase is not driven by a particular market type.

Furthermore, we consider the determinants of outcomes when both balanced and imbalanced markets are included. Table 4 presents the results for the following regression model:

$$\begin{aligned} y_i \quad = \quad & \beta_1 \text{assortative}_i + \beta_2 \text{ESIC}_i + \beta_3 \text{balanced}_i + \beta_4 \text{assortative}_i \text{ESIC}_i + \beta_5 \text{assortative}_i \text{balanced}_i \\ & + \beta_6 \text{round}_i + \beta_7 \text{round}_i \text{balanced}_i + \beta_8 \text{order}_i + \beta_9 \text{order}_i \text{balanced}_i + c + \varepsilon_g, \end{aligned} \tag{2}$$

where balanced_i indicates whether the market in game i is balanced.

ESIC increases the number of matched pairs by 9.56% (8.03%), the number of efficiently matched pairs by 38.7% (45.1%), and the surplus by 7.78% (10.4%) in wave 1 (wave 2), and it also increases instances of full matching, efficient matching, and stable outcome. Assortativity has mixed results. Controlling for other changes, assortativity increases the number of matches by 2.94% (0.03%), the number of efficiently matched pairs by 6.45% (-9.17%), and the surplus by 4.32% (-0.34%) in wave 1 (wave 2). The insignificance is particularly obvious in wave 2. Having one additional player increases the number of matches by 9.87% (15%), the number of efficient matches by 25.9% (51.2%), and the surplus by 7.46% (15.0%) in wave 1 (wave 2). Both waves show the significant effects of market thickness, and wave 2 is even more conspicuous. In wave 1, playing an additional round of any game (i.e., the round effect) increases the matching by 0.97%, efficient matching by 2.96%, and surplus by 1.30%, but the round and order effects disappear in wave 2.

In summary, including the imbalanced markets, equal-splits in the core continues to play a prominent role in determining matching and efficiency, and assortativity plays a lesser role, both statistically and

Table 4: Determinants of aggregate outcomes in balanced and imbalanced markets

(a) Determinants of outcomes in all markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	log (# matched pairs+1)	log (# efficiently matched pairs+1)	log surplus	whether full matching	whether efficient matching	whether stable outcome
ESIC	0.0956^{***}	0.387^{***}	0.0778^{**}	0.317^{***}	0.411^{***}	0.476^{***}
	(4.76)	(7.61)	(3.31)	(4.48)	(5.68)	(10.51)
assortative	0.0294^{**}	0.0645^{*}	0.0432^{*}	0.107^{**}	0.0536	$3.99e-15^{***}$
	(2.89)	(2.16)	(2.60)	(3.14)	(1.11)	(10.71)
balanced	-0.0987^{***}	-0.259^{**}	-0.0746	-0.319^{***}	-0.319^{**}	-0.153^{**}
	(-3.61)	(-3.16)	(-1.92)	(-3.61)	(-2.93)	(-2.95)
ESIC*assortative	-0.0303	-0.135^{*}	-0.00706	-0.0893	-0.107	0.164^{*}
	(-1.49)	(-2.34)	(-0.32)	(-1.22)	(-1.33)	(2.53)
assortative*balanced	0.0246	0.0835	-0.00210	0.0646	0.108	0.0232
	(1.44)	(1.39)	(-0.09)	(1.08)	(1.40)	(0.96)
round	0.00974^{***}	0.0296^{***}	0.0130^{***}	0.0326^{***}	0.0424^{***}	$1.56e-16^{**}$
	(4.70)	(5.05)	(4.72)	(4.78)	(4.26)	(3.27)
round*balanced	-0.00483	-0.0136	-0.00455	-0.0175	-0.0139	0.0223^{***}
	(-1.74)	(-1.60)	(-1.28)	(-1.88)	(-1.16)	(3.62)
order	0.00399	0.0217	0.00694	0.0129	0.0121	$-2.57e-15^{***}$
	(0.84)	(1.70)	(1.02)	(0.80)	(0.63)	(-6.53)
order*balanced	0.00990	0.00405	0.0149	0.0321	0.0398	0.0438^{**}
	(1.41)	(0.21)	(1.56)	(1.35)	(1.33)	(2.90)
constant	1.265^{***}	0.941^{***}	5.106^{***}	0.588^{***}	0.379^{***}	$5.16e-15^{**}$
	(59.79)	(15.53)	(170.27)	(8.51)	(4.72)	(3.29)
observations	1,288	1,288	1,288	1,288	1,288	1,288
clusters	46	46	46	46	46	46

t statistics in parentheses; standard errors clustered at the group level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Determinants of outcomes in all markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	log (# matched pairs)	log (# efficiently matched pairs+1)	log surplus	whether full matching	whether efficient matching	whether stable outcome
ESIC	0.0803^{**}	0.451^{***}	0.104^{**}	0.249^{**}	0.529^{***}	0.723^{***}
	(3.50)	(6.64)	(3.76)	(3.84)	(7.58)	(9.25)
assortative	0.0000332	-0.0917^{*}	-0.00339	0.000115	-0.145^{**}	0.0121
	(0.01)	(-2.68)	(-0.60)	(0.01)	(-2.96)	(0.43)
balanced	-0.150^{***}	-0.512^{***}	-0.150^{***}	-0.461^{***}	-0.577^{***}	-0.156^{*}
	(-4.64)	(-4.55)	(-5.35)	(-4.79)	(-3.92)	(-2.35)
ESIC*assortative	-0.0629^{*}	-0.0455	-0.0549	-0.157^{*}	-0.0771	-0.0254
	(-2.69)	(-0.45)	(-1.72)	(-2.29)	(-0.67)	(-0.21)
assortative*balanced	0.0484^{*}	0.109	0.0455	0.140^{*}	0.205	0.128
	(2.70)	(1.13)	(1.78)	(2.32)	(1.84)	(1.75)
round	-0.000719	0.0103	0.000223	-0.00250	0.00750	-0.01000
	(-0.44)	(0.98)	(0.07)	(-0.44)	(0.47)	(-1.84)
round*balanced	0.0101	0.0286	0.00721	0.0350^{*}	0.0425	0.0500^{**}
	(1.71)	(1.73)	(0.95)	(2.11)	(1.90)	(3.37)
order	0.0000189	0.0225	0.00182	0.0000659	0.0134	0.0105
	(0.03)	(1.46)	(0.84)	(0.03)	(0.50)	(1.13)
order*balanced	0.0159^{*}	0.0279	0.0181^{*}	0.0426^{*}	0.0293	0.00295
	(2.33)	(0.97)	(2.63)	(2.53)	(0.76)	(0.09)
constant	1.385^{***}	1.195^{***}	5.268^{***}	0.997^{***}	0.761^{***}	0.0228
	(269.34)	(17.97)	(356.45)	(55.77)	(7.79)	(0.74)
observations	399	399	399	399	399	399
clusters	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

quantitatively. Market thickness helps increase matching and efficiency. Robustness checks with alternative dependent variables and alternative specifications in the appendix reach similar conclusions.

4.2 Individual payoffs

We consider the individual payoffs when efficient matching is reached and compare them to existing solutions that refine the core. In imbalanced markets, the core predicts a zero payoff for a matched player on the longer side of the market who has the least bargaining power. We formally test whether the payoffs of these matched players are different from zero (Table 5). The tests demonstrate that the payoffs are all statistically significantly above zero. There are only a few instances in wave 2 in which a matched player gets a zero payoff. This inconsistency between the core and the experiment warrants further attention, which we address in our noncooperative model.

Table 5: T-tests for payoffs for matched players with predicted zero core payoffs in imbalanced markets

(a) T-tests for payoffs of matched players with zero core payoffs in unbalanced markets: wave 1

	data	theory	t-stat	df	CI
EA7w1	9.57	0	16.467***	19	8.43,10.71
EA7w4	8.23	0	15.022***	19	7.16,9.30
EM7w3	14.15	0	15.121***	19	12.31,15.98
EM7w4	14.62	0	22.240***	19	13.33,15.91
NA7w1	13.77	0	15.787***	19	12.06,15.47
NA7w4	13.87	0	17.056***	19	12.27,15.46
NM7w3	8.17	0	10.823***	18	6.69,9.65
NM7w4	7.82	0	10.267***	19	6.33,9.31

t statistics in parentheses; standard errors clustered at the group level
* p<0.05, ** p<0.01, *** p<0.001

(b) T-tests for payoffs of matched players with zero core payoffs in unbalanced markets: wave 2

	data	theory	t-stat	df	CI
EA7w1	5.06	0	7.652***	9	3.76,6.36
EA7w4	5.38	0	3.754**	8	2.57,8.19
EM7w3	9.07	0	5.959***	9	6.09,12.06
EM7w4	11.25	0	4.130**	9	5.91,16.58
NA7w1	7.75	0	5.170***	9	4.81,10.68
NA7w4	8.98	0	5.997***	9	6.05,11.92
NM7w3	2.91	0	4.222**	9	1.56,4.25
NM7w4	5.75	0	3.541**	9	2.57,8.94

t statistics in parentheses; standard errors clustered at the group level
* p<0.05, ** p<0.01, *** p<0.001

Tables 6 and 6' present t-tests between cooperative solutions and the experimental payoffs of balanced markets in waves 1 and 2, respectively. When the t-tests do not detect statistically significant differences, the solution is consistent with the experimental finding. Among single-valued solutions, we provide (1) the Shapley value, which assigns each player a payoff relative to how "important" that player is to overall surplus attainable (Shapley, 1953); (2) the nucleolus, the lexicographical center of core payoffs (Schmeidler, 1969); (3) the fair division point, the midpoint between the row- and column-optimal payoffs (Thompson, 1980); (4) the median stable matching, which gives each player their median payoff (Schwarz and Yenmez, 2011). Among these solutions, the nucleolus and median stable matching do not match the payoffs when the matching is efficient (except for EA6). The fair division point performs well in the balanced ESIC markets, but not in NM6 markets. The limit equilibrium values from the noncooperative game, which we present in the next section, match well with our experimental values across all markets.

5 Noncooperative theory

Existing cooperative solutions—either set-valued ones like the core or singleton-valued ones like the nucleolus—depart from the experimental results in systematic ways. To rationalize the individual payoffs

Table 6: T-tests for payoffs of matched players in efficient matching in balanced markets: wave 1

	wave 1 data	our model	Shapley vale (Shapley, 1953)	nucleolus (Schmeidler, 1969)	fair division (Thompson, 1980)	median stable matching (Schwarz & Yenmez, 2011)
EA6m1	15.1	15.0	18.2***	15.0	15.0	15.0
	(0.00)	(0.85)	(-36.31)	(0.85)	(0.85)	(0.85)
EA6m2	29.9	30.0	31.3***	30.0	30.0	30.0
	(0.00)	(-0.74)	(-10.60)	(-0.74)	(-0.74)	(-0.74)
EA6m3	55.0	55.0	50.5***	55.0	55.0	55.0
	(0.00)	(0.27)	(26.60)	(0.27)	(0.27)	(0.27)
EA6w1	14.9	15.0	18.2***	15.0	15.0	15.0
	(0.00)	(-0.85)	(-38.02)	(-0.85)	(-0.85)	(-0.85)
EA6w2	30.1	30.0	31.3***	30.0	30.0	30.0
	(0.00)	(0.74)	(-9.12)	(0.74)	(0.74)	(0.74)
EA6w3	55.0	55.0	50.5***	55.0	55.0	55.0
	(0.00)	(-0.27)	(26.07)	(-0.27)	(-0.27)	(-0.27)
EM6m1	31.2	30.0	31.8	32.5	30.0	32.2
	(0.00)	(1.31)	(-0.68)	(-1.40)	(1.31)	(-1.10)
EM6m2	48.5	50.0	45.7*	47.5	50.0	47.8
	(0.00)	(-1.24)	(2.44)	(0.89)	(-1.24)	(0.65)
EM6m3	19.8	20.0	21.8***	20.0	20.0	20.0
	(0.00)	(-0.60)	(-5.04)	(-0.60)	(-0.60)	(-0.60)
EM6w1	21.4	20.0	18.2*	20.0	20.0	20.0
	(0.00)	(1.15)	(2.60)	(1.15)	(1.15)	(1.15)
EM6w2	29.6	30.0	28.2***	27.5***	30.0	27.8***
	(0.00)	(-1.31)	(4.58)	(6.74)	(-1.31)	(5.84)
EM6w3	49.1	50.0	54.3***	52.5*	50.0	52.2*
	(0.00)	(-0.75)	(-4.20)	(-2.74)	(-0.75)	(-2.52)
NA6m1	48.0	50.0*	46.2*	55.0***	50.0*	55.0***
	(0.00)	(-2.63)	(2.51)	(-9.34)	(-2.63)	(-9.34)
NA6m2	30.2	30.0	31.3*	30.0	30.0	30.0
	(0.00)	(0.34)	(-2.50)	(0.34)	(0.34)	(0.34)
NA6m3	20.9	20.0	22.5**	15.0***	20.0	15.0***
	(0.00)	(1.71)	(-2.95)	(11.02)	(1.71)	(11.02)
NA6w1	47.8	50.0	46.2	55.0***	50.0	55.0***
	(0.00)	(-1.62)	(1.24)	(-5.35)	(-1.62)	(-5.35)
NA6w2	30.3	30.0	31.3*	30.0	30.0	30.0
	(0.00)	(0.53)	(-2.18)	(0.53)	(0.53)	(0.53)
NA6w3	22.4	20.0*	22.5	15.0***	20.0*	15.0***
	(0.00)	(2.10)	(-0.11)	(6.51)	(2.10)	(6.51)
NM6m1	29.1	30.0	28.0	17.5***	20.0***	18.3***
	(0.00)	(-1.55)	(1.99)	(20.58)	(16.15)	(19.09)
NM6m2	42.1	40.0	31.7***	20.0***	25.0***	20.6***
	(0.00)	(1.89)	(9.56)	(20.30)	(15.70)	(19.79)
NM6m3	27.6	30.0**	27.7	22.5***	20.0***	22.8***
	(0.00)	(-3.23)	(-0.15)	(6.69)	(10.00)	(6.32)
NM6w1	57.9	60.0	68.3***	80.0***	75.0***	79.4***
	(0.00)	(-1.89)	(-9.56)	(-20.30)	(-15.70)	(-19.79)
NM6w2	30.9	30.0	32.0	42.5***	40.0***	41.7***
	(0.00)	(1.55)	(-1.99)	(-20.58)	(-16.15)	(-19.09)
NM6w3	12.4	10.0**	12.3	17.5***	20.0***	17.2***
	(0.00)	(3.23)	(0.15)	(-6.69)	(-10.00)	(-6.32)

t statistics in parentheses; standard errors clustered at the group level
Stars indicate significant differences between data and theory: * p<0.05, ** p<0.01, *** p<0.001

Table 6': T-tests for payoffs of matched players in efficient matching in balanced markets: wave 2

	wave 2 data	our model	Shapley vale (Shapley, 1953)	nucleolus (Schmeidler, 1969)	fair division (Thompson, 1980)	median stable matching (Schwarz & Yenmez, 2011)
EA6m1	14.9	15.0	18.2***	15.0	15.0	15.0
	(0.00)	(-0.47)	(-12.41)	(-0.47)	(-0.47)	(-0.47)
EA6m2	29.9	30.0	31.3***	30.0	30.0	30.0
	(0.00)	(-0.58)	(-9.59)	(-0.58)	(-0.58)	(-0.58)
EA6m3	55.0	55.0	50.5***	55.0	55.0	55.0
	(0.00)	(-0.08)	(40.14)	(-0.08)	(-0.08)	(-0.08)
EA6w1	15.1	15.0	18.2***	15.0	15.0	15.0
	(0.00)	(0.47)	(-11.46)	(0.47)	(0.47)	(0.47)
EA6w2	30.1	30.0	31.3***	30.0	30.0	30.0
	(0.00)	(0.58)	(-8.44)	(0.58)	(0.58)	(0.58)
EA6w3	55.0	55.0	50.5***	55.0	55.0	55.0
	(0.00)	(0.08)	(40.31)	(0.08)	(0.08)	(0.08)
EM6m1	30.3	30.0	31.8**	32.5***	30.0	32.2***
	(0.00)	(0.87)	(-4.64)	(-6.66)	(0.87)	(-5.82)
EM6m2	49.2	50.0	45.7***	47.5*	50.0	47.8*
	(0.00)	(-1.50)	(6.56)	(3.16)	(-1.50)	(2.63)
EM6m3	19.9	20.0	21.8***	20.0	20.0	20.0
	(0.00)	(-0.47)	(-8.70)	(-0.47)	(-0.47)	(-0.47)
EM6w1	20.1	20.0	18.2***	20.0	20.0	20.0
	(0.00)	(0.47)	(8.70)	(0.47)	(0.47)	(0.47)
EM6w2	29.7	30.0	28.2**	27.5***	30.0	27.8***
	(0.00)	(-0.87)	(4.64)	(6.66)	(-0.87)	(5.82)
EM6w3	50.8	50.0	54.3***	52.5*	50.0	52.2*
	(0.00)	(1.50)	(-6.56)	(-3.16)	(1.50)	(-2.63)
NA6m1	48.6	50.0	46.2*	50.0	50.0	55.0***
	(0.00)	(-1.64)	(2.90)	(-1.64)	(-1.64)	(-7.58)
NA6m2	31.3	30.0	31.3	30.0	30.0	30.0
	(0.00)	(2.18)	(0.03)	(2.18)	(2.18)	(2.18)
NA6m3	21.8	20.0	22.5	20.0	20.0	15.0***
	(0.00)	(1.64)	(-0.70)	(1.64)	(1.64)	(6.31)
NA6w1	48.2	50.0	46.2	50.0	50.0	55.0***
	(0.00)	(-1.64)	(1.95)	(-1.64)	(-1.64)	(-6.31)
NA6w2	28.7	30.0	31.3**	30.0	30.0	30.0
	(0.00)	(-2.18)	(-4.33)	(-2.18)	(-2.18)	(-2.18)
NA6w3	21.4	20.0	22.5	20.0	20.0	15.0***
	(0.00)	(1.64)	(-1.32)	(1.64)	(1.64)	(7.58)
NM6m1	25.7	30.0**	28.0*	17.5***	20.0***	18.3***
	(0.00)	(-4.69)	(-2.50)	(8.97)	(6.24)	(8.05)
NM6m2	39.5	40.0	31.7**	20.0***	25.0***	20.6***
	(0.00)	(-0.24)	(3.54)	(8.84)	(6.57)	(8.58)
NM6m3	22.5	30.0***	27.7**	22.5	20.0	22.8
	(0.00)	(-5.65)	(-3.90)	(-0.01)	(1.88)	(-0.22)
NM6w1	60.5	60.0	68.3**	80.0***	75.0***	79.4***
	(0.00)	(0.24)	(-3.54)	(-8.84)	(-6.57)	(-8.58)
NM6w2	34.3	30.0**	32.0*	42.5***	40.0***	41.7***
	(0.00)	(4.69)	(2.50)	(-8.97)	(-6.24)	(-8.05)
NM6w3	17.5	10.0***	12.3**	17.5	20.0	17.2
	(0.00)	(5.65)	(3.90)	(0.01)	(-1.88)	(0.22)

t statistics in parentheses; standard errors clustered at the group level
Stars indicate significant differences between data and theory: * p<0.05, ** p<0.01, *** p<0.001

in the experiment, consider the following continuous-time model that captures the essence of our experimental setup. At time zero, no one is matched. At each instant $t \geq 0$, any agent can propose to anyone on the other side of the market. A person receiving a proposal must accept or reject the proposal within time length Δ. Neither a proposer nor a receiver of a proposal can make another proposal within the time length Δ. At each instant, when several offers are made simultaneously, proposals from one side of the market are randomly selected to be sent, and whenever tie-breaking is needed next, proposals from the other side of the market are sent.[12] When a proposal is accepted, the match becomes temporary, and the temporary match and the temporarily agreed upon division of surplus are publicly announced. People who are temporarily matched can still propose to anyone on the other side of the market, other than their matched partner. The game ends when there is no new proposal in the last $\Delta \cdot (1 + \varepsilon)$ units of time, where $\varepsilon \in (0, 1)$, and all matches become final. Suppose each individual has a discount rate of r. Define $\delta \equiv e^{-r\Delta}$. Taking $\Delta \to 0$ is equivalent to taking $\delta \to 1$.

We consider the Markov perfect equilibria of the game. At each instant, the state of the game is summarized by the temporary matching μ and the temporary payoffs $\{U_m\}_{m \in M}$ and $\{V_w\}_{w \in W}$. Because of the rule whereby agents cannot make another offer before Δ units of time, in equilibrium, effectively, actions occur only at times that are integer multiples of Δ. Barring technical details, given the specific tie-breaking rule, we can alternatively think of a discrete-time model in which agents have discount factors δ and, at the initial period agents on one side of the market are randomly chosen to propose. In subsequent periods the two sides alternate in making proposals, and the game ends when there is no proposal in a period.

5.1 Balanced markets

Suppose there is a unique efficient matching μ^* in a balanced matching market, as in the four balanced markets in our experiment. Consider the following (Markov perfect) equilibrium in which players propose to their partners in the efficient matching. At time zero, each man $m \in M$ proposes to woman $\mu^*(m) \in W$ with the surplus division U_m^p to m and $s_{m\mu^*(m)} - U_m^p$ to $\mu^*(m)$, and each woman $w \in W$ proposes to man $\mu^*(w) \in M$ with the surplus division $s_{\mu^*(w)w} - V_w^p$ to $\mu^*(w)$ and V_w^p to w. Each man $m \in M$ accepts the highest acceptable offer, where an offer above $\delta \cdot U_m^r$ is weakly acceptable and U_m^r is the optimal value when m rejects the current offer. Each woman $w \in W$ accepts the highest offer, where an offer above $\delta \cdot V_w^r$ is weakly acceptable and V_w^r is the optimal value when w rejects the current offer. At each instant after time zero, each person makes an offer that maximizes their payoff given the current temporary payoffs, and each person accepts the highest acceptable offer if it is above their current temporary payoff. On the equilibrium path, each man $m \in M$ proposes to woman $\mu^*(m) \in W$ and each woman $w \in W$ proposes to man $\mu^*(w) \in M$ with the division specified above, and each person accepts the offer at time zero and does not make another offer. The proposal each man $m \in M$ makes to woman $\mu^*(m) \in W$ at time zero yields

[12] We assume this tie-breaking rule for analytic convenience. Alternative tie-breaking rules, such as having each pair of conflicting proposals being independently determined at each instant, will not change the limit payoffs that match the experimental results, but will introduce complications in the expression of equilibrium payoffs due to combinatorial proposer-receiver possibilities.

him a payoff of

$$U_m^p = s_{m\mu^*(m)} - \max\left\{\delta \cdot V^r_{\mu^*(m)}, \max_{m'\in M\backslash m}\left\{s_{m'\mu^*(m)} - U^p_{m'}\right\}\right\}, \tag{3}$$

where

$$V^r_{\mu^*(m)} = s_{m\mu^*(m)} - \max\left\{\delta \cdot U_m^p, \max_{w'\in W\backslash \mu^*(m)}\left\{s_{mw'} - \left[s_{\mu^*(w')w'} - U^p_{\mu^*(w')}\right]\right\}\right\}. \tag{4}$$

Note that $U^p_{m'}$ is the payoff of m' when $\mu^*(m')$ accepts, and $s_{\mu(w')w'} - U^p_{\mu(w')}$ is the payoff of w' when w' accepts. The offer man $m \in M$ proposes to woman $\mu^*(m) \in W$ is $s_{m\mu^*(m)} - U^p_m$, which is the maximum of (i) $\delta \cdot V^r_{\mu^*(m)}$, the continuation value that woman $\mu^*(m) \in W$ can get if she rejects, and (ii) $\max_{m'\in M\backslash\{m\}}\left\{s_{m'\mu^*(m)} - U^p_{m'}\right\}$, the highest possible deviation payoff that another man $m' \in M\backslash\{m\}$ can offer to $\mu^*(m)$. The expected payoff that woman $\mu^*(m) \in W$ gets if she rejects, $V^r_{\mu^*(m)}$, results from her proposing to man $m \in M$, while ensuring that no other woman $w' \in W\backslash\{w\}$ is able to offer $s_{mw'} - [s_{\mu^*(w')w'} - U^p_{\mu^*(w')}]$ to $m \in M$ to poach him. Analogously, the proposal each woman $w \in W$ makes to man $\mu^*(w) \in M$ at time zero is

$$V_w^p = s_{\mu^*(w)w} - \max\left\{\delta \cdot U^r_{\mu^*(w)}, \max_{w'\in W\backslash w}\left\{s_{\mu^*(w)w} - V^p_{w'}\right\}\right\}, \tag{5}$$

where

$$U^r_{\mu^*(w)} = s_{\mu^*(w)w} - \max\left\{\delta \cdot V_w^p, \max_{m'\in M\backslash \mu^*(w)}\left\{s_{m'w} - \left[s_{m'\mu^*(m')} - V^p_{\mu^*(m')}\right]\right\}\right\}. \tag{6}$$

Note that when $\delta = 1$, all core payoffs satisfy the system of $n_M + n_W$ equations for $\{U_m^p\}_{m\in M}$ and $\{V_w^p\}_{w\in W}$. When $\delta < 1$, we can show that there is a unique set of payoffs $\{U_m^p\}_{m\in M}$ and $\{V_w^p\}_{w\in W}$ that satisfy the system of equations. The proofs are provided in Appendix C.

Theorem 1. *For any $\delta \in (0,1)$, there exists a unique solution to the system of equations (3)–(6). Moreover, if we replace μ^* with any $\mu \neq \mu^*$ in the system of equations (3)–(6), solution fails to exist.*

Theorem 1 establishes the existence of a unique solution to the system of equations with efficient matching, which is supported as a MPE. Also, inefficient matching cannot be supported in any MPE. This result contrasts Proposition 2, which shows that the set of stable payoffs is not a singleton in the canonical cooperative model. Furthermore, Proposition 3 implies that we should expect equal-splits as the unique equilibrium outcome in the limit if and only if equal-splits is in the core.

Proposition 3. *Suppose $s_{mw} > 0$ for any $m \in M$ and $w \in W$. There exists a $\underline{\delta} \in (0,1)$, such that for any $\delta \in (\underline{\delta}, 1)$, when equal-splits is in the core, the equilibrium values are*

$$U_m^p = \frac{s_{m\mu^*(m)}}{1+\delta} \text{ for any } m \in M \text{ and } V_w^r = \frac{s_{\mu^*(w)w}}{1+\delta} \text{ for any } w \in W.$$
$$V_w^p = \frac{s_{\mu^*(w)w}}{1+\delta} \text{ for any } w \in W \text{ and } U_m^r = \frac{s_{m\mu^*(m)}}{1+\delta} \text{ for any } m \in M.$$

When equal-splits is not in the core, there exists a $\underline{\delta} \in [0,1)$, such that for any $\delta \in [\underline{\delta}, 1)$, the equilibrium values above are not satisfied.

Table 7: Payoffs in comparable experiments in the literature

Nalbantian and Schotter (1995)		m1/m2/m3			w1/w2/w3		
surplus matrix	type	theory	efficient	all	theory	efficient	all
(4, 3, 3; 3, 4, 3; 3, 3, 4)	EA6	2	2.21	2	2	1.79	2
Agranov and Elliott (2021)		m1/w2			m2/w1		
surplus matrix	type	theory	efficient	all	theory	efficient	all
(20, 15; 0 20)	AE4	10	10.0 (0.03)	9.8 (0.12)	10	10.0 (0.03)	9.8 (0.09)
Agranov and Elliott (2021)		m1/w2			m2/w1		
surplus matrix	type	theory	efficient	all	theory	efficient	all
(20, 25; 0 20)	AN4	7.5	7.5 (0.18)	6.2 (0.35)	12.5	12.3 (0.08)	12.3 (0.16)
Agranov and Elliott (2021)		m1/w2			m2/w1		
surplus matrix	type	theory	efficient	all	theory	efficient	all
(20, 30; 0 20)	AN4	5	4.9 (0.18)	3.6 (0.05)	15	15.0 (0.14)	14.2 (0.05)
Agranov et al. (2022)		m1/w1		m2/w2		m3/w3	
surplus matrix	type	theory	all	theory	all	theory	all
(8, 16, 24; 16, 32, 48; 24, 48, 72)	EA6	4	4.11 (0.06)	16	16.07 (0.37)	36	35.86 (0.1)
(8, 32, 56; 32, 48, 64; 56, 64, 72)	NA6	16	16.07 (0.37)	24	23.81 (0.25)	40	38.87 (0.45)

Note. We report the results from the CIEA setting in Nalbantian and Schotter (1995), Experiment III in Agranov and Elliott (2021), and the complete-information setting in Agranov et al. (2022). We report the surplus matrices used in the experiments, their types according to our categorization of assortativity, ESIC, and number of players, and their average payoffs in all and/or efficient matches, with standard errors in parentheses whenever they are reported. Agranov et al. (2022) do not separate efficient matches from all matches, possibly because of high efficiency achieved in their complete-information part of the experiment, while the other two papers do.

The expected equilibrium payoffs are $U_m \equiv U_m^p/2 + [s_{m\mu^*(m)} - V^p_{\mu^*(m)}]/2$ for each $m \in M$ and $V_w \equiv V_w^p/2 + [s_{\mu^*(w)w} - U^p_{\mu^*(w)}]/2$ for each $w \in W$. These values as $\delta \to 1$ coincide with the payoffs in the experiment. Notably, $U_m^p = U_m^r$ and $V_w^p = V_w^r$ as $\delta \to 1$ in the games with equal-splits in the core, but $U_m^p \neq U_m^r$ and $V_w^p \neq V_w^r$ in the two games with equal-splits not in the core, even in the limit as $\delta \to 1$. This suggests that on one hand, in markets with equal-splits in the core, outside options do not play a role in equilibrium and agents effectively engage in Nash/Rubinstein bargaining in pairs; in other words, market forces are minimal. On the other hand, in markets with equal-splits not in the core, outside threats alter bargaining and influence equilibrium payoffs, and market forces play a significant role. These distinctions between markets with and without equal-splits in the core are also observed in noncooperative games with permanently accepted offers (Elliott and Nava, 2019; Talamàs, 2020; Agranov et al., 2022; Agranov and Elliott, 2021). By calculating the equilibrium payoffs in the four balanced markets, we formalize the following hypothesis:[13]

Hypothesis 2a. *The average individual payoffs for men in the four balanced markets are* $U_1 = 15$, $U_2 = 30$, *and* $U_3 = 55$ *in EA6;* $U_1 = 50$, $U_2 = 30$, *and* $U_3 = 20$ *in NA6;* $U_1 = 30$, $U_2 = 50$, *and* $U_3 = 20$ *in EM6; and* $U_1 = 30$, $U_2 = 40$, *and* $U_3 = 30$ *in NM6.*

[13] We only demonstrate men's payoffs as women's payoffs are pinned down by men's in efficient matching.

Figure 2a shows the match between data and the predictions of our model for the balanced markets. The theoretically predicted payoffs in the efficient matching fall in the 99% confidence interval of the data mean. The theory not only matches well with the average payoff, but also with the more detailed realized behavior. The modal outcome matches the theoretical prediction, shown in Figures B1a and B1'a in Appendix B for wave 1 and wave 2, respectively. The figures present the histograms of payoffs of individuals in the efficient matching, with bandwidth of 1.[14] In addition, our theory matches other experimental results in the literature with comparable experimental settings, as summarized in Table 7, which reports the surplus matrices in other experiments, their types according to categorization of assortativity, ESIC, and number of players, and average payoffs of all and/or efficient matches, with the standard errors included whenever they are reported. By our categorization, all of the surplus matrices in previous experiments are assortative, while some have equal-splits in the core and some do not. In comparison, we vary whether equal-splits is in the core, and examine markets with nonassortative surplus matrices.

5.2 Imbalanced markets

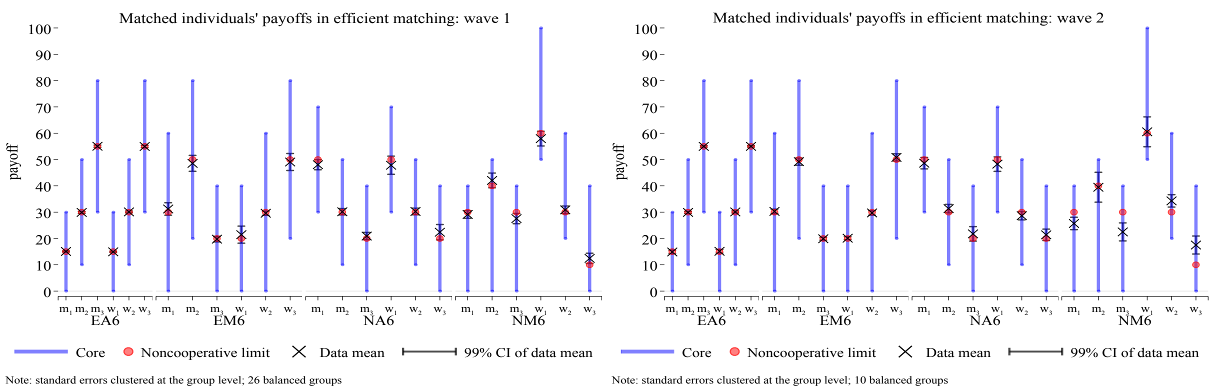
Consider an imbalanced market in which two individuals are identical in terms of the surplus they generate with anyone on the other side of the market; in the four imbalanced markets in our experiment, we have $w^*, w^{**} \in W$ such that $s_{mw^*} = s_{mw^{**}}$ for all $m \in M$. There are two efficient matching outcomes μ^* and μ^{**} such that between w^* and w^{**}, only w^* is matched and only w^{**} is matched, respectively.

There are various (Markov perfect) equilibrium outcomes in this imbalanced market, in the spirit of the folk theorem. To fix ideas, consider the simplest imbalanced matching market of one man m^* and two women w^* and w^{**}, with either pair being able to generate a surplus of $s^* > 0$. In the first type of equilibrium, man m^* proposes to either woman w^* or woman w^{**} a division of the surplus s^* into s^* for himself and 0 for her; woman w^* and woman w^{**} propose to man m^* the same division; man m^* accepts a payoff weakly above s^*; and each woman accepts any division of surplus. The equilibrium outcome is a core outcome in an imbalanced matching market, and is what we call a competitive outcome, since the two women are competing to benefit the man on the short side of the market. However, in this dynamic noncooperative setting, there are other equilibrium outcomes. Consider the following equilibrium strategies. When man m^* is unmatched, woman w^* proposes to man m^* the Rubinstein division of surplus s^* with $s^*/(1+\delta)$ for her and $\delta \cdot s^*/(1+\delta)$ for the man; man m^* proposes to woman w^* the Rubinstein division $s^*/(1+\delta)$ for himself and $\delta \cdot s^*/(1+\delta)$ for woman w^*, and accepts any offer above $\delta \cdot s^*/(1+\delta)$ and above his current temporary payoff. When m^* is matched with w^{**}, woman w^* proposes to man m^* the competitive division of surplus s^* with s^* for man m^* and 0 for woman w^*, and man proposes to woman w^* the same competitive offer. Woman w^{**} does not propose or accept any offer. This is an optimal strategy for woman w^{**}, as she knows that any proposal to or any acceptance of proposal from man m^* would still lead to a zero payoff for her. We call this equilibrium outcome a noncompetitive outcome, since the agents on the long side of the market, the women, are not competing. Finally, using this "grim-trigger" type of strategy, any equilibrium outcome that yields a payoff U between $\delta \cdot s^*/(1+\delta)$ and s^* for man m^* is possible if woman

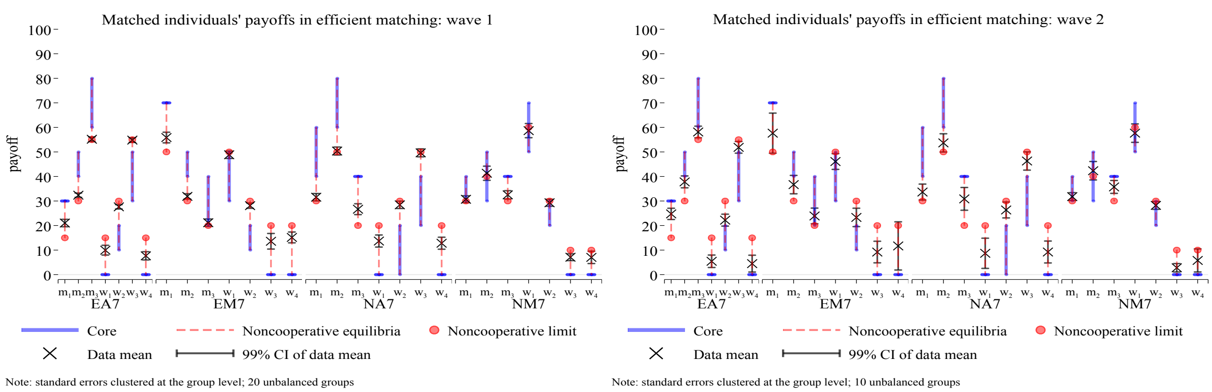
[14] The same pattern holds if we consider all matched individuals—not just the matched individuals in the efficient matching—as shown in Figure B2a and Figure B2'a , for wave 1 and wave 2 respectively, in Appendix B.

Figure 2: Average payoffs in efficient matching

(a) Balanced markets (3 men and 3 women)



(b) Imbalanced markets (3 men and 4 women)



Note. The figures show the average payoffs of all efficiently matched individuals. The blue intervals indicate the range of values in the core. The red dots in balanced markets indicate the noncooperative equilibrium payoffs in the frictionless limit. The red dashed lines in imbalanced markets indicate the range of noncooperative equilibria, and red dots indicate the payoffs in the noncompetitive equilibrium in the frictionless limit. The crosses indicate data mean and the segments indicate 99% confidence intervals of data mean. The figures show that the average experimental payoffs in the balanced markets are predicted by the limit equilibrium payoffs in our noncooperative model, and the average experimental payoffs in the imbalanced markets are not in the core but are between the competitive and noncompetitive equilibrium payoffs in our noncooperative model.

w^{**} accepts any offer that yields a payoff weakly above $s^* - U$. This results in a partially competitive outcome in which men benefit from some competition but not maximally. This indeterminacy resonates with Rubinstein and Wolinsky (1990), a noncooperative setting with permanently accepted offers.

We can generalize these arguments to the imbalanced matching markets with more individuals in which there are two identical women w^* and w^{**}. Consider a generalization of the noncompetitive equilibrium described above, each man $m \in M$ and each woman $w \in W \backslash \{w^{**}\}$ behave as if they are in the equilibrium in the balanced market with μ^* being the equilibrium matching with woman $w^{**} \in W$ remaining unmatched, and woman $w^{**} \in W$ does not attempt to make or accept a proposal. For any woman $w \in W \backslash \{w^{**}\}$, whenever man $\mu^*(w) \in M$ is temporarily matched with woman w^{**}, woman w would choose to make a proposal that yields a payoff $s_{\mu^*(w) w^{**}}$ for man $\mu^*(w)$. Given this grim-trigger strategy of any woman $w \in W \backslash \{w^{**}\}$, woman w^{**} has no (strict) incentive to propose to or accept a proposal from any man, because she knows that eventually she receives a payoff of 0. Analogously, we can have matching μ^{**} to be sustained in equilibrium in a similar way. In this type of equilibrium, despite the imbalance of the market, the short side does not benefit from it.[15]

The second class of equilibria generalizes the other extreme of competitive equilibrium in which women w^* and w^{**} compete for man $\mu^*(w^*) = \mu^{**}(w^{**}) \equiv m^*$. In this class, both woman w^* and woman w^{**} propose to man m^* a division of the surplus $s_{m^* w^*} = s_{m^* w^{**}} \equiv s^*$ with payoff s^* for man m^* and 0 for herself; meanwhile, man m^* proposes to either woman w^* or woman w^{**} the same division of surplus.

These offers yield a payoff of $U_{m^*} = s^*$ for man m^* and payoff 0 for w^* and w^{**}. There are two possibilities for the other pairs of agents. First, they may be unaffected by these competitions between w^* and w^{**}, since they continue to get the noncompetitive outcome in equilibrium, and they can maintain those noncompetitive outcomes by invoking grim-trigger strategies. Second, agents on the long side of the market may be influenced by the competition with the unmatched woman w^{**}. To maximally deter the unmatched woman, the matched women may actively choose to offer $s_{\mu^*(w) w^{**}}$ to man $\mu^*(w)$, so that he has no incentive to match with woman w^{**}, and woman w^{**} has no way to poach man $\mu^*(w)$. The maximum deterrence is to offer $s_{\mu^*(w) w^{**}}$ to man, but any payoff between $s_{\mu^*(w) w} - V_w^p$ and $s_{\mu^*(w) w^{**}}$ for man $\mu^*(w)$ can be supported in equilibrium for any woman w, generating a range of equilibrium outcomes.

In the experiment, the core payoffs—the competitive outcome—are not the most plausible predictions for these imbalanced matching markets. As a consequence, any refinement of the core with the cooperative approach will not yield a satisfying prediction for the imbalanced markets. Rather, we observe a range of payoffs for men and women between the competitive outcome and the noncompetitive outcome, as shown by the histograms of realized individual payoffs. This multiplicity is also observed in other experiments. For example, Leng (2020) meticulously follows the continuous-time setup of Perry and Reny (1994) that supposedly generates only core outcomes; a range of noncore outcomes analogous to our noncompetitive outcomes arises in markets with unequal numbers of participants on the two sides (to be precise, markets with one seller and two buyers).

Hypothesis 2b. *The lower bounds of the average individual payoffs for men in the four imbalanced markets are $U_1 = 15$, $U_2 = 30$, and $U_3 = 55$ in EA7; $U_1 = 50$, $U_2 = 30$, and $U_3 = 20$ in NA7; $U_1 = 30$, $U_2 = 50$, and $U_3 = 20$ in EM7; and $U_1 = 30$, $U_2 = 40$, and $U_3 = 30$ in NM7.*[16]

Adding one player to a balanced market shrinks the core. The payoffs of the players on the short side of the market increase, and those of the players on the long side decrease; some matched players' payoffs are driven to zero in the cases we consider in our experiment. However, experimentally, players' average payoffs do not change that drastically, as shown in Figure 2b. Only a few participants in wave 2 end up

[15]Note that the folk-theorem-like equilibrium multiplicity in imbalanced markets is not possible in balanced markets in which individuals can make additional nonbinding offers. A threat to a competitor in a balanced market is not credible, because the competitor has a positive "outside option" with another partner. A threat to an agent on the opposing side is also not credible, because offers can be made by both sides; think of bilateral Rubinstein bargaining as a balanced market with one agent on each side: there is a unique Markov perfect equilibrium.

[16]Note that these numbers are identical to those in Hypothesis 2a because they correspond to the equilibrium payoffs in the non-competitive equilibrium. We state the lower bounds for the purpose of hypothesis testing.

with the competitive core outcome of zero payoffs. The noncompetitive outcome is much more frequent. Figure B1b and Figure B1'b in Appendix B show that the modal payoffs of matched players remain to be the noncompetitive payoffs in both wave 1 and wave 2; the same pattern holds if we consider all matched individuals—not just the matched individuals in efficient matching—as shown in Figure B2b and Figure B2'b in Appendix B. Furthermore, notably, although they are on the long side of the market, women with the highest bargaining power slightly gain in the imbalanced market (Figure B3 and Figure B3' in Appendix B). This in general supports our prediction of a noncompetitive equilibrium in the imbalanced markets.

Overall, there is some competition, which is an equilibrium outcome in our noncooperative model. There is enough competition to reject the noncompetitive outcome as the sole outcome, but competition does not drive the relevant players' payoffs to zero or affect other players' payoffs drastically. The payoffs stay close to the noncompetitive outcome. In general, if the observed payoffs are not predicted by our noncompetitive limit payoffs, then the observed payoffs are between our noncompetitive limit payoffs and the lower (upper) bound of core payoffs for players on the short (long) side of the market.

6 Other experimental results

We have rich information about whom players propose to, and the process of negotiation: the terms of the offers and their acceptance and rejection. We can also explore why agents become unmatched at the end of the game. We also explore whether demographic characteristics such as gender and major affect bargaining outcomes in the appendix.

6.1 Proposing activities

We investigate the factors that affect the chance a player proposes to someone on the opposite side. Tables B15a and B15b in Appendix B provide two patterns. First, proposers are more likely to propose to a receiver when their total surplus stands out among all the matches the proposer can achieve. For example, in NM6, m_2 proposes to w_1 much more frequently than w_1 propose to m_2. This is potentially because w_1's alternative matches have relatively better surplus than m_2's alternative matches. Similar patterns can be seen in pairs m_2w_3 in EM7, m_2w_1 in NM7, and m_1w_3 and m_3w_1 in NA6 and NA7. To account for this factor, we create a variable

$$Attract_{ij} = s_{ij} \Bigg/ \frac{\sum_k s_{kj}}{3}$$

which measures player i's attractiveness to player j, where s_{ij} is the surplus generated when players i and j are matched, and k denotes the three possible matches for player j.[17]

Second, proposers are more likely to propose to a receiver if they appear more attractive to the receivers. For example, for players $m3$ in EM7, although the total surplus is identical when they are matched with either $w1$ or $w2$, $m3$ propose to $w1$ much more frequently than they propose to $w2$, potentially because they are relatively more attractive to w1 than to $w2$. Similar patterns can be observed in pair $m1w1$ in both EA6 and EA7. To account for this factor, we create another variable $RelativeAttract_{ij}$, which measures

[17] In the imbalanced markets, we treat the two duplicate players as one single player.

player i's relative attractiveness to player j among all the possible matches player i could achieve.

$$RelativeAttract_{ij} = Attract_{ij} \Bigg/ \frac{\sum_k Attract_{ik}}{3}$$

where Attract_{ij} is the variable defined above, representing the attractiveness of player i to player j, and k denotes the three possible matches for player i.

Table 8 presents the regressions results of the determinants of whom to propose to and the frequency of equal-spilts proposals. In the regressions, $Attract_{rp}$ captures the receivers' attractiveness to the proposer, and *RelativeAttract*$_{pr}$ captures the proposer's relative attractiveness to the receiver. C_p and C_r are dummy variables, which equal to 1 if the proposer or the receiver has a duplicate player in the imbalanced markets.

We first look at the determinants of whom to propose to. In columns (1) and (2) of Table 8, the dependent variable is the rate of proposals each player proposes to a certain receiver. The OLS regression results show that at the first round of each game, the attractiveness of the receivers to the proposers ($Attract_{rp}$) plays a significant role on proposers' proposing choices. When it comes to the fifth round of each game, $Attract_{rp}$ still has a significant effect, but the effect is much smaller. In contrast, the relative attractiveness of the proposer to the receiver (*RelativeAttract*$_{pr}$) becomes more important over time. In the imbalanced markets, we find that proposers with a duplicate competitor do not seem to care for the receivers' attractiveness, but they are more likely to propose to someone when they find themselves more attractive to them, even at the first round.

In columns (3)-(6) of Table 8, we look at when proposers propose an equal split. We run the regressions separately for markets with and without ESIC. We find that *RelativeAttract*$_{pr}$ always have a significant effect, and the effect is similar in round 1 and round 5. Interestingly, in the markets with ESIC, subjects are more likely to make equal-splits proposals when they are more attractive to the receivers. However, in the markets without ESIC, *RelativeAttract*$_{pr}$ has a significantly negative effect instead.

6.2 Bargaining activities

The aggregate surplus gradually increases from time zero (Figure B4 and Figure B4' in Appendix B for wave 1 and wave 2, respectively) through a series of proposals. In the balanced markets, the number of proposals is 12.4% (resp. 26.6%) fewer in assortative settings, and 30.5% (resp. 94.1%) fewer in the settings with equal-splits in the core, in wave 1 as shown in Column (2) in Table 9a (resp. wave 2 as shown in Column (2) in Table 9b). The number of proposals also decreases by round: An additional round decreases the number of proposals by 2.93% (resp. 8.91 %), and having played 7 (resp. 5) rounds of other market games ahead of the current market decreases the number of proposals by 9.96% (resp. 8.91%), which averages to 1.42% (resp. 1.78%) per round, in wave 1 as shown in Column (2) of Table 9a (resp. wave 2 as shown in Column (2) of Table 9b). In both wave 1 and 2, the effect of assortativity disappears in the analysis regarding balanced and imbalanced markets, but the effect of equal-splits in the core persists (Columns (3)-(4) of Table 9a and Table 9b).

The average number of all proposals (accepted, rejected, ignored, and expired) per player per round is between 1.98 (resp. 1.70) and 2.76 (resp. 5.44) across different types of games in wave 1 (resp. wave 2) as shown in Figure 3 (resp. Figure 3'). There does not appear to be a decline or increase in the number of proposals across periods.

Figure 4 and Figure 4' illustrates the proportion of equal-splits in wave 1 and wave 2, respectively, where we define a division to be an equal split whenever two agents' payoffs do not differ by more than 2, in proposed, temporarily accepted, and permanent offers. Equal-splits offers dominate the markets with equal-splits in the core (EA6 and EM6).

6.3 Reasons for being unmatched in balanced markets

In the first wave of the experiment, some subjects are unmatched in 33.6% of balanced markets (15.9% of EA6, 39.0% of NA6, 24.2% of EM6, and 56.5% of NM6). Overall, 5.31% of agents in EA6, 13.19% in NA6, 8.61% in EM6, and 19.05% in NM6 are unmatched. It is worthwhile to understand the reasons they end up unmatched, because a significant amount of potential surpluses is left unrealized, and the loss due to being unmatched far exceeds the loss due to inefficient mismatches.

To this end, we categorize a few reasons why people are left unmatched. Namely, we define four categories. A person is **unlucky** if he/she was matched within the last 30 seconds of the game (i.e., after 150 seconds of the game) but was left unmatched by the end. A person is **unattractive** if he/she was unmatched for the last 30 seconds, was never proposed to, and proposed to others but was rejected by others. A person is **picky** if the person was unmatched for the last 30 seconds, did not propose to anyone in the last 30 seconds, and rejected any incoming proposals in the last 30 seconds of the game. A person is **trying** if the person has both been rejected and rejected others in the last 30 seconds of the game.

Table 10 lists the reason for being unmatched. The leading factor for being unmatched is that a person is suddenly released from a match within 30 seconds of the end of the game. About half of the singles (48.3% in EA6, 47.9% in NA6, 63.0% in EM6, and 48.6% in NM6) are left unmatched for this reason. Among the rest of the singles, a little less than half are left unmatched because they are unattractive, i.e., in the last 30 seconds, their offers were not accepted and no one ever proposed to them. Among the last quarter of the singles, half were picky—i.e., they did not make any offer and rejected all incoming proposals in the last 30 seconds—half of them were actively participating without success. We also check whether some subjects tend to always be unlucky, picky, unattractive or trying, and this is not the case. The majority of subjects who have been unlucky, picky, unattractive, or trying experienced this only once or twice.

Table 11 shows the effects of the environment on being unmatched. There is no strong evidence that the different unmatched types show up in different ways in different configurations. The "individual efficient surplus" is the theoretically predicted total surplus an individual can generate in the match. The "individual random surplus" is the expected total surplus an individual gets with their partner. For example, for m_1 in AE, the individual efficient surplus is 30, and the individual random surplus is $(30 + 40 + 50)/3 = 40$. The larger these factors, the higher the surplus an individual can provide. Therefore, as row 2 of Table 11 shows, a higher individual random surplus is associated with a lower chance of being unmatched, and—conditional on being unmatched—a lower chance that an agent is left single for being unattractive.

Table 8: Determinants of whom to propose to and equal-spilts proposals: wave 1 & 2

	Rate of proposing to someone (OLS)		Whether equal-splits (Probit)			
			ESIC		ESNIC	
	Round=1	Round=5	Round=1	Round=5	Round=1	Round=5
	(1)	(2)	(3)	(4)	(5)	(6)
total surplus	0.0011	0.0015*	-0.0011	-0.0092	-0.0193**	-0.0052
	(1.49)	(2.03)	(-0.14)	(-0.97)	(-2.73)	(-0.64)
Attract$_{rp}$	0.626***	0.374***	0.119	0.247	1.706**	-0.893
	(12.66)	(5.96)	(0.17)	(0.35)	(2.77)	(-1.50)
RelativeAttract$_{pr}$	0.0662	0.593***	4.947*	4.765**	-2.322*	-1.991*
	(0.64)	(5.55)	(2.20)	(2.59)	(-2.47)	(-2.16)
Attract$_{rp}$*C$_p$	-0.763***	-0.655***	-0.829	-0.743	-2.447	2.189
	(-8.19)	(-6.54)	(-0.83)	(-0.54)	(-0.60)	(0.69)
Attract$_{rp}$*C$_r$	-0.316*	-0.351*	45.45***	0	0.0224	0
	(-2.59)	(-2.23)	(6.63)	(.)	(0.02)	(.)
RelativeAttract$_{pr}$*C$_p$	1.499***	1.208***	-8.923	-8.680*	6.382	-2.745
	(6.00)	(5.11)	(-1.94)	(-2.30)	(0.66)	(-0.36)
RelativeAttract$_{pr}$*C$_r$	-0.107	0.500	47.90***	0	-1.528	0
	(-0.33)	(1.93)	(3.44)	(.)	(-0.66)	(.)
wave=2	0.0053	0.0222	0.316	0.0192	0.0512	-0.140
	(0.32)	(0.96)	(1.12)	(0.06)	(0.23)	(-0.50)
constant	0.256***	0.218***	-0.792	-0.345	0.463	0.00974
	(4.82)	(4.31)	(-1.25)	(-0.45)	(0.84)	(0.02)
Observation	267	256	128	110	139	127
cluster	65	62	57	51	54	51

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3: Number of proposals: wave 1

(a) Number of proposals per player per round

(b) Number of proposals per round

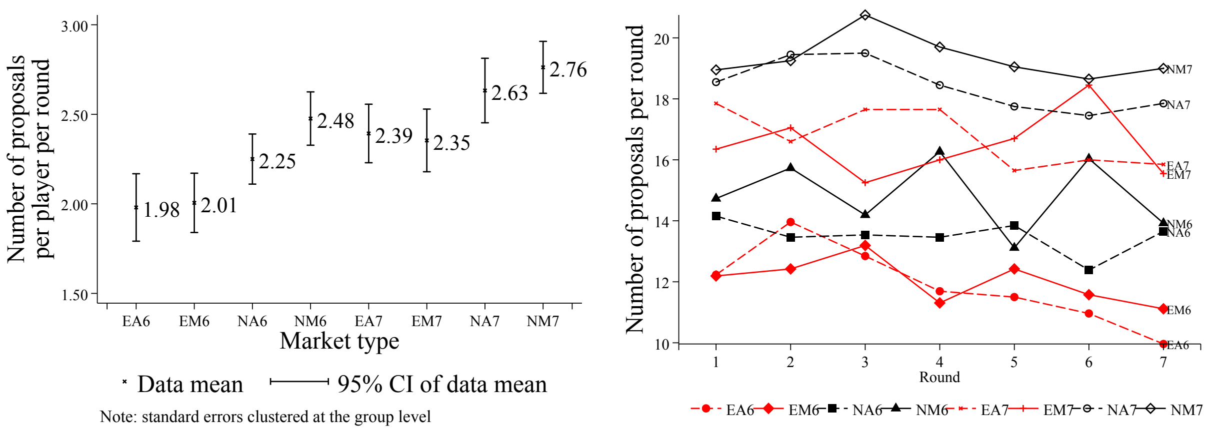


Table 9: Determinants of number of proposals

(a) Determinants of number of proposals per player per round in balanced and all markets: wave 1

	(1) proposal	(2) log proposal	(3) proposal	(4) log proposal
assortative	-0.251^{*}	-0.124^{*}	-0.0454	-0.0232
	(-2.63)	(-2.57)	(-0.50)	(-0.69)
ESIC	-0.483^{***}	-0.305^{***}	-0.483^{***}	-0.305^{***}
	(-4.29)	(-4.87)	(-4.32)	(-4.92)
assortative*ESIC	0.225	0.0964	0.225	0.0964
	(1.28)	(1.14)	(1.29)	(1.15)
round	-0.0388^{**}	-0.0293^{**}	-0.0229	-0.0136^{*}
	(-3.21)	(-3.22)	(-1.61)	(-2.22)
order	-0.159^{***}	-0.0996^{***}	0.0162	-0.00121
	(-3.76)	(-5.38)	(0.34)	(-0.06)
balanced			0.432	0.276^{**}
			(1.70)	(2.80)
assortative*balanced			-0.205	-0.101
			(-1.57)	(-1.72)
round*balanced			-0.0159	-0.0156
			(-0.85)	(-1.44)
order*balanced			-0.175^{**}	-0.0984^{***}
			(-2.76)	(-3.73)
constant	3.041^{***}	1.209^{***}	2.609^{***}	0.933^{***}
	(17.23)	(16.20)	(14.18)	(14.23)
observations	728	728	1,288	1,288
clusters	26	26	46	46

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Determinants of number of proposals per player per round in balanced and all markets: wave 2

	(1) proposal	(2) log proposal	(3) proposal	(4) log proposal
assortative	-1.877^{**}	-0.266	-0.432	-0.00539
	(-3.37)	(-1.98)	(-0.69)	(-0.04)
ESIC	-3.390^{***}	-0.941^{**}	-3.390^{***}	-0.941^{***}
	(-4.80)	(-4.04)	(-4.93)	(-4.16)
assortative*ESIC	1.577^{**}	0.143	1.577^{**}	0.143
	(3.34)	(0.62)	(3.44)	(0.64)
round	-0.317^{*}	-0.0891^{**}	-0.391	-0.0710
	(-2.90)	(-3.33)	(-1.45)	(-1.86)
order	-0.285	-0.0891	-1.056^{*}	-0.227^{**}
	(-1.89)	(-1.42)	(-2.43)	(-3.33)
balanced			-1.031	-0.0747
			(-0.40)	(-0.21)
assortative*balanced			-1.445	-0.260
			(-1.75)	(-1.45)
round*balanced			0.0748	-0.0181
			(0.26)	(-0.39)
order*balanced			0.771	0.138
			(1.68)	(1.51)
constant	7.106^{***}	1.839^{***}	8.137^{**}	1.914^{***}
	(5.96)	(8.32)	(3.57)	(6.77)
observations	200	200	399	399
clusters	10	10	20	20

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3’: Number of proposals: wave 2

(a) Number of proposals per player per round

(b) Number of proposals per round

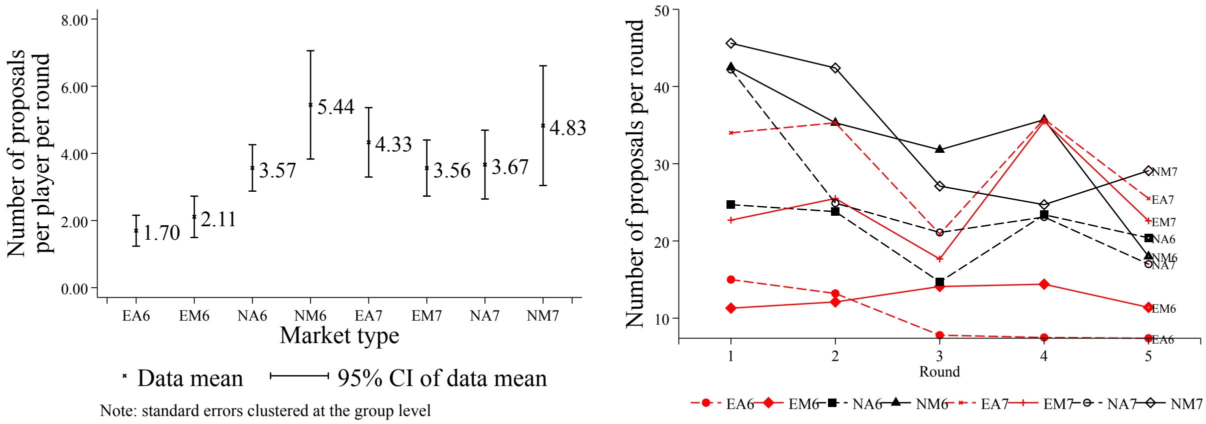


Figure 4: Proportion of equal-splits offers: wave 1

(a) All offers

(b) Temporarily accepted offers

(c) Permanent offers

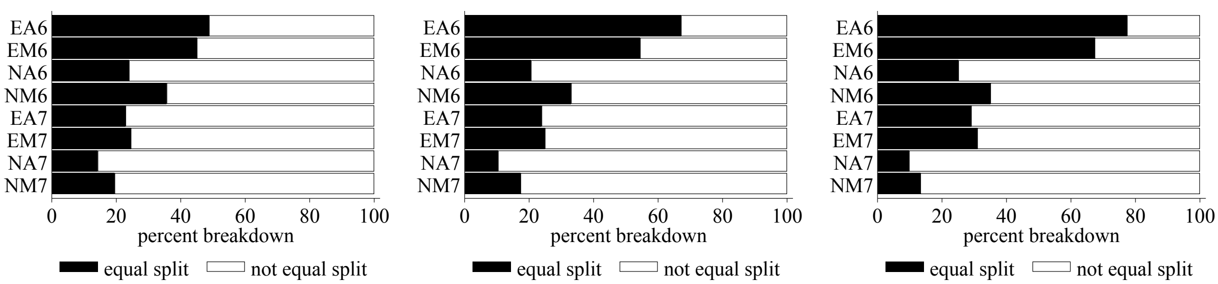


Figure 4’: Proportion of equal-splits offers: wave 2

(a) All offers

(b) Temporarily accepted offers

(c) Permanent offers

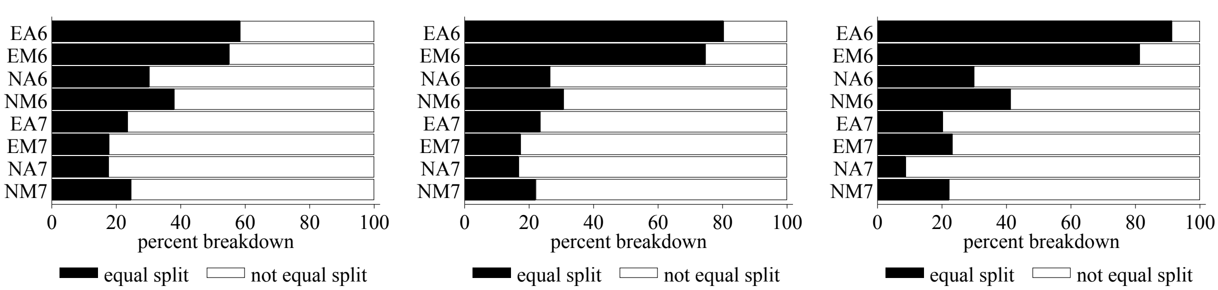


Table 10: Reasons for being unmatched: wave 1

Single reason	AE6	AN6	ME6	MN6	Total
	%	%	%	%	%
unlucky	48.3	47.9	63.0	48.6	51.0
unattractive	22.4	20.8	14.1	26.4	22.1
picky	13.8	20.1	9.8	11.1	13.7
trying	15.5	11.1	13.0	13.9	13.1
Total	100.0	100.0	100.0	100.0	100.0

Table 11: Determinants of reasons for being unmatched: wave 1

	(1)	(2)	(3)	(4)	(5)
	unmatched	unlucky	unattractive	picky	trying
individual efficient surplus	0.0286	-0.534	0.650*	0.174	-0.189
	(0.44)	(-1.65)	(2.26)	(0.77)	(-0.84)
individual random surplus	-0.106***	0.277***	-0.349***	-0.0614	0.0434
	(-6.34)	(3.41)	(-4.82)	(-1.08)	(0.77)
assortative	-0.0612***	-0.00623	-0.0291	0.0828*	-0.0237
	(-4.57)	(-0.11)	(-0.60)	(2.17)	(-0.63)
ESIC	-0.108***	0.129*	-0.129*	-0.0209	-0.00318
	(-8.03)	(2.06)	(-2.32)	(-0.48)	(-0.07)
assortative*ESIC	0.0301	-0.132	0.110	-0.0440	0.0477
	(1.59)	(-1.34)	(1.25)	(-0.64)	(0.70)
round	-0.00251	0.0184	-0.0184	-0.00221	-0.00295
	(-1.03)	(1.70)	(-1.91)	(-0.29)	(-0.39)
period	-0.00241***	0.00183	-0.00313	-0.00353	0.00287
	(-3.98)	(0.64)	(-1.22)	(-1.76)	(1.45)
Constant	0.547	1.534	-0.901	-0.315	0.730
	(1.89)	(1.03)	(-0.68)	(-0.30)	(0.71)
N	4,368	502	502	502	502

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.4 Demographic characteristics

We investigate whether individual characteristics have any effects on the number of matches and payoffs in each configuration. We use regressions with individual fixed effects to investigate the effects of age, gender, grade, and major on the number of matched pairs a subject reaches in each of the four balanced markets. There is hardly any effect of these characteristics, except that subjects from economics or business have a higher number of matches in NA6, and male students have a higher number of matches in NM6. In terms of the demographic differences in payoffs, only in NM6 male students earn a higher payoff than female students. For imbalanced markets, the only significant finding is that males earn less than females in NA7. These results indicate a modest role of gender and major in the two-sided matching markets. The tables of results are in Appendix B.

7 Conclusion

We experimentally investigated an influential class of matching models that has received extensive theoretical and empirical scrutiny. Our contributions are threefold. First, we find that factors that are abstracted away in the basic apparatus play important roles in determining the rate of matching, stability, and efficiency. Specifically, (i) whether agents can sort on their productivity and (ii) whether agents can split their surpluses by half as a sustainable outcome both influence the outcome of the two-sided matching market. Second, we provide a noncooperative theory that makes a unique prediction of individual payoffs in the balanced markets, which is experimentally supported by our results and results in the literature. Third, we investigate imbalanced markets and find that noncompetitive outcomes may arise both theoretically and experimentally.

Our experiment serves as an initial step in understanding decentralized matching and bargaining markets by considering 3-by-3 and 3-by-4 markets. Interesting next steps worth pursuing include investigating (i) the outcome when the market is larger (e.g., 6 by 6) in order to study the effects of market thickness on stable bargaining outcomes; (ii) the effects of more imbalanced ratio of the two sides (e.g., 3 by 6) and hence more competition on aggregate and individual outcomes of the market; (iii) the effects of different bargaining protocols on outcomes; and (iv) the effects of asymmetric information on outcomes.

References

M. Agranov and M. Elliott. Commitment and (in)efficiency: A bargaining experiment. *Journal of the European Economic Association*, 19(2), April 2021.

M. Agranov, A. Dianat, L. Samuelson, and L. Yariv. Paying to match: Decentralized markets with information frictions. Mimeo, May 2022.

N. Anbarci and N. Feltovich. How sensitive are bargaining outcomes to changes in disagreement payoffs? *Experimental Economics*, 16:560–596, 2013.

N. Anbarci and N. Feltovich. How fully do people exploit their bargaining position? The effects of bargaining institution and the 50-50 norm. *Journal of Economic Behavior and Organization*, 145:320–334, 2018.

G. S. Becker. A theory of marriage: Part I. *Journal of Political Economy*, 81(4):813–846, July-August 1973.

J. Bednar, Y. Chen, T. X. Liu, and S. Page. Behavioral spillovers and cognitive load in multiple games: an experimental study. *Games and Economic Behavior*, 74(1):12–31, 2012.

G. E. Bolton and A. Ockenfels. ERC: A theory of equity, reciprocity, and competition. *American Economic Review*, 90:166–193, 2000.

C. F. Camerer. *Behavioral Game Theory: Experiments in Strategic Interaction.* Princeton University Press, 2003.

H. Chade, J. Eeckout, and L. Smith. Sorting through search and matching models in economics. *Journal of Economic Literature*, 55:493–544, 2017.

Y. Chen, E. Fehr, U. Fischbacher, and P. Morg. Decentralized matching and social segregation. *Games and Economic Behavior*, 90:17–43, 2015.

P.-A. Chiappori. *Matching with Transfers: The Economics of Love and Marriage*. The Gorman Lectures in Economics. Princeton University Press, 2017.

P.-A. Chiappori and B. Salanié. The econometrics of matching models. *Journal of Economic Literature*, 54: 832–861, 2016.

P.-A. Chiappori, M. Iyigun, and Y. Weiss. Investment in schooling and the marriage market. *American Economic Review*, 99(5):1689–1713, 2009.

A. Dolgopolov, D. Houser, C. Martinelli, and T. Stratmann. Assignment markets: Theory and experiments. Mimeo, December 2020.

F. Echenique and L. Yariv. An experimental study of decentralized matching. Mimeo, 2013.

M. Elliott and F. Nava. Decentralized bargaining in matching markets: Efficient stationary equilibria and the core. *Theoretical Economics*, 14:211–251, 2019.

E. Fehr and K. M. Schmidt. A theory of fairness, competition and cooperation. *Quarterly Journal of Economics*, 114:817–868, 1999.

U. Fischbacher. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 2007.

X. Gabaix and A. Landier. Why has CEO pay increased so much? *Quarterly Journal of Economics*, 123(1): 49–100, February 2008.

D. Gale and L. S. Shapley. College admissions and the stability of marriage. *The American Mathematical Monthly*, 69(1):9–15, January 1962.

F. Galeotti, M. Montero, and A. Poulsen. Efficiency versus equality in bargaining. *Journal of the European Economic Association*, 17(6):1941–1970, 2018.

A. Galichon. *Optimal Transport Methods in Economics*. Princeton University Press, 2016.

R. Hakimov and D. Kübler. Experiments on matching markets: A survey. Mimeo, April 2019.

J. W. Hatfield, C. R. Plott, and T. Tanaka. Understanding price controls and nonprice competition with matching theory. *American Economic Review Papers and Proceedings*, 102(3):371–75, 2012.

J. W. Hatfield, S. D. Kominers, A. Nichifor, M. Ostrovsky, and A. Westkamp. Stability and competitive equilibrium in trading networks. *Journal of Political Economy*, 121(5):966–1005, 2013.

J. W. Hatfield, C. R. Plott, and T. Tanaka. Price controls, non-price quality competition, and the nonexistence of competitive equilibrium. *Games and Economic Behavior*, 99:134–163, 2016.

S. He and J. Wu. Compromise and coordination: An experimental study. *Games and Economic Behavior*, 119:216–233, 2020.

D. Herreiner and C. Puppe. Inequality aversion and efficiency with ordinal and cardinal social preferences-an experimental study. *Journal of Economic Behavior and Organization*, 76:238–253, 2010.

E. Hoffman and M. Spitzer. The coase theorem: Some experimental tests. *Journal of Law and Economics*, 25(1):73–98, 1982.

Y. Hou, K. Tang, J. Wang, D. Xie, and H. Zhang. Assortative mating on blood type: Evidence from one million Chinese pregnancies. *Proceedings of the National Academy of Sciences*, 119(51):e2209643119, 2022.

A. Isoni, A. Poulsen, R. Sugden, and K. Tsutsui. Efficiency, equality, and labeling: An experimental investigation of focal points in explicit bargaining. *American Economic Review*, 104(10):3256–3287, 2014.

L. F. Katz and K. M. Murphy. Changes in relative wages, 1963–1987: Supply and demand factors. *The Quarterly Journal of Economics*, 107(1):35–78, 1992.

A. S. J. Kelso and V. P. Crawford. Job matching, coalition formation, and gross substitutes. *Econometrica*, 50(6):1483–1504, November 1982.

M. Kremer. The O-ring theory of economic development. *Quarterly Journal of Economics*, 108(3):551–575, August 1993.

A. Leng. An experimental implementation of cooperative games. Mimeo, April 2020.

W. Luhan, A. Poulsen, and M. Roos. Real-time tacit bargaining, payoff focality, and coordination complexity: Experimental evidence. *Games and Economic Behavior*, 102:687–699, 2017.

H. R. Nalbantian and A. Schotter. Matching and efficiency in the baseball free-agent system: An experimental examination. *Journal of Labor Economics*, 13(1):1–31, January 1995.

J. F. J. Nash. The bargaining problem. *Econometrica*, 18(2):155–162, 1950.

M. Núñez and C. Rafels. A survey on assignment markets. *Journal of Dynamics and Games*, 2(3 & 4): 227–256, 2015.

J. Ochs and A. Roth. An experimental study of sequential bargaining. *American Economic Review*, 79(3): 355–384, 1989.

P. E. Otto and F. Bolle. Matching markets with price bargaining. *Experimental Economics*, 14:3222–348, 2011.

J. Pais, A. Pinter, and R. F. Veszteg. Decentralized matching markets with(out) frictions: A laboratory experiment. *Experimental Economics*, 23:212–239, 2020.

M. Perry and P. J. Reny. A noncooperative view of coalition formation and the core. *Econometrica*, 62: 795–817, 1994.

C. Plott, R. Roll, H. Seo, and H. Zhao. Tick size, price grids and market performance: Stable matches as a model of market dynamics and equilibrium. *Games and Economic Behavior*, 118:7–28, 2019.

R. A. Pollak. How bargaining in marriage drives marriage market equilibrium. *Journal of Labor Economics*, 37(1):297–321, 2019.

S. Rochford. Symmetrically pairwise-bargained allocations in an assignment market. *Journal of Economic Theory*, 34:262–281, 1984.

A. Roth. Bargaining experiments. In J. H. Kagel and A. E. Roth, editors, *Handbook of Experimental Economics*, pages 253–348. Elsevier, 1995.

A. Roth. Experiments in market design. In *The Handbook of Experimental Economics*, volume 2, chapter 5, pages 221–310. Elsevier, 2015.

A. Roth and M. Malouf. Game-theoretic models and the role of information in bargaining. *Psycological Review*, 86(6):574–594, 1979.

A. Roth and K. Murnighan. The role of information in bargaining: An experimental study. *Econometrica*, 50(5):1123–1142, 1982.

A. Roth, K. Murnighan, and F. Schoumaker. The deadline effect in bargaining: Some experimental evidence. *American Economic Review*, 78(4):806–823, 1989.

A. Rubinstein. Perfect equilibrium in a bargaining model. *Econometrica*, 50(1):97–109, 1982.

A. Rubinstein and A. Wolinsky. Decentralized trading, strategic behaviour and the Walrasian outcome. *Review of Economic Studies*, 57:63–78, 1990.

T. Schelling. *The Strategy of Conflict.* Harvard University Press, 1960.

D. Schmeidler. The nucleolus of a characteristic function game. *SIAM Journal on Applied Mathematics*, 17 (6):1163–1170, 1969.

M. Schwarz and M. B. Yenmez. Median stable matching for markets with wages. *Journal of Economic Theory*, 146:619–637, 2011.

L. Shapley. A value for n-person games. In H. W. Kuhn and A. W. Tucker, editors, *Contributions to the Theory of Games*, volume II of *Annals of Mathematics Studies*, pages 307–317. Princeton University Press, Princeton, 1953.

L. S. Shapley and M. Shubik. The assignment game I: The core. *International Journal of Game Theory*, 1(1): 111–130, 1972.

A. Siow. Testing Becker's theory of positive assortative matching. *Journal of Labor Economics*, 33(2): 409–444, April 2015.

E. Talamàs. Nash bargaining with endogenous outside options. Mimeo, August 2020.

G. L. Thompson. Auctions and market games. In R. Aumann, editor, *Game Theory and Mathematical Economics in Honour of Oskar Morgenstern*, page 181196. Bibliographisches Institute AG, 1980.

S. Wei and X. Zhang. The competitive saving motive: Evidence from rising sex ratios and savings rates in china. *Journal of Political Economy*, 119:511–564, 2011.

H. Zhang. Pre-matching gambles. *Games and Economic Behavior*, 121:76–89, May 2020.

H. Zhang. An investment-and-marriage model with differential fecundity: On the college gender gap. *Journal of Political Economy*, 129(5):1464–1486, May 2021.

H. Zhang and B. Zou. A marriage-market perspective on risk-taking and career choices. Mimeo, December 2022.

Online appendices

A Experiment instructions

Experimental instructions are in Chinese. We present the English translation for balanced markets in the first wave of the experiment. The instructions for imbalanced markets and ones in the second wave of the experiment are appropriately modified. Figure 5 presents a screenshot of the experiment.

Figure 5: A (translated) screenshot of the experiment

Instructions for balanced markets

Welcome page

Welcome to this experiment on decision-making. Please read the following instructions carefully.

This experiment will last about two hours. During the experiment, do not communicate with other participants in any way. If you have any question at any time, please raise your hand, and an experimenter will come and assist you privately.

At the beginning of the experiment, you will be randomly assigned to a group of six participants, and this is fixed throughout the experiment. Each participant sits behind behind a private computer, and all decisions are made on the computer screen. This is an anonymous experiment: Experimenters and other participants cannot link your name to your desk number, and thus will not know your identity or that of other participants who make the specific decisions.

Payoffs

Throughout the experiment, your earnings are denoted in points. Your earnings depend on your own choices and the choices of other participants. At the end of the experiment, your earnings will be converted to RMB at the following rate: 12 points = 1 RMB. In addition, you will receive 20 RMB as show-up fee. This a show-up fee is added to your earnings during the experiment. Your total earnings will be paid to you privately at the end of the experiment.

There are three cold colors and three warm colors in experimental roles. Cold colors are Blue, Cyan, and Green. Warm colors are Pink, Red, and Yellow. In each of the matching games (there are 28 games in total), each of the six participants will be randomly assigned one of the six role colors. In these matching games, a cold color can only be matched with a warm color, and vice versa. Two cold colors and two warm colors cannot be matched. For example, a Cyan can match with a Pink (if they both want to).

When a cold color is matched with a warm color, they can share their total earnings. The total earnings of two colors are depicted in the table below. In this table, you can see that a Blue and a Yellow can share total earnings of 10 points. That is, their total earnings must equal 10.

	w_1	w_2	w_3
m_1	50	20	10
m_2	20	30	60
m_3	30	50	20

Matching Stage

In order to reach a match, all of the six participants will go through a short matching stage that lasts for 3 minutes.

Proposing. Each participant can propose to any of the other three colors on the opposite side of the market. When proposing to someone, you can first click that color in the screen, and decide how you want to share the total earnings.

For example, if the Red (proposer) wants to propose to the Green (receiver), the Red has to decide how to allocate the total 60 points between them. Once the proposal is made, the Green will receive a notification of the proposal on his or her private information board. The notification contains all of the information about the proposal (who proposes and how many points each gets). Note that except for the Green (the receiver of the proposal), other people will not receive any information about this proposal.

Accepting/rejecting proposals. When a proposal is made from a proposer to a receiver, the receiver has 30 seconds to either accept or reject the proposal.

If the receiver rejects the proposal within 30 seconds or does not accept it within the 30 seconds, this proposal is no longer valid and will disappear on the receiver's private information board.

If the receiver accepts the proposal within 30 seconds, a temporary match between the receiver and the proposer is made. Once a temporary match is made, a matching posting will appear on the public information board with full information (who matched and how many points each gets).

Before the receiver decides to accept or reject a proposal (and before the 30 seconds are over), the proposer of this proposal is not able to make any proposals to any other colors (or to make a new proposal to the same receiver); however, the proposer of this proposal can accept a proposal from others. In this case, his or her previous proposal becomes invalid.

Moreover, it is possible that one participant receives multiple proposals from different proposers at the same time. In this case, the receiver can choose to accept at most one proposal (or reject all of them).

Temporary match. Once a temporary match is made, the two people in this match are still able to make proposals to others, and they can also receive proposals from other proposers.

In the former case, if one's new proposal is accepted, then the previous temporary match is ended, and a new temporary match is formed. In this case, the person who is previously matched with him or her will be notified, and the matching posting will be updated on the public board.

As long as the matching stage has not ended, one can always break his or her current temporary match by forming a new temporary match (by proposing and accepting, or by accepting another proposal). One cannot break a current temporary match without forming a new match. If one is passively broken up with by someone within the last 15 seconds, he or she will be granted 15 seconds to make new proposals to others. This process of adding 15 additional seconds continues until no new proposal is accepted.

Permanent match. When the matching stage ends at the 3-minute mark, all of the temporary matches at the end of the matching stage become permanent. All participants with a permanent match will receive the points allocated to him or her in the match (as made by the proposers), and all of the remaining participants are unmatched, and will receive zero points. Once everyone receives his or her points, the game is finished.

Repetition

In this experiment, you will play four different matching games. In each of the matching games the procedures are the same; the only difference is the game payoff. The game payoff matrix will be shown to you once a new game is being played. Each of the matching games will be repeated for 7 rounds. Therefore, there are 28 rounds in total for the entire experiment. Throughout the 28 rounds, you will stay in the same group of six participants. Before the start of the 28 rounds, you will also have the opportunity to play one practice round. The goal of the practice round is to let you get familiar with the procedure; the points you receive in this round will not be included in your final earnings.

All of the six participants in a group can also see the matching results from past rounds. The matching results contain information about which colors are matched with each other and the number of points they earned in the match.

Earnings

At the end of the experiment, you will receive the sum of the 240 points (endowed in the beginning) and the points from each round. Your total earnings in the experiment are equal to the total points divided by 12.

B Robustness checks and additional results

This section contains robustness checks of main empirical results, and additional experimental results.

Contents

B.1 Determinants of outcomes in balanced markets

To check the robustness of our results regarding Hypothesis 4, we present the results from regressions with alternative dependent variables and alternative specifications: We consider (i) the outcomes of interest directly as dependent variables in addition to their logged values, and (ii) the following specifications, in which specification (1) is the leading specification we presented in the main text.

$$
\begin{aligned}
&(1) \quad y_i = \beta_1 \cdot \text{assortative}_i + \beta_2 \cdot \text{ESIC}_i + \beta_3 \cdot \text{assortative}_i \cdot \text{ESIC}_i + \beta_4 \cdot \text{round}_i + \beta_5 \cdot \text{order}_i + c + \varepsilon_g,\\
&(2) \quad y_i = \beta_1 \cdot \text{assortative}_i + \beta_2 \cdot \text{ESIC}_i + \beta_3 \cdot \text{assortative}_i \cdot \text{ESIC}_i + \beta_4 \cdot \text{round}_i +\\
&\qquad\quad \beta_5 \cdot (\text{treat}_i = 2) + \beta_6 \cdot (\text{treat}_i = 3) + \beta_7 \cdot (\text{treat}_i = 4) + c + \varepsilon_g,\\
&(3) \quad y_i = \beta_1 \cdot \text{assortative}_i + \beta_2 \cdot \text{ESIC}_i + \beta_3 \cdot \text{assortative}_i \cdot \text{ESIC}_i + \beta_4 \cdot \text{round}_i +\\
&\qquad\quad \beta_5 \cdot (\text{treat}_i = 2) + \beta_6 \cdot (\text{treat}_i = 3) + \beta_7 \cdot (\text{treat}_i = 4) + c + \varepsilon_g\\
&\qquad\quad \beta_8 \cdot (\text{order}_i = 2) + \beta_9 \cdot (\text{order}_i = 3) + \beta_{10} \cdot (\text{order}_i = 4) + c + \varepsilon_g,
\end{aligned}
$$

where i is the index of a game (out of 728 balanced markets); y_i is the variable of interest or its log (or log of #efficient matches+1); assortative$_i$ is the indicator of whether the market played in the game is assortative; ESIC$_i$ is the indicator of whether the market has equal-splits in the core; round$_i$ is the round (out of 7) the same market has been played; order$_i$ is the order (out of 4) the game is played in; treat$_i$ is the treatment order (out of 4).

Table B1 presents the results for determinants of the number of matched pairs and its log. All else equal, assortativity increases the number of matched pairs by 0.176 to 0.183 (or by 7.45% to 7.75%), whereas equal-splits in the core increases the number of matches by 0.324 to 0.328 (or by 13.5% to 13.6%), depending on whether learning over time is controlled for. The evidence suggests that ESIC plays a more important role than assortativity in determining the number of matches. There is evidence that learning mildly improves the expected number of matches over time. Having played the same game for one more round increases the number of matches by about 0.07%, and having played any game for one more round increases the number of matches by about 0.28%. Having played 7 more other games increases the number of matches by 1.99%.

Table B2 presents the results for determinants of the number of efficiently matched pairs. All else equal, assortativity increases the number of efficiently matched pairs by 0.368 to 0.380 (or by 14.4% to 14.8%), and equal-splits in the core increases the number of efficiently matched pairs by 0.989 to 0.995 (or by 38.5% to 38.7%), depending on whether learning over time is controlled for.

Table B3 presents the results for determinants of the surplus. All else equal, assortativity increases surplus by 3.78% to 4.11%, and equal-splits in the core increases surplus by 7.61% to 7.78%, depending on whether learning is controlled for. There is some gain from learning. Having the same game one more round increases efficiency by about 0.85%, and having played any game one more round increases efficiency by about 0.31%. Having played 7 more other games increases efficiency by 2.18%.

Table B1: Determinants of number of matched pairs in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	0.183***	0.176**	0.183**	0.0775***	0.0745**	0.0775***
	(3.78)	(3.48)	(3.72)	(3.95)	(3.59)	(3.88)
ESIC	0.328***	0.324***	0.326***	0.136***	0.135***	0.136***
	(4.65)	(4.56)	(4.63)	(4.77)	(4.67)	(4.75)
assortative*ESIC	-0.101	-0.0934	-0.0979	-0.0441	-0.0410	-0.0430
	(-1.40)	(-1.27)	(-1.38)	(-1.54)	(-1.39)	(-1.52)
round	0.0165*	0.0165*	0.0165*	0.00708*	0.00708*	0.00708*
	(2.58)	(2.57)	(2.57)	(2.68)	(2.68)	(2.67)
order	0.0473*			0.0199*		
	(2.63)			(2.67)		
treat=2		-0.00510	-0.00510		-0.00207	-0.00207
		(-0.11)	(-0.11)		(-0.11)	(-0.11)
treat=3		0.0391	0.0391		0.0141	0.0141
		(0.65)	(0.64)		(0.55)	(0.55)
treat=4		0.111*	0.111*		0.0431*	0.0431*
		(2.72)	(2.71)		(2.57)	(2.57)
order=2			0.0857			0.0347
			(1.36)			(1.36)
order=3			0.126*			0.0527*
			(2.38)			(2.41)
order=4			0.144*			0.0603*
			(2.07)			(2.10)
constant	2.263***	2.351***	2.259***	0.794***	0.832***	0.794***
	(39.06)	(57.55)	(39.92)	(31.50)	(49.41)	(32.69)
observations	728	728	728	728	728	728
clusters	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B1': Determinants of number of matched pairs in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	0.160*	0.160	0.153*	0.0706*	0.0706	0.0679*
	(2.65)	(2.02)	(3.06)	(2.72)	(2.04)	(3.17)
ESIC	0.270**	0.260**	0.268**	0.116**	0.111**	0.115**
	(3.53)	(3.48)	(3.80)	(3.31)	(3.30)	(3.54)
assortative*ESIC	-0.201*	-0.180*	-0.196*	-0.0939*	-0.0845*	-0.0924*
	(-2.58)	(-2.81)	(-2.54)	(-2.61)	(-2.87)	(-2.49)
round	0.0325	0.0325	0.0325	0.0132	0.0132	0.0132
	(1.76)	(1.75)	(1.73)	(1.50)	(1.49)	(1.48)
order	0.0516*			0.0235		
	(2.35)			(2.22)		
treat=2		-0.00833	-0.00833		0.00381	0.00381
		(-0.12)	(-0.12)		(0.12)	(0.12)
treat=3		-0.0917	-0.0917		-0.0348	-0.0348
		(-1.56)	(-1.55)		(-1.15)	(-1.14)
treat=4		-0.0500	-0.0500		-0.0131	-0.0131
		(-0.83)	(-0.83)		(-0.44)	(-0.44)
order=2			-0.00469			-0.00132
			(-0.07)			(-0.04)
order=3			0.0796			0.0393
			(1.52)			(1.50)
order=4			0.144			0.0650
			(2.00)			(1.87)
constant	2.526***	2.695***	2.644***	0.894***	0.965***	0.940***
	(26.34)	(31.77)	(26.70)	(20.58)	(24.59)	(18.98)
observations	200	200	200	200	200	200
clusters	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B2: Determinants of number of efficiently matched pairs in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y+1)	log(y+1)	log(y+1)
assortative	0.380**	0.368**	0.380**	0.148**	0.144*	0.148**
	(3.01)	(2.81)	(3.03)	(2.82)	(2.67)	(2.82)
ESIC	0.995***	0.989***	0.992***	0.387***	0.385***	0.386***
	(8.23)	(7.97)	(8.09)	(7.55)	(7.37)	(7.40)
assortative*ESIC	-0.309*	-0.297	-0.302*	-0.135*	-0.131*	-0.133*
	(-2.12)	(-1.95)	(-2.08)	(-2.32)	(-2.20)	(-2.28)
round	0.0433**	0.0433**	0.0433**	0.0160*	0.0160*	0.0160*
	(2.89)	(2.89)	(2.88)	(2.56)	(2.55)	(2.55)
order	0.0784*			0.0257		
	(2.23)			(1.77)		
treat=2		0.0306	0.0306		0.0192	0.0192
		(0.12)	(0.12)		(0.18)	(0.18)
treat=3		0.279	0.279		0.114	0.114
		(1.32)	(1.32)		(1.33)	(1.33)
treat=4		0.374	0.374		0.155	0.155
		(1.94)	(1.93)		(1.96)	(1.95)
order=2			0.168			0.0564
			(1.48)			(1.22)
order=3			0.248			0.0798
			(1.90)			(1.60)
order=4			0.234			0.0780
			(1.93)			(1.51)
constant	1.146***	1.189***	1.021***	0.698***	0.697***	0.641***
	(8.50)	(7.44)	(4.89)	(12.82)	(11.11)	(7.79)
observations	728	728	728	728	728	728
clusters	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B2': Determinants of number of efficiently matched pairs in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y+1)	log(y+1)	log(y+1)
assortative	0.0600	0.0600	0.0571	0.0173	0.0173	0.0162
	(0.27)	(0.25)	(0.24)	(0.19)	(0.17)	(0.15)
ESIC	1.162***	1.140***	1.155***	0.451***	0.441***	0.449***
	(7.18)	(5.93)	(6.94)	(6.46)	(5.23)	(6.15)
assortative*ESIC	-0.124	-0.0800	-0.110	-0.0455	-0.0254	-0.0412
	(-0.50)	(-0.35)	(-0.42)	(-0.44)	(-0.25)	(-0.37)
round	0.105*	0.105*	0.105*	0.0388*	0.0388*	0.0388*
	(3.13)	(3.12)	(3.09)	(2.94)	(2.93)	(2.91)
order	0.111			0.0503		
	(1.79)			(2.02)		
treat=2		0.142	0.142		0.0587	0.0587
		(0.79)	(0.79)		(0.82)	(0.81)
treat=3		0.158**	0.158**		0.0655*	0.0655*
		(3.68)	(3.65)		(2.48)	(2.46)
treat=4		-0.175**	-0.175**		-0.0765***	-0.0765***
		(-4.13)	(-4.09)		(-5.02)	(-4.98)
order=2			0.206			0.0767
			(1.00)			(0.82)
order=3			0.151			0.0792
			(0.71)			(0.85)
order=4			0.385			0.167
			(1.73)			(1.85)
constant	1.314***	1.535***	1.351***	0.722***	0.826***	0.746***
	(5.50)	(15.12)	(6.53)	(7.19)	(16.86)	(7.95)
observations	200	200	200	200	200	200
clusters	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B3: Determinants of surplus in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	6.781*	6.264*	6.469*	0.0411*	0.0378*	0.0391*
	(2.60)	(2.21)	(2.40)	(2.51)	(2.11)	(2.30)
ESIC	13.95**	13.68**	13.75**	0.0779**	0.0761**	0.0765**
	(3.60)	(3.47)	(3.43)	(3.28)	(3.15)	(3.12)
assortative*ESIC	-1.245	-0.714	-0.846	-0.00716	-0.00370	-0.00447
	(-0.33)	(-0.18)	(-0.23)	(-0.32)	(-0.16)	(-0.20)
round	0.819	1.315***	1.235**	0.00525*	0.00847***	0.00792**
	(2.04)	(3.73)	(3.54)	(2.08)	(3.74)	(3.59)
order	2.414**			0.0157**		
	(3.12)			(3.20)		
treat=2		-2.194	-2.194		-0.0138	-0.0138
		(-0.75)	(-0.75)		(-0.74)	(-0.74)
treat=3		0.204	0.204		-0.00216	-0.00216
		(0.05)	(0.05)		(-0.08)	(-0.08)
treat=4		4.371	4.371		0.0232	0.0232
		(1.81)	(1.80)		(1.46)	(1.46)
order=2			-5.533*			-0.0350
			(-2.10)			(-1.98)
order=3			1.153			0.00883
			(0.43)			(0.53)
order=4			2.632			0.0177
			(0.81)			(0.89)
constant	158.6***	164.4***	164.9***	5.047***	5.087***	5.090***
	(53.25)	(69.89)	(59.26)	(234.78)	(321.45)	(271.71)
observations	728	728	728	728	728	728
clusters	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B3': Determinants of surplus in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	5.800	5.800	5.429	0.0421	0.0421	0.0395
	(1.56)	(1.16)	(1.60)	(1.64)	(1.26)	(1.76)
ESIC	17.05**	16.40**	16.91***	0.104**	0.0999**	0.103**
	(4.62)	(4.26)	(4.81)	(3.66)	(3.52)	(3.83)
assortative*ESIC	-7.694	-6.400	-7.429	-0.0549	-0.0470	-0.0534
	(-1.59)	(-1.44)	(-1.59)	(-1.68)	(-1.54)	(-1.67)
round	1.575	1.575	1.575	0.00743	0.00743	0.00743
	(1.63)	(1.63)	(1.61)	(1.04)	(1.04)	(1.03)
order	3.236*			0.0199*		
	(3.03)			(2.97)		
treat=2		1.583	1.583		0.0103	0.0103
		(0.94)	(0.94)		(0.92)	(0.91)
treat=3		-1.083	-1.083		-0.0117	-0.0117
		(-0.55)	(-0.55)		(-0.69)	(-0.69)
treat=4		-1.000	-1.000		-0.00374	-0.00374
		(-0.53)	(-0.53)		(-0.30)	(-0.29)
order=2			0.343			-0.00363
			(0.09)			(-0.14)
order=3			5.143			0.0321
			(1.66)			(1.69)
order=4			9.200*			0.0545*
			(2.72)			(2.55)
constant	169.4***	177.5***	174.0***	5.118***	5.169***	5.150***
	(44.07)	(58.57)	(42.05)	(208.98)	(274.58)	(189.74)
observations	200	200	200	200	200	200
clusters	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.2 Learning effects in balanced markets

The following regression directly tests whether previous experience of a particular market affects current outcome of a different market:

$$y_i = \beta_1 \cdot \text{round}_i + \beta_2 \cdot \text{playedEA6}_i + \beta_3 \cdot \text{playedNA6}_i + \beta_4 \cdot \text{playedEM6}_i + \beta_5 \cdot \text{playedNM6}_i + c + \varepsilon_g,$$

where y_i is the variable of interest restricted to each of the four types of markets (in columns (1)-(4)), and its log (in columns (5)–(8)). Tables B4, B5, and B6 show the results for matched pairs, efficiently matched pairs, and surplus, respectively.

There are minimal experience effects. The only significant effects of experience are that having played AN reduces the number of efficiently matched pairs in AE (by 0.425), and having played NM increases the number of matched pairs in AE (by 0.167) and increases the number of efficiently matched pairs in EM (by 0.541). However, these effects disappear for the logged number of matched or efficiently matched pairs.

Table B4: Learning effects on number of matched pairs in balanced markets: wave 1

	(1) AE6	(2) AN6	(3) ME6	(4) MN6	(5) log(y)	(6) log(y)	(7) log(y)	(8) log(y)
playedAE	0	0.0816	0.0204	0.0612	0	0.0331	0.00827	0.0248
	(.)	(0.63)	(0.19)	(0.51)	(.)	(0.63)	(0.19)	(0.51)
playedAN	-0.0714	0	0.136	-0.0408	-0.0290	0	0.0552	-0.00970
	(-0.78)	(.)	(1.16)	(-0.47)	(-0.78)	(.)	(1.16)	(-0.27)
playedME	0.0476	-0.0238	0	-0.0476	0.0193	-0.00965	0	-0.0193
	(0.77)	(-0.19)	(.)	(-0.53)	(0.77)	(-0.19)	(.)	(-0.46)
playedMN	0.167	0.143	0.105	0	0.0676	0.0579	0.0428	0
	(1.56)	(1.15)	(0.96)	(.)	(1.56)	(1.15)	(0.96)	(.)
round	0.0220	0.0110	0.0234	0.00962	0.00891	0.00446	0.00947	0.00548
	(1.85)	(0.78)	(1.51)	(0.46)	(1.85)	(0.78)	(1.51)	(0.59)
constant	2.648***	2.457***	2.549***	2.447***	0.956***	0.878***	0.916***	0.863***
	(24.64)	(22.94)	(21.81)	(23.62)	(21.94)	(20.23)	(19.32)	(17.67)
observations	182	182	182	182	182	182	182	182
clusters	26	26	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B4': Learning effects on number of matched pairs in balanced markets: wave 2

	(1) AE6	(2) AN6	(3) ME6	(4) MN6	(5) log(y)	(6) log(y)	(7) log(y)	(8) log(y)
playedAE	0	-0.0155	0.0340	0.227	0	-0.00629	0.0138	0.0889
	(.)	(-0.10)	(1.02)	(1.89)	(.)	(-0.10)	(1.02)	(1.80)
playedAN	0.00465	0	0.00644	0.262	0.00255	0	0.00261	0.115
	(0.62)	(.)	(0.59)	(1.83)	(0.62)	(.)	(0.59)	(1.90)
playedME	0.102	0.130	0	0.137	0.0562	0.0528	0	0.0390
	(1.10)	(1.85)	(.)	(0.71)	(1.10)	(1.85)	(.)	(0.43)
playedMN	0.0233	-0.0806	0.00129	0	0.0128	-0.0327	0.000522	0
	(0.62)	(-1.70)	(0.59)	(.)	(0.62)	(-1.70)	(0.59)	(.)
round	0.0372	0.0216	0.0192	0.0294	0.0204	0.00874	0.00777	0.00867
	(0.88)	(0.56)	(0.92)	(0.67)	(0.88)	(0.56)	(0.92)	(0.43)
constant	2.819***	2.841***	2.926***	2.452***	0.999***	1.034***	1.069***	0.877***
	(16.24)	(35.40)	(39.31)	(23.16)	(10.48)	(31.78)	(35.41)	(20.46)
observations	50	50	50	50	50	50	50	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B5: Learning effects on number of efficiently matched pairs in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE6	AN6	ME6	MN6	log(y+1)	log(y+1)	log(y+1)	log(y+1)
playedAE	0	0.204	-0.245	1.44e-16	0	0.0601	-0.123	0.00693
	(.)	(0.99)	(-0.69)	(0.00)	(.)	(0.65)	(-0.83)	(0.09)
playedAN	-0.425	0	0.109	-0.119	-0.175	0	0.0343	-0.0367
	(-1.15)	(.)	(0.43)	(-0.56)	(-1.09)	(.)	(0.38)	(-0.38)
playedME	0.190	-0.190	0	0.0238	0.0592	-0.0729	0	-0.0137
	(1.72)	(-0.59)	(.)	(0.09)	(1.41)	(-0.58)	(.)	(-0.13)
playedMN	0.316	0.544	0.541	0	0.137	0.214	0.225	0
	(1.01)	(1.75)	(1.68)	(.)	(1.04)	(1.74)	(1.65)	(.)
round	0.00137	0.0549	0.0302	0.0865^{**}	-0.00550	0.0227	0.0104	0.0363^{*}
	(0.05)	(1.32)	(1.29)	(3.06)	(-0.43)	(1.24)	(1.28)	(2.55)
constant	2.322^{***}	1.325^{***}	2.290^{***}	1.264^{***}	1.144^{***}	0.762^{***}	1.149^{***}	0.732^{***}
	(8.31)	(6.93)	(11.44)	(5.71)	(10.16)	(8.79)	(16.78)	(8.41)
observations	182	182	182	182	182	182	182	182
clusters	26	26	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B5’: Learning effects on number of efficiently matched pairs in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE6	AN6	ME6	MN6	log(y+1)	log(y+1)	log(y+1)	log(y+1)
playedAE	0	-0.433	$1.77e-17^{*}$	0.0667	0	-0.208	$-7.10e-17^{***}$	0.0423
	(.)	(-1.16)	(2.93)	(0.17)	(.)	(-1.35)	(-35.18)	(0.27)
playedAN	0.133	0	0.200	-0.0667	0.0462	0	0.0654	1.06e-16
	(1.11)	(.)	(1.93)	(-0.18)	(1.11)	(.)	(1.81)	(0.00)
playedME	-0.133	0.767	0	0.900^{*}	-0.0462	0.277	0	0.402
	(-1.11)	(1.17)	(.)	(2.31)	(-1.11)	(1.07)	(.)	(2.17)
playedMN	0.200	-2.04e-17	-2.22e-18	0	0.0693	0.0693	$4.62e-17^{***}$	0
	(1.29)	(-0.00)	(-0.25)	(.)	(1.29)	(0.31)	(15.19)	(.)
round	0.0800	0.0700	-0.0200	0.290	0.0277	0.0277	-0.00811	0.108
	(1.44)	(0.71)	(-0.41)	(1.99)	(1.44)	(0.77)	(-0.50)	(1.73)
constant	2.640^{***}	1.793^{**}	2.840^{***}	0.520	1.262^{***}	0.915^{***}	1.337^{***}	0.379^{*}
	(11.16)	(4.44)	(33.16)	(1.62)	(15.39)	(5.69)	(52.37)	(2.62)
observations	50	50	50	50	50	50	50	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B6: Learning effects on surplus in balanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE6	AN6	ME6	MN6	log(y)	log(y)	log(y)	log(y)
playedAE	5.345	6.010	5.079	9.266	0.0369	0.0348	0.0346	0.0677
	(0.86)	(0.78)	(0.79)	(1.12)	(0.87)	(0.74)	(0.87)	(1.35)
playedAN	-1.541	2.537	14.88	-3.021	-0.00676	0.0193	0.0980	-0.0150
	(-0.18)	(0.29)	(1.71)	(-0.55)	(-0.12)	(0.35)	(1.76)	(-0.42)
playedME	3.949	0.508	-12.06	-2.375	0.0254	0.00858	-0.0785	-0.0173
	(0.82)	(0.05)	(-1.59)	(-0.40)	(0.80)	(0.15)	(-1.62)	(-0.37)
playedMN	5.854	6.792	-4.591	2.477	0.0345	0.0384	-0.0353	0.0259
	(0.88)	(0.92)	(-0.43)	(0.36)	(0.85)	(0.87)	(-0.51)	(0.59)
round	0.816	0.809	3.093*	0.803	0.00490	0.00426	0.0197*	0.00497
	(0.62)	(0.63)	(2.24)	(0.74)	(0.55)	(0.54)	(2.25)	(0.71)
constant	178.1***	164.4***	163.9***	166.8***	5.161***	5.089***	5.070***	5.094***
	(26.10)	(27.39)	(17.37)	(25.40)	(124.22)	(142.58)	(83.29)	(105.28)
observations	182	182	182	182	182	182	182	182
clusters	26	26	26	26	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B6': Learning effects on surplus in balanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE6	AN6	ME6	MN6	log(y)	log(y)	log(y)	log(y)
playedAE	0	-6.333*	-8.33e-17	9.000	0	-0.0349*	1.25e-17***	0.0535
	(.)	(-2.52)	(-0.00)	(1.96)	(.)	(-2.70)	(13.19)	(1.90)
playedAN	0.667	0	4.667	12.67	0.00342	0	0.0272	0.0990
	(1.11)	(.)	(1.40)	(1.81)	(1.11)	(.)	(1.36)	(1.61)
playedME	-0.667	8.667*	0	-3.667	-0.00342	0.0482*	0	-0.0495
	(-1.11)	(2.46)	(.)	(-0.42)	(-1.11)	(2.59)	(.)	(-0.73)
playedMN	9.000	5.000*	1.11e-16	0	0.0598	0.0282**	-1.28e-18*	0
	(1.29)	(2.87)	(0.00)	(.)	(1.29)	(3.60)	(-3.12)	(.)
round	2	1	1	2.300	0.0130	0.00562	0.00611	0.00501
	(1.07)	(0.64)	(0.77)	(0.82)	(1.05)	(0.63)	(0.80)	(0.21)
constant	185***	184.3***	192.3***	170.1***	5.200***	5.211***	5.253***	5.155***
	(15.68)	(42.63)	(27.55)	(16.78)	(66.35)	(208.86)	(126.34)	(65.84)
observations	50	50	50	50	50	50	50	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.3 Determinants of outcomes in all markets

To check the robustness of our results regarding Hypothesis 4, we present the results from regressions with alternative dependent variables and alternative specifications: We consider (i) the outcomes of interest directly as dependent variables in addition to their logged values, and (ii) the following specifications:

$$
\begin{aligned}
(1) \qquad y_i = {} & \beta_1 \text{assortative}_i + \beta_2 \text{ESIC}_i + \beta_3 \text{balanced}_i + \beta_4 \text{assortative}_i \text{ESIC}_i + \beta_5 \text{assortative}_i \text{balanced}_i \\
& + \beta_6 \text{round}_i + \beta_7 \text{round}_i \text{balanced}_i + \beta_8 \text{order}_i + \beta_9 \text{order}_i \text{balanced}_i + c + \varepsilon_g, \\
(2) \qquad y_i = {} & \beta_1 \text{assortative}_i + \beta_2 \text{ESIC}_i + \beta_3 \text{balanced}_i + \beta_4 \text{assortative}_i \text{ESIC}_i + \beta_5 \text{assortative}_i \text{balanced}_i \\
& + \beta_6 \text{round}_i + \beta_7 \text{round}_i \text{balanced}_i \\
& + \beta_8 (\text{treat}_i = 2) + \beta_9 (\text{treat}_i = 3) + \beta_{10} (\text{treat}_i = 4) + c + \varepsilon_g \\
& + \beta_{11} (\text{treat}_i = 2) \text{balanced}_i + \beta_{12} (\text{treat}_i = 3) \text{balanced}_i + \beta_{13} (\text{treat}_i = 4) \text{balanced}_i, \\
(3) \qquad y_i = {} & \beta_1 \text{assortative}_i + \beta_2 \text{ESIC}_i + \beta_3 \text{balanced}_i + \beta_4 \text{assortative}_i \text{ESIC}_i + \beta_5 \text{assortative}_i \text{balanced}_i \\
& + \beta_6 \text{round}_i + \beta_7 \text{round}_i \text{balanced}_i + \beta_8 \text{order}_i + \beta_9 \text{order}_i \text{balanced}_i \\
& + \beta_{10} (\text{treat}_i = 2) + \beta_{11} (\text{treat}_i = 3) + \beta_{12} (\text{treat}_i = 4) + c + \varepsilon_g \\
& + \beta_{13} (\text{treat}_i = 2) \text{balanced}_i + \beta_{14} (\text{treat}_i = 3) \text{balanced}_i + \beta_{15} (\text{treat}_i = 4) \text{balanced}_i,
\end{aligned}
$$

where i is the index of a game (out of 728 balanced markets); y_i is the variable of interest or its log (or log of #efficient matches+1); assortative$_i$ is the indicator of whether the market played in the game is assortative; ESIC$_i$ is the indicator of whether the market has equal-splits in the core; round$_i$ is the round (out of 7) the same market has been played; order$_i$ is the order (out of 4) the game is played in; treat$_i$ is the treatment order (out of 4).

The results are very stable across the different specifications.

Table B7 shows the determinants of the number of matched pairs when both balanced and imbalanced markets are considered. Assortativity and ESIC continue to have significant influences on market outcome: Assortative markets have 0.104 (or 4.10%) more matched pairs, and ESIC markets have 0.324 to 0.327 (or 13.5% to 13.6%) more matched pairs. An additional player in the imbalanced markets increases the number of matched pairs. In particular, 0.336 to 0.324 more pairs are matched in in the imbalanced markets on average, which increases the matching rate by 14.1% to 17.7%.

Tables B8 shows that assortativity does not increase the number of efficiently matched pairs at a statistically significant level. In comparison, having equal-splits in the core increases the number of efficiently matched pairs by 0.989 to 0.995 (or by 38.5% to 38.7%). Market thickness increases the number of efficiently matched pairs by 0.702 to 1.02 (or by 25.9% to 38.6%). Note that there are significantly more efficiently matched pairs in balanced assortative (EA6 and NA6) markets.

Tables B9 shows that assortativity increases surplus by 4.32%; having equal-splits in the core increases surplus by 7.61% to 7.78%; and market thickness increases surplus by 6.2% to 10.1%, and all are statistically significant at at least the 95% significance level.

Table B7: Determinants of number of matched pairs, all markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	0.104**	0.104**	0.104**	0.0410**	0.0410**	0.0410**
	(2.97)	(2.96)	(2.96)	(2.83)	(2.83)	(2.83)
ESIC	0.328***	0.324***	0.328***	0.136***	0.135***	0.136***
	(4.69)	(4.60)	(4.68)	(4.81)	(4.71)	(4.80)
bal(anced)	-0.336***	-0.336***	-0.424***	-0.141***	-0.140***	-0.177***
	(-3.63)	(-6.18)	(-4.81)	(-3.58)	(-6.26)	(-4.79)
assortative*ESIC	-0.101	-0.0934	-0.101	-0.0441	-0.0410	-0.0441
	(-1.41)	(-1.28)	(-1.41)	(-1.55)	(-1.40)	(-1.54)
assortative*bal	0.0795	0.0723	0.0795	0.0365	0.0335	0.0365
	(1.34)	(1.18)	(1.34)	(1.51)	(1.33)	(1.50)
round	0.0335***	0.0335***	0.0335***	0.0138***	0.0138***	0.0138***
	(4.73)	(4.73)	(4.72)	(4.67)	(4.66)	(4.66)
round*bal	-0.0170	-0.0170	-0.0170	-0.00675	-0.00675	-0.00675
	(-1.79)	(-1.79)	(-1.79)	(-1.71)	(-1.71)	(-1.70)
order	0.0136		0.0136	0.00571		0.00571
	(0.83)		(0.83)	(0.84)		(0.84)
order*bal	0.0338		0.0338	0.0142		0.0142
	(1.39)		(1.39)	(1.42)		(1.41)
treat2		-0.0429	-0.0429		-0.0174	-0.0174
		(-1.53)	(-1.53)		(-1.53)	(-1.53)
treat3		-0.0571	-0.0571		-0.0232	-0.0232
		(-1.51)	(-1.51)		(-1.51)	(-1.51)
treat4		-0.121	-0.121		-0.0513	-0.0513
		(-1.79)	(-1.79)		(-1.76)	(-1.76)
treat2*bal		0.0378	0.0378		0.0153	0.0153
		(0.69)	(0.69)		(0.69)	(0.69)
treat3*bal		0.0963	0.0963		0.0373	0.0373
		(1.36)	(1.36)		(1.25)	(1.25)
treat4*bal		0.232**	0.232**		0.0944**	0.0944**
		(2.94)	(2.94)		(2.81)	(2.81)
constant	2.582***	2.671***	2.638***	0.928***	0.965***	0.951***
	(35.76)	(71.56)	(41.12)	(30.67)	(63.41)	(35.95)
observations	1,288	1,288	1,288	1,288	1,288	1,288
clusters	46	46	46	46	46	46

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B7': Determinants of number of matched pairs, all markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	0.000115	2.15e-15	3.03e-15	0.0000467	8.39e-16	1.20e-15
	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
ESIC	0.270**	0.260**	0.270**	0.116**	0.111**	0.116**
	(3.63)	(3.58)	(3.60)	(3.40)	(3.40)	(3.37)
bal(anced)	-0.504***	-0.345**	-0.474**	-0.216***	-0.150**	-0.209**
	(-4.77)	(-3.61)	(-3.68)	(-4.53)	(-3.43)	(-3.37)
assortative*ESIC	-0.201*	-0.180**	-0.201*	-0.0939*	-0.0845**	-0.0939*
	(-2.66)	(-2.89)	(-2.64)	(-2.68)	(-2.96)	(-2.66)
assortative*bal	0.160*	0.160	0.160*	0.0706*	0.0706	0.0706*
	(2.65)	(2.04)	(2.63)	(2.72)	(2.07)	(2.70)
round	-0.00250	-0.00250	-0.00250	-0.00101	-0.00101	-0.00101
	(-0.44)	(-0.43)	(-0.43)	(-0.44)	(-0.43)	(-0.43)
round*bal	0.0350	0.0350	0.0350	0.0142	0.0142	0.0142
	(1.85)	(1.84)	(1.84)	(1.60)	(1.59)	(1.59)
order	0.0000659		1.48e-15	0.0000267		5.03e-16
	(0.03)		(0.00)	(0.03)		(0.00)
order*bal	0.0516*		0.0516*	0.0235*		0.0235*
	(2.40)		(2.38)	(2.28)		(2.26)
treat2		-0.0167	-0.0167		-0.00676	-0.00676
		(-1.17)	(-1.17)		(-1.17)	(-1.17)
treat3		1.68e-15	1.42e-15		7.86e-16	6.88e-16
		(0.00)	(0.00)		(0.00)	(0.00)
treat4		-0.0250	-0.0250		-0.0101	-0.0101
		(-1.36)	(-1.35)		(-1.36)	(-1.35)
treat2*bal		0.00833	0.00833		0.0106	0.0106
		(0.12)	(0.12)		(0.33)	(0.33)
treat3*bal		-0.0917	-0.0917		-0.0348	-0.0348
		(-1.60)	(-1.60)		(-1.18)	(-1.18)
treat4*bal		-0.0250	-0.0250		-0.00294	-0.00294
		(-0.41)	(-0.41)		(-0.10)	(-0.10)
constant	2.997***	3.007***	3.007***	1.097***	1.102***	1.102***
	(167.62)	(122.68)	(161.80)	(151.37)	(110.83)	(146.17)
observations	399	399	399	399	399	399
clusters	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B8: Determinants of number of efficiently matched pairs, all markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y+1)	log(y+1)	log(y+1)
assortative	0.139	0.139	0.139	0.0645*	0.0645*	0.0645*
	(1.75)	(1.68)	(1.74)	(2.16)	(2.07)	(2.16)
ESIC	0.995***	0.989***	0.995***	0.387***	0.385***	0.387***
	(8.30)	(8.04)	(8.29)	(7.61)	(7.43)	(7.59)
bal(anced)	-0.702**	-0.956***	-1.020***	-0.259**	-0.374***	-0.386***
	(-3.41)	(-5.19)	(-3.91)	(-3.16)	(-5.29)	(-3.73)
assortative*ESIC	-0.309*	-0.297	-0.309*	-0.135*	-0.131*	-0.135*
	(-2.14)	(-1.96)	(-2.13)	(-2.34)	(-2.22)	(-2.34)
assortative*bal	0.241	0.229	0.241	0.0835	0.0795	0.0835
	(1.62)	(1.49)	(1.62)	(1.39)	(1.29)	(1.39)
round	0.0786***	0.0786***	0.0786***	0.0296***	0.0296***	0.0296***
	(5.10)	(5.09)	(5.09)	(5.05)	(5.04)	(5.03)
round*bal	-0.0353	-0.0353	-0.0353	-0.0136	-0.0136	-0.0136
	(-1.65)	(-1.65)	(-1.65)	(-1.60)	(-1.59)	(-1.59)
order	0.0550		0.0550	0.0217		0.0217
	(1.67)		(1.67)	(1.70)		(1.70)
order*bal	0.0234		0.0234	0.00405		0.00405
	(0.49)		(0.49)	(0.21)		(0.21)
treat2		-0.114	-0.114		-0.0462	-0.0462
		(-1.29)	(-1.29)		(-1.44)	(-1.44)
treat3		-0.143	-0.143		-0.0540	-0.0540
		(-1.33)	(-1.33)		(-1.36)	(-1.35)
treat4		-0.379**	-0.379**		-0.141*	-0.141*
		(-2.77)	(-2.77)		(-2.69)	(-2.68)
treat2*bal		0.145	0.145		0.0655	0.0655
		(0.53)	(0.53)		(0.59)	(0.59)
treat3*bal		0.422	0.422		0.168	0.168
		(1.79)	(1.79)		(1.79)	(1.79)
treat4*bal		0.753**	0.753**		0.296**	0.296**
		(3.20)	(3.20)		(3.13)	(3.13)
constant	1.805***	2.102***	1.964***	0.941***	1.055***	1.001***
	(11.73)	(21.43)	(14.25)	(15.53)	(29.80)	(19.16)
observations	1,288	1,288	1,288	1,288	1,288	1,288
clusters	46	46	46	46	46	46

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B8': Determinants of number of efficiently matched pairs, all markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y+1)	log(y+1)	log(y+1)
assortative	-0.257**	-0.266**	-0.256*	-0.0927*	-0.0962**	-0.0923*
	(-2.89)	(-2.97)	(-2.84)	(-2.83)	(-2.92)	(-2.78)
ESIC	1.161***	1.140***	1.161***	0.451***	0.441***	0.451***
	(7.51)	(6.11)	(7.45)	(6.72)	(5.38)	(6.67)
bal(anced)	-1.287***	-1.337***	-1.493***	-0.519***	-0.523***	-0.596***
	(-4.84)	(-8.57)	(-5.54)	(-4.90)	(-8.10)	(-5.72)
assortative*ESIC	-0.123	-0.0800	-0.123	-0.0441	-0.0254	-0.0441
	(-0.51)	(-0.36)	(-0.51)	(-0.44)	(-0.26)	(-0.44)
assortative*bal	0.314	0.326	0.312	0.108	0.113	0.108
	(1.37)	(1.32)	(1.35)	(1.14)	(1.06)	(1.12)
round	0.0183	0.0275	0.0181	0.00658	0.0103	0.00654
	(0.68)	(1.04)	(0.67)	(0.64)	(0.98)	(0.63)
round*bal	0.0645	0.0775	0.0646	0.0225	0.0286	0.0226
	(1.36)	(1.84)	(1.35)	(1.20)	(1.72)	(1.19)
order	0.0738		0.0748	0.0295		0.0298
	(1.09)		(1.10)	(1.29)		(1.30)
order*bal	0.104		0.103	0.0484		0.0481
	(0.90)		(0.88)	(1.09)		(1.08)
treat2		-0.133	-0.133		-0.0510	-0.0510
		(-0.96)	(-0.96)		(-1.07)	(-1.07)
treat3		-0.277	-0.279		-0.0949	-0.0957
		(-1.88)	(-1.91)		(-1.75)	(-1.79)
treat4		-0.292*	-0.292*		-0.112**	-0.112**
		(-2.51)	(-2.50)		(-2.99)	(-2.99)
treat2*bal		0.275	0.275		0.110	0.110
		(1.24)	(1.24)		(1.30)	(1.30)
treat3*bal		0.436*	0.438**		0.160*	0.161*
		(2.85)	(2.88)		(2.68)	(2.71)
treat4*bal		0.117	0.117		0.0352	0.0352
		(0.95)	(0.94)		(0.88)	(0.87)
constant	2.493***	2.767***	2.644***	1.206***	1.310***	1.261***
	(14.87)	(22.22)	(13.49)	(19.55)	(27.97)	(17.71)
observations	399	399	399	399	399	399
clusters	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B9: Determinants of surplus, all markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	6.786*	6.786*	6.786*	0.0432*	0.0432*	0.0432*
	(2.60)	(2.57)	(2.59)	(2.60)	(2.57)	(2.59)
ESIC	13.94***	13.68**	13.94***	0.0778**	0.0761**	0.0778**
	(3.63)	(3.50)	(3.62)	(3.31)	(3.18)	(3.31)
bal(anced)	-12.66*	-10.88*	-17.12**	-0.0746	-0.0620*	-0.101*
	(-2.20)	(-2.59)	(-2.90)	(-1.92)	(-2.30)	(-2.61)
assortative*ESIC	-1.232	-0.714	-1.232	-0.00706	-0.00370	-0.00706
	(-0.33)	(-0.19)	(-0.33)	(-0.32)	(-0.16)	(-0.32)
assortative*bal	-0.00466	-0.522	-0.00466	-0.00210	-0.00545	-0.00210
	(-0.00)	(-0.14)	(-0.00)	(-0.09)	(-0.22)	(-0.09)
round	2.121***	2.121***	2.121***	0.0130***	0.0130***	0.0130***
	(4.82)	(4.81)	(4.81)	(4.72)	(4.71)	(4.71)
round*bal	-0.805	-0.805	-0.805	-0.00455	-0.00455	-0.00455
	(-1.43)	(-1.43)	(-1.43)	(-1.28)	(-1.28)	(-1.28)
order	0.971		0.971	0.00694		0.00694
	(0.89)		(0.89)	(1.02)		(1.02)
order*bal	2.391		2.391	0.0149		0.0149
	(1.57)		(1.57)	(1.56)		(1.56)
treat2		-2.786	-2.786		-0.0208	-0.0208
		(-0.87)	(-0.87)		(-0.98)	(-0.98)
treat3		-2.929	-2.929		-0.0166	-0.0166
		(-0.92)	(-0.92)		(-0.85)	(-0.85)
treat4		-10.29*	-10.29*		-0.0633	-0.0633
		(-2.03)	(-2.03)		(-1.95)	(-1.95)
treat2*bal		0.592	0.592		0.00702	0.00702
		(0.14)	(0.14)		(0.25)	(0.25)
treat3*bal		3.133	3.133		0.0145	0.0145
		(0.60)	(0.60)		(0.43)	(0.43)
treat4*bal		14.66*	14.66*		0.0865*	0.0865*
		(2.61)	(2.61)		(2.40)	(2.40)
constant	168.8***	175.3***	172.8***	5.106***	5.149***	5.132***
	(36.80)	(50.05)	(37.31)	(170.27)	(234.75)	(175.36)
observations	1,288	1,288	1,288	1,288	1,288	1,288
clusters	46	46	46	46	46	46

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B9': Determinants of surplus, all markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)
	y	y	y	log(y)	log(y)	log(y)
assortative	-0.823	-0.853	-0.820	-0.00359	-0.00378	-0.00358
	(-0.80)	(-0.84)	(-0.79)	(-0.64)	(-0.68)	(-0.63)
ESIC	16.95***	16.40***	16.95***	0.103**	0.0999**	0.103**
	(4.78)	(4.38)	(4.75)	(3.80)	(3.62)	(3.77)
bal(anced)	-24.87***	-19.23***	-26.02***	-0.145***	-0.111***	-0.151***
	(-5.84)	(-5.63)	(-5.97)	(-5.64)	(-5.31)	(-5.67)
assortative*ESIC	-7.504	-6.400	-7.504	-0.0535	-0.0470	-0.0535
	(-1.67)	(-1.48)	(-1.66)	(-1.76)	(-1.58)	(-1.75)
assortative*bal	6.531	6.653	6.528	0.0452	0.0459	0.0452
	(1.75)	(1.34)	(1.73)	(1.76)	(1.40)	(1.75)
round	-0.0315	6.83e-14	-0.0317	0.0000310	0.000223	0.0000304
	(-0.06)	(0.00)	(-0.06)	(0.01)	(0.07)	(0.01)
round*bal	1.031	1.575	1.032	0.00397	0.00721	0.00397
	(0.97)	(1.46)	(0.96)	(0.53)	(0.94)	(0.53)
order	0.252		0.254	0.00154		0.00154
	(0.41)		(0.41)	(0.46)		(0.46)
order*bal	4.349**		4.347**	0.0259**		0.0259**
	(2.94)		(2.92)	(2.99)		(2.97)
treat2		-2.333	-2.333		-0.0141	-0.0141
		(-0.73)	(-0.73)		(-0.75)	(-0.75)
treat3		-1.451	-1.457		-0.00731	-0.00735
		(-1.20)	(-1.21)		(-1.10)	(-1.10)
treat4		-1.083	-1.083		-0.00564	-0.00564
		(-1.23)	(-1.22)		(-1.21)	(-1.20)
treat2*bal		3.917	3.917		0.0244	0.0244
		(1.09)	(1.09)		(1.13)	(1.12)
treat3*bal		0.367	0.374		-0.00441	-0.00437
		(0.16)	(0.17)		(-0.25)	(-0.25)
treat4*bal		0.0833	0.0833		0.00191	0.00191
		(0.04)	(0.04)		(0.15)	(0.14)
constant	195.1***	196.8***	196.3***	5.271***	5.280***	5.277***
	(83.92)	(113.94)	(92.98)	(372.19)	(528.62)	(439.86)
observations	399	399	399	399	399	399
clusters	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.4 Learning effects in imbalanced markets

The following regression directly tests whether previous experience of a particular market affects the outcome of a different market:

$$y_i = \beta_1 \cdot \text{round}_i + \beta_2 \cdot \text{playedEA7}_i + \beta_3 \cdot \text{playedNA7}_i + \beta_4 \cdot \text{playedEM7}_i + \beta_5 \cdot \text{playedNM7}_i + c + \varepsilon_g,$$

where y_i is the variable of interest restricted to each of the four types of markets (in columns (1)-(4)), and its log (in columns (5)–(8)). Tables B4, B5, and B6 show the results for matched pairs, efficiently matched pairs, and surplus, respectively.

There are mild experience effects in imbalanced markets. The only statistically significant effects of experience are (i) having played EA7 increases the number of matched pairs in EA7 (by 0.200, or 8.11%), (ii) having played NM7 reduces the number of matched pairs in EM7 (by 0.143, or 5.79%) and reduces the number of efficiently matched pairs in EM7 (by 0.657, or 23.6%). They are significant at the 95% significance level, but not at the 99% or the 99.9% level.

Table B10: Learning effects on number of matched pairs in unbalanced markets: wave 1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE7	AN7	ME7	MN7	log	log	log	log
playedAE	0	0.0286	0.200*	9.21e-17	0	0.0116	0.0811*	-6.77e-18
	(.)	(0.23)	(2.75)	(0.00)	(.)	(0.23)	(2.75)	(-0.00)
playedAN	0.0571	0	-0.114	0.0571	0.0232	0	-0.0463	0.0232
	(1.75)	(.)	(-1.36)	(0.43)	(1.75)	(.)	(-1.36)	(0.43)
playedME	0.114	1.15e-17	0	0.0857	0.0546	-1.92e-16	0	0.0348
	(1.36)	(0.00)	(.)	(0.53)	(1.37)	(-0.00)	(.)	(0.53)
playedMN	-0.114	-0.0857	-0.143**	0	-0.0546	-0.0348	-0.0579**	0
	(-1.22)	(-0.57)	(-3.80)	(.)	(-1.26)	(-0.57)	(-3.80)	(.)
round	0.0321*	0.0250	0.00714	0.0696***	0.0141	0.0101	0.00290	0.0282***
	(2.10)	(1.25)	(0.57)	(4.16)	(2.07)	(1.25)	(0.57)	(4.16)
constant	2.814***	2.700***	2.857***	2.264***	1.019***	0.977***	1.041***	0.800***
	(27.98)	(18.74)	(40.87)	(19.24)	(24.11)	(16.72)	(36.71)	(16.77)
observations	140	140	140	140	140	140	140	140
clusters	20	20	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B10': Learning effects on number of matched pairs in unbalanced markets: wave 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	AE7	AN7	ME7	MN7	log	log	log	log
playedAE	0	0	0	0.0667	0	0	0	0.0270
	(.)	(.)	(.)	(1.11)	(.)	(.)	(.)	(1.11)
playedAN	6.34e-19	0	0	-0.0667	2.40e-18	0	0	-0.0270
	(0.14)	(.)	(.)	(-1.11)	(0.01)	(.)	(.)	(-1.11)
playedME	0.100	0	0	-9.07e-18	0.0405	0	0	4.41e-18
	(1.29)	(.)	(.)	(-0.46)	(1.29)	(.)	(.)	(0.45)
playedMN	-0.100	0	0	0	-0.0405	0	0	0
	(-1.29)	(.)	(.)	(.)	(-1.29)	(.)	(.)	(.)
round	-0.0200	0	0	0.0100	-0.00811	0	0	0.00405
	(-0.96)	(.)	(.)	(0.96)	(-0.96)	(.)	(.)	(0.96)
constant	3.060***	3	3	2.970***	1.123***	1.099	1.099	1.086***
	(48.87)	(.)	(.)	(94.87)	(44.23)	(.)	(.)	(85.59)
observations	50	50	49	50	50	50	49	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B11: Learning effects on number of efficiently matched pairs in unbalanced markets: wave 1

	(1) AE7	(2) AN7	(3) ME7	(4) MN7	(5) log	(6) log	(7) log	(8) log
playedAE	0	0.0286	0.314	0.286*	0	0.0183	0.107	0.122*
	(.)	(0.11)	(1.87)	(2.26)	(.)	(0.19)	(1.88)	(2.37)
playedAN	0.286*	0	-0.0857	0.0571	0.112*	0	-0.0247	0.0164
	(2.60)	(.)	(-0.48)	(0.23)	(2.65)	(.)	(-0.39)	(0.17)
playedME	0.314	-0.0286	0	0.229	0.0990	0.0149	0	0.0807
	(1.71)	(-0.10)	(.)	(0.89)	(1.49)	(0.14)	(.)	(0.77)
playedMN	-0.429	0.143	-0.657**	0	-0.148	0.0396	-0.236**	0
	(-1.82)	(0.40)	(-3.51)	(.)	(-1.85)	(0.29)	(-3.29)	(.)
round	0.0482	0.100*	0.0161	0.150**	0.0200	0.0356*	0.00257	0.0601**
	(1.40)	(2.73)	(0.45)	(3.47)	(1.49)	(2.49)	(0.20)	(3.16)
constant	2.464***	1.743***	2.536***	1.114***	1.191***	0.939***	1.241***	0.659***
	(10.25)	(8.53)	(11.74)	(6.22)	(14.00)	(11.38)	(16.12)	(7.67)
observations	140	140	140	140	140	140	140	140
clusters	20	20	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B11': Learning effects on number of efficiently matched pairs in unbalanced markets: wave 2

	(1) AE7	(2) AN7	(3) ME7	(4) MN7	(5) log	(6) log	(7) log	(8) log
playedAE	0	0.200	0.133	0.267	0	0.0924	0.0541	0.0924
	(.)	(0.61)	(0.79)	(2.23)	(.)	(0.80)	(0.88)	(2.23)
playedAN	0.367	0	0.311	-0.0667	0.133*	0	0.105	-0.0231
	(2.08)	(.)	(1.95)	(-0.34)	(2.34)	(.)	(1.78)	(-0.34)
playedME	0.300	0.200	0	9.47e-17	0.139*	0.0811	0	-1.43e-17
	(1.72)	(1.29)	(.)	(0.00)	(3.11)	(1.29)	(.)	(-0.00)
playedMN	-0.600*	-0.400	0.0333	0	-0.237*	-0.146*	0.00566	0
	(-2.31)	(-2.23)	(0.34)	(.)	(-3.02)	(-2.49)	(0.15)	(.)
round	0.0200	0.0800	-0.0500	0.0600	-1.49e-18	0.0347	-0.0144	0.0208
	(0.18)	(0.90)	(-0.62)	(1.10)	(-0.00)	(0.95)	(-0.54)	(1.10)
constant	2.540***	2.160***	2.372***	2.620***	1.248***	1.059***	1.166***	1.255***
	(6.11)	(5.30)	(9.56)	(13.76)	(8.01)	(6.26)	(14.09)	(19.01)
observations	50	50	49	50	50	50	49	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B12: Learning effects on surplus in unbalanced markets: wave 1

	(1) AE7	(2) AN7	(3) ME7	(4) MN7	(5) log	(6) log	(7) log	(8) log
playedAE	0	-1.429	13.43	4.857	0	-0.00823	0.0888	0.0390
	(.)	(-0.17)	(1.77)	(0.99)	(.)	(-0.16)	(1.72)	(1.14)
playedAN	6.571*	0	-9.429	1.714	0.0370*	0	-0.0644	0.00233
	(2.64)	(.)	(-1.30)	(0.22)	(2.64)	(.)	(-1.29)	(0.05)
playedME	9.429	-0.857	0	7.429	0.0697	-0.00342	0	0.0445
	(1.47)	(-0.10)	(.)	(0.75)	(1.60)	(-0.07)	(.)	(0.71)
playedMN	-10.29	0.571	-17.43**	0	-0.0705	0.00347	-0.100*	0
	(-1.28)	(0.06)	(-2.92)	(.)	(-1.33)	(0.06)	(-2.84)	(.)
round	2.464*	1.964	0.161	3.893**	0.0167*	0.0113	-0.000165	0.0242**
	(2.29)	(2.01)	(0.16)	(3.64)	(2.25)	(1.95)	(-0.03)	(3.24)
constant	181.9***	175.9***	188.8***	151.6***	5.182***	5.158***	5.234***	5.006***
	(22.16)	(24.49)	(39.56)	(23.25)	(97.90)	(117.09)	(172.95)	(111.87)
observations	140	140	140	140	140	140	140	140
clusters	20	20	20	20	20	20	20	20

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B12': Learning effects on surplus in unbalanced markets: wave 2

	(1) AE7	(2) AN7	(3) ME7	(4) MN7	(5) log	(6) log	(7) log	(8) log
playedAE	0	4.667	-3.333	5.333	0	0.0287	-0.0189	0.0321
	(.)	(0.93)	(-1.09)	(1.36)	(.)	(0.97)	(-1.10)	(1.32)
playedAN	0.333	0	3.556	-4.333	0.00143	0	0.0192	-0.0270
	(0.10)	(.)	(1.20)	(-1.08)	(0.08)	(.)	(1.13)	(-1.09)
playedME	4.000	-2.000	0	-3.61e-16	0.0223	-0.0108	0	-2.61e-18
	(1.63)	(-1.29)	(.)	(-0.00)	(1.57)	(-1.29)	(.)	(-0.00)
playedMN	-7.000*	3.45e-15	3.667	0	-0.0380*	0.000370	0.0202	0
	(-2.74)	(0.00)	(1.05)	(.)	(-2.60)	(0.04)	(1.02)	(.)
round	-0.400	1.500	-2	0.900	-0.00241	0.00913	-0.0112	0.00533
	(-0.38)	(0.99)	(-1.10)	(1.19)	(-0.42)	(0.99)	(-1.11)	(1.17)
constant	199.2***	186.8***	197.1***	196.3***	5.295***	5.221***	5.284***	5.277***
	(58.43)	(21.67)	(37.27)	(84.88)	(287.43)	(99.21)	(180.30)	(378.25)
observations	50	50	49	50	50	50	49	50
clusters	10	10	10	10	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.5 First games or first rounds

Since experience with the negotiation has a mild yet statistically significant influence on outcomes, besides controlling for learning effects, we also consider the determinants of the outcomes when the learning effect is minimal. We consider the determinants in the first games subjects play (i.e., the first period of 28) and the first time a particular game is played (i.e., the first round of 7 for each game). The results are presented in Tables B13 and B14. The small number of groups (26) causes the test to lose statistical power. Nevertheless, the results for the first rounds are consistent with the full results with multiple rounds.

Table B13: Determinants of outcomes in balanced markets, first games: wave 1

	(1) log matches	(2) log (efficient matches+1)	(3) log surplus
assortative	-0.106	-0.231	-0.0904
	(-1.00)	(-1.10)	(-1.51)
ESIC	-0.135	0.183	-0.196
	(-1.20)	(0.92)	(-1.57)
assortative*ESIC	0.193	0.329	0.250
	(1.22)	(1.22)	(1.70)
constant	1.031***	0.924***	5.235***
	(15.37)	(6.37)	(156.72)
observations	26	26	26
clusters	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B13': Determinants of outcomes in balanced markets, first games: wave 2

	(1) log matches	(2) log (efficient matches+1)	(3) log surplus
assortative	0.0676	0.144	0.101
	(0.29)	(0.29)	(0.71)
ESIC	0.0676	0.741	0.112
	(0.29)	(1.45)	(0.66)
assortative*ESIC	-0.482	-0.395	-0.281
	(-0.84)	(-0.66)	(-0.85)
constant	0.896***	0.549	5.067***
	(4.84)	(1.10)	(44.18)
observations	10	10	10
clusters	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B14: Determinants of outcomes in balanced markets, first rounds: wave 1

	(1) log matches	(2) log (efficient matches+1)	(3) log surplus
assortative	0.120	0.354**	0.0756
	(1.81)	(3.25)	(1.31)
ESIC	0.151*	0.588***	0.0888
	(2.55)	(5.38)	(1.65)
assortative*ESIC	-0.0888	-0.354*	-0.0274
	(-1.22)	(-2.36)	(-0.42)
order	-0.00173	0.0192	0.0111
	(-0.09)	(0.65)	(0.63)
constant	0.827***	0.557***	5.044***
	(9.48)	(5.49)	(61.89)
observations	104	104	104
clusters	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B14': Determinants of outcomes in balanced markets, first rounds: wave 2

	(1) log matches	(2) log (efficient matches+1)	(3) log surplus
assortative	0.162**	0.306	0.0857*
	(4.02)	(1.67)	(2.92)
ESIC	0.179	0.714**	0.133*
	(2.20)	(4.75)	(2.79)
assortative*ESIC	-0.264	-0.459	-0.138
	(-1.90)	(-1.77)	(-1.53)
order	0.0816	0.107*	0.0585*
	(1.97)	(2.53)	(2.74)
constant	0.692***	0.398	4.995***
	(5.21)	(1.99)	(72.08)
observations	40	40	40
clusters	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.6 Individual payoffs

Figure B1 shows the histogram of payoffs for all efficiently matched individuals. Figure B2a shows the histograms of payoffs for all matched individuals—rather than individuals in efficient matching only, as in the main text—in the balanced and imbalanced markets. Figure B3 shows the average payoffs of men and women in balanced versus imbalanced markets, by time.

B.7 Other experimental results

B.7.1 Proposing activities

Tables B15a and B15b show the frequency distribution of proposals players send to each player on the opposite side in the balanced and imbalanced markets, respectively.

B.7.2 Bargaining activities

Table B16 shows alternative specifications for regression on determinants of the number of proposals for balanced markets. The alternative specifications yield conclusions similar to our leading specification (3), presented in Column (2) of Table 9a.

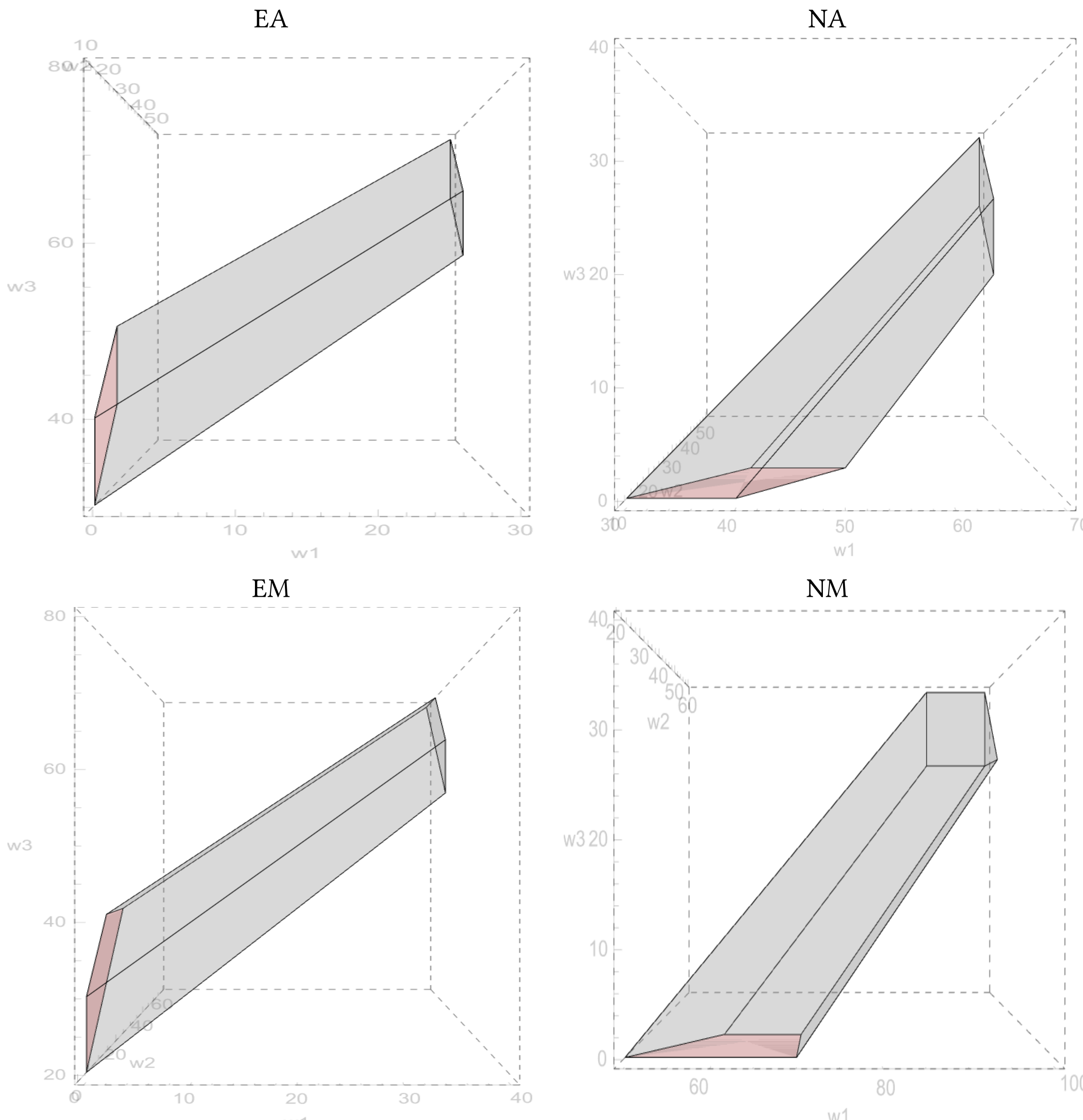
Figure B4 shows the percentage of surplus achieved by time for balanced and imbalanced markets.

Figure B5 reports the word clouds of subjects' responses to the following questions regarding their behavior. In general, subjects are mostly behaving to maximize their payoffs, with very minimal concerns for fairness.

B.7.3 Demographic characteristics

We investigate whether individual characteristics have any effects on the number of matches and payoffs in each configuration. Using regressions with individual fixed effects, Table B17a shows the effect of age, gender, grade, and major on the number of matched pairs a subject reaches in each of the four balanced markets. There is hardly any effect of these characteristics, except that in NA6, subjects from economics or business have a higher number of matches, and in NM6, male students have a higher number of matches. In Table B17b, we can see the effects of these characteristics on payoffs, and only male students in the NM6 game earn a higher payoff compared with female students. For the imbalanced markets, Tables B18a and B18b present the effect of these individual characteristics on the number of matched pairs and payoffs, respectively. The only significant finding is that male students earn less than female students in NA7. These results indicate a modest role of gender and major in the two-sided matching markets.

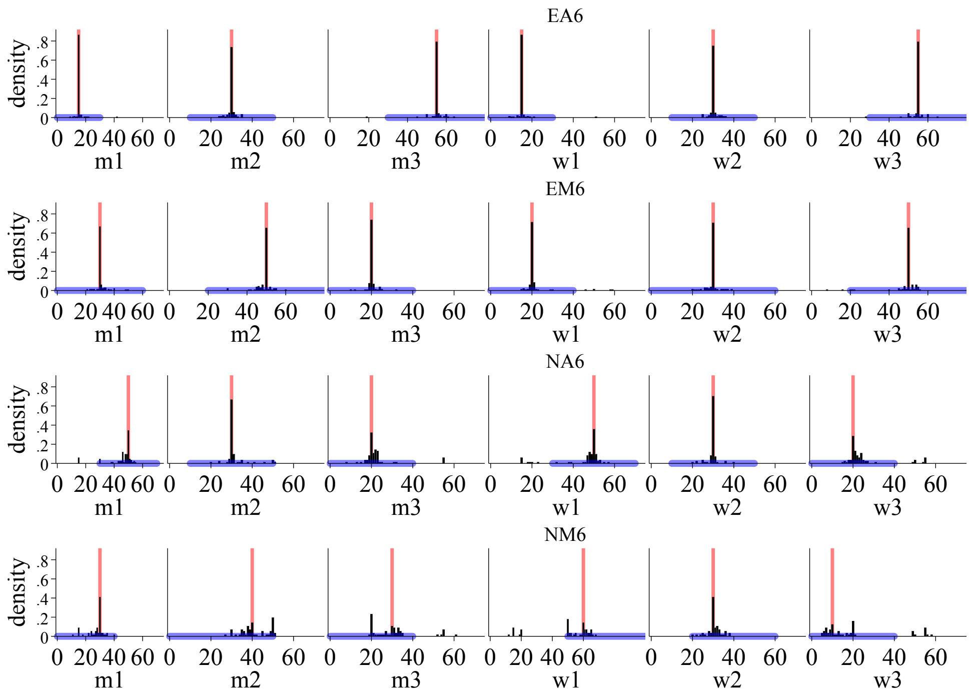
Figure B0: Core payoffs



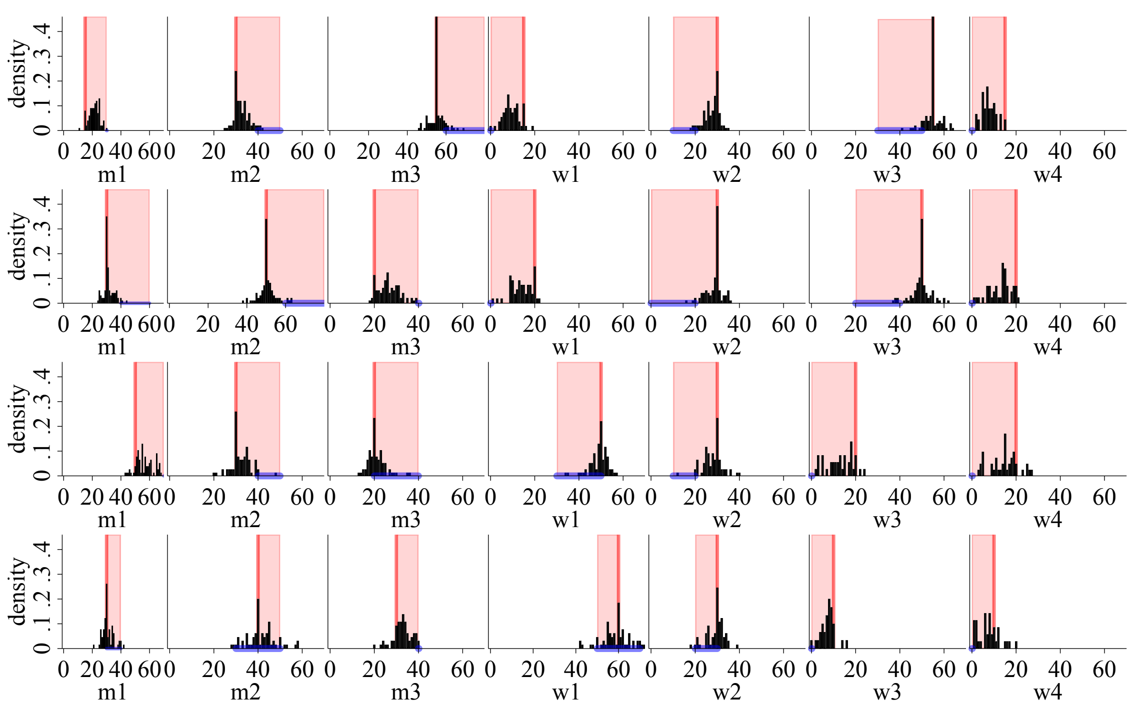
Note. The gray area in each figure illustrates the polyhedron of women's core payoffs in the balanced market. The red shaded area represents the reduced dimension of women's core payoffs in the imbalanced markets. The set of men's core payoffs is isomorphic to that of women's core payoffs.

Figure B1: Histogram of payoffs in efficient matching: wave 1

(a) Balanced market



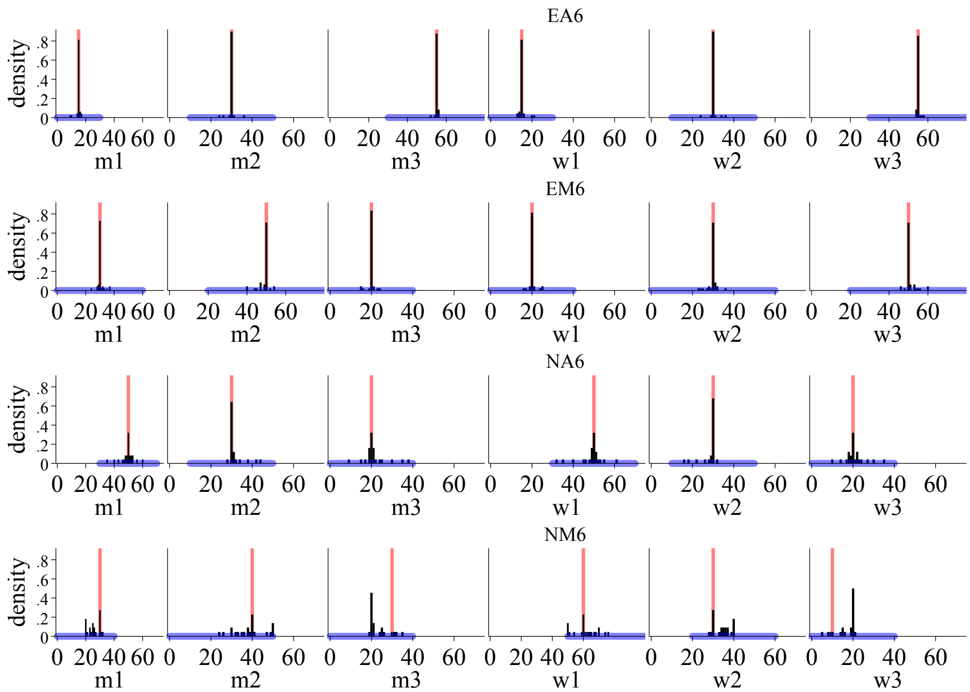
(b) Imbalanced market



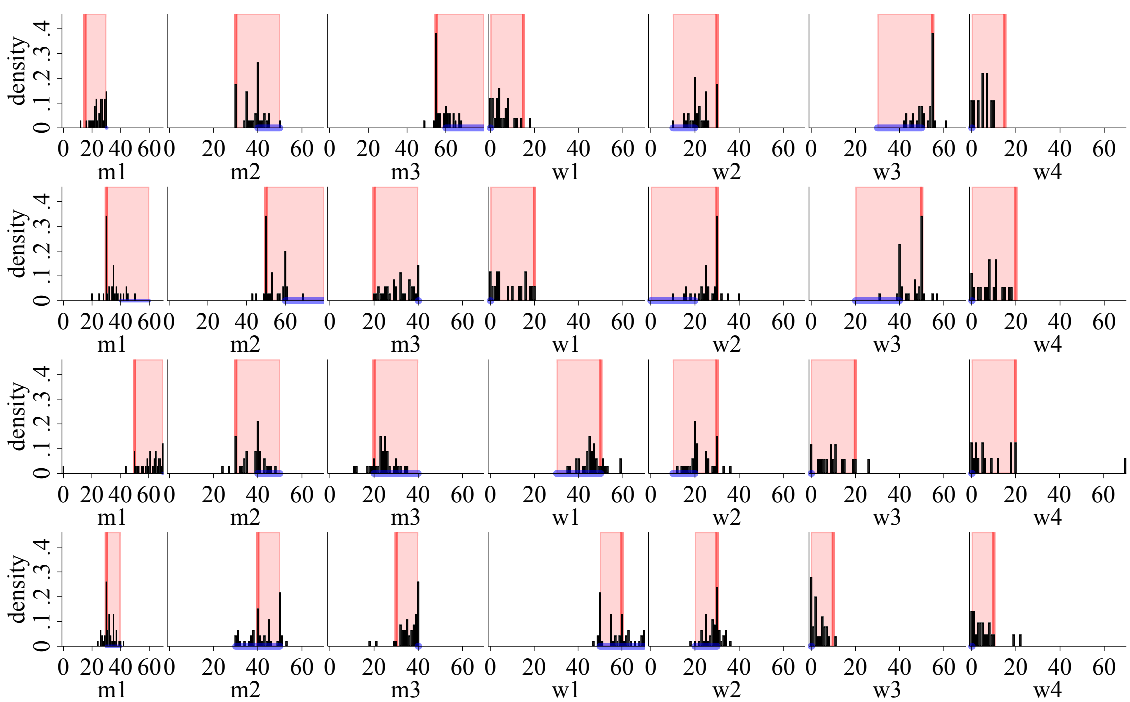
Note. Blue horizontal lines represent the range of core payoffs in the cooperative model. Red shaded areas represent the range of equilibrium payoffs in the noncooperative model, and red vertical lines represent the noncompetitive limit payoffs in the noncooperative model. The histogram is in black.

Figure B1': Histogram of payoffs in efficient matching: wave 2

(a) Balanced market



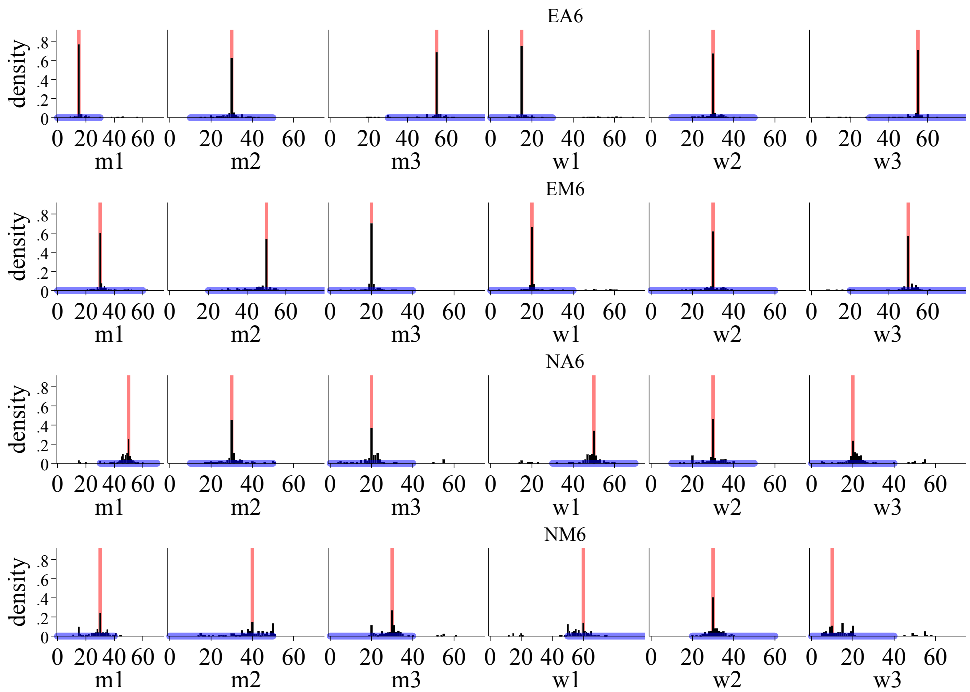
(b) Imbalanced market



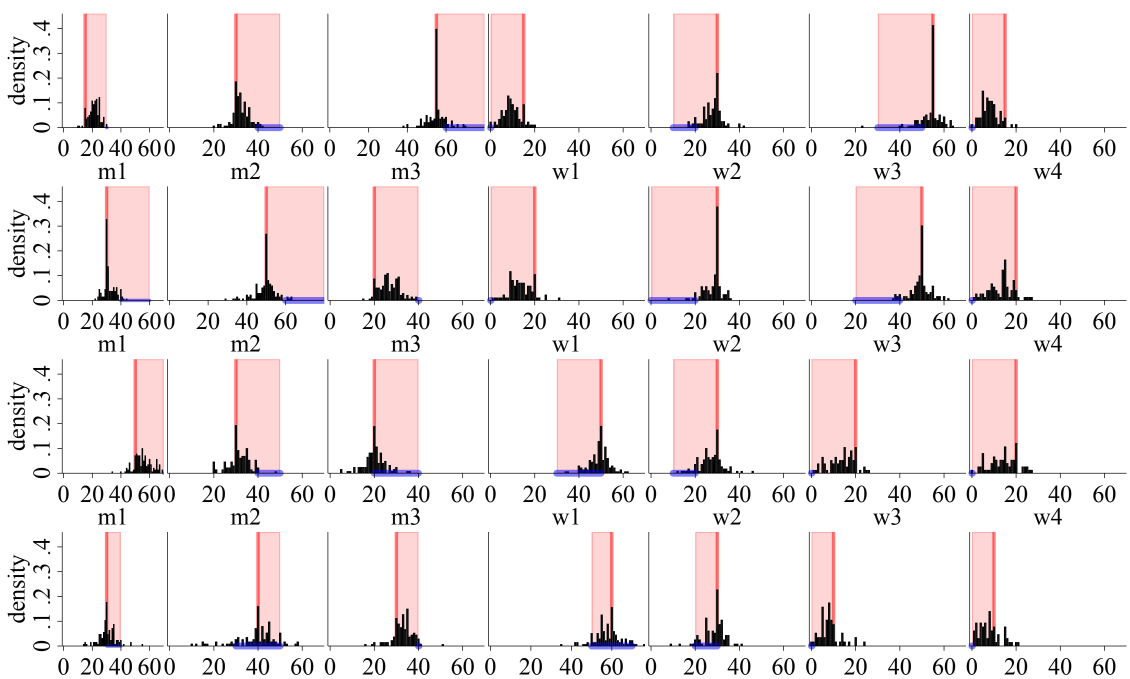
Note. Blue horizontal lines represent the range of core payoffs in the cooperative model. Red shaded areas represent the range of equilibrium payoffs in the noncooperative model, and red vertical lines represent the noncompetitive limit payoffs in the noncooperative model. The histogram is in black.

Figure B2: Histogram of payoffs for matched individuals: wave 1

(a) Balanced market



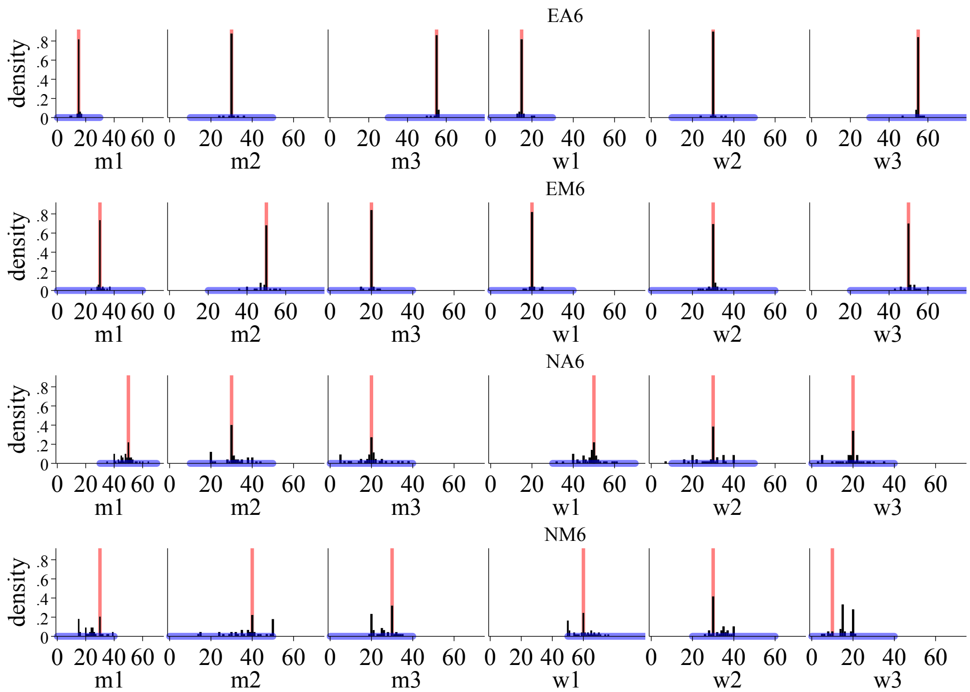
(b) Imbalanced market



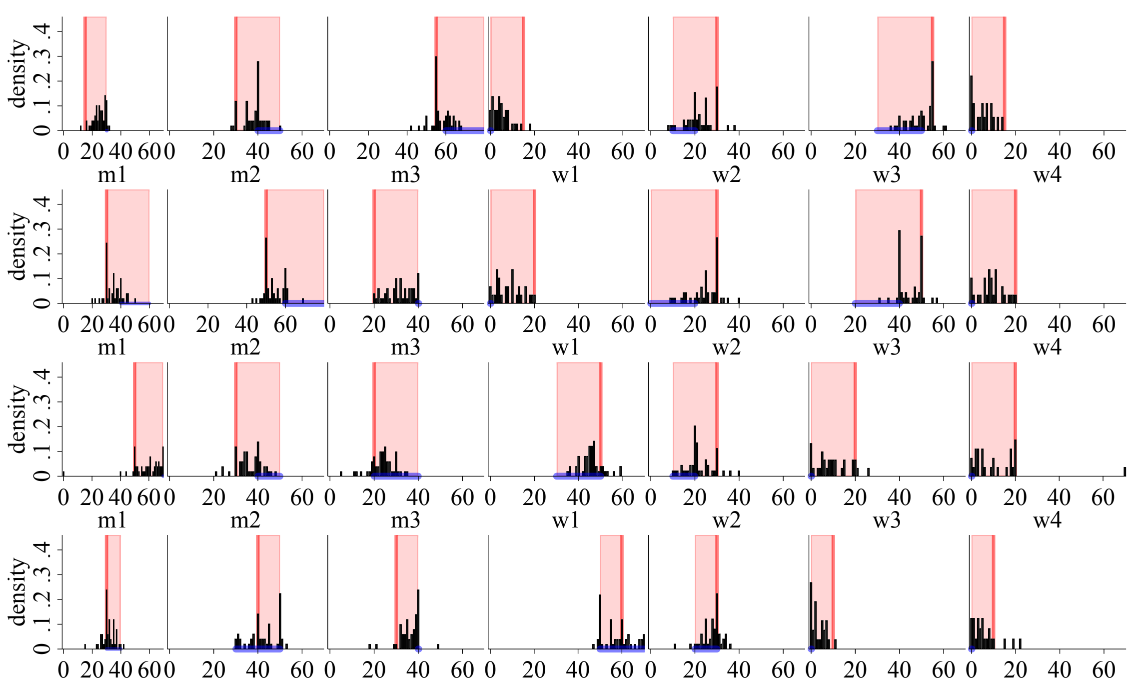
Note. Blue horizontal lines represent the range of core payoffs in the cooperative model. Red shaded areas represent the range of equilibrium payoffs in the noncooperative model, and red vertical lines represent the noncompetitive limit payoffs in the noncooperative model. The histogram is in black.

Figure B2’: Histogram of payoffs for matched individuals: wave 2

(a) Balanced market



(b) Imbalanced market



Note. Blue horizontal lines represent the range of core payoffs in the cooperative model. Red shaded areas represent the range of equilibrium payoffs in the noncooperative model, and red vertical lines represent the noncompetitive limit payoffs in the noncooperative model. The histogram is in black.

Figure B3: Men’s and women’s payoffs in balanced versus imbalanced markets: wave 1

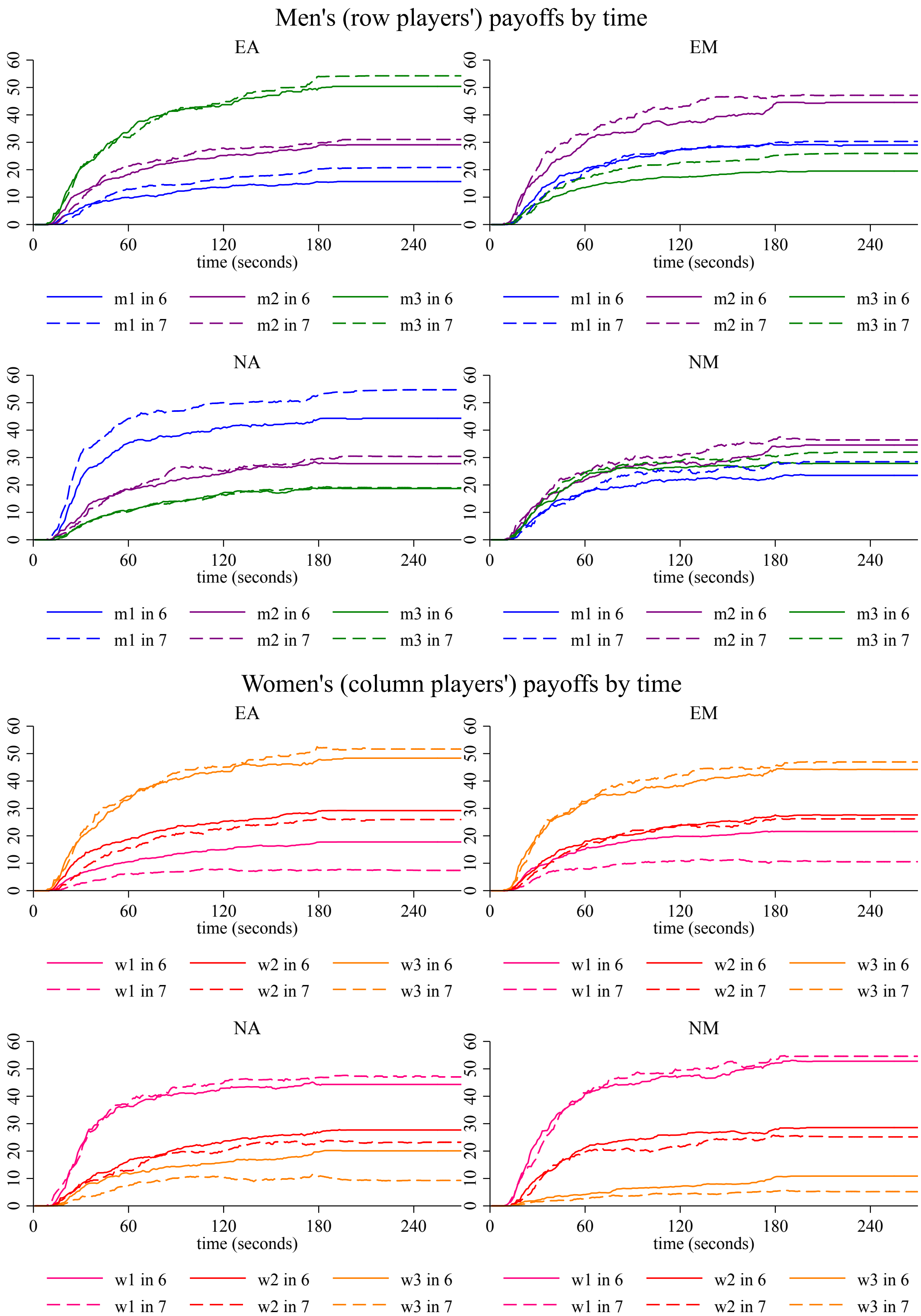


Figure B3': Men's and women's payoffs in balanced versus imbalanced markets: wave 2

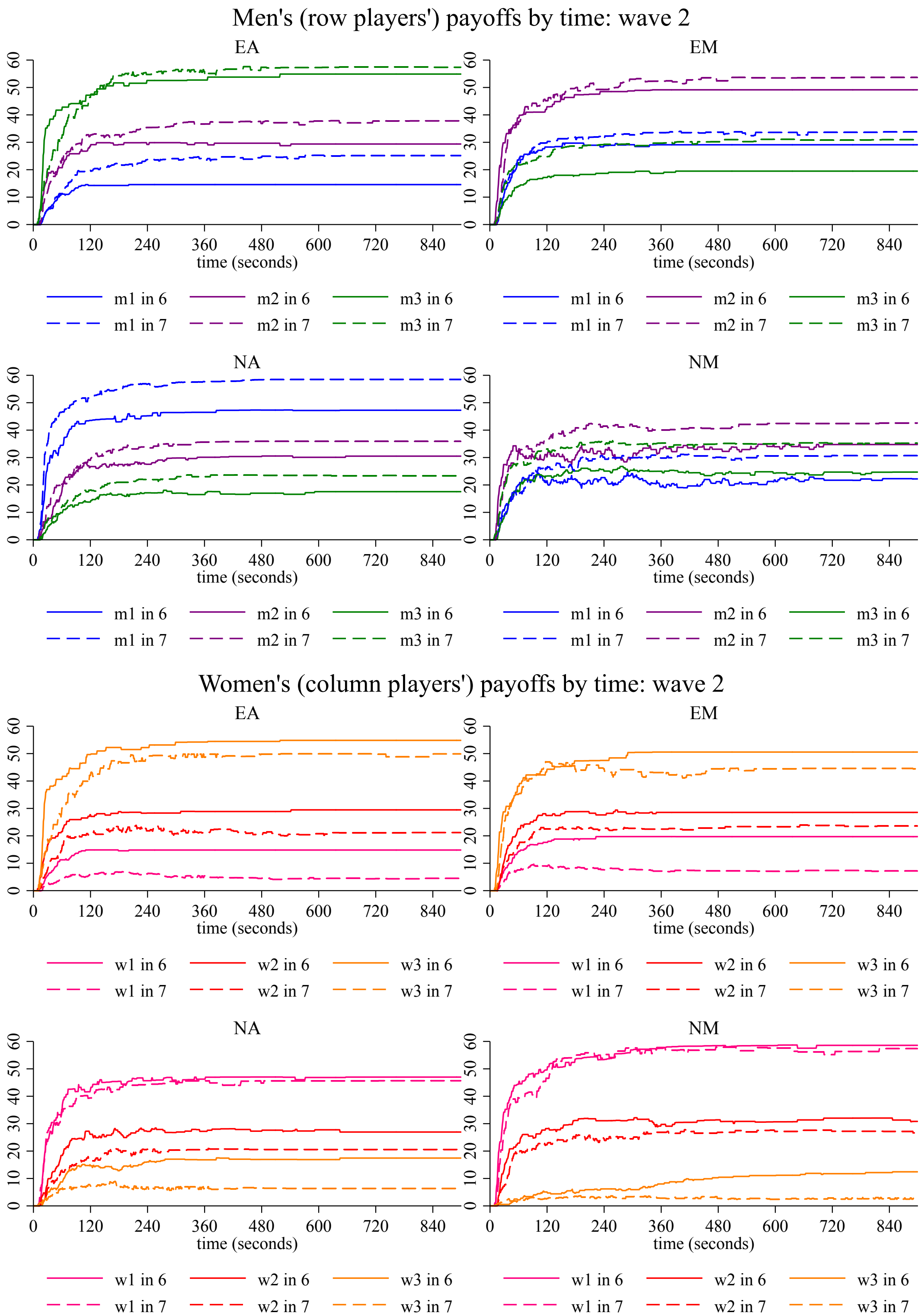


Table B15: Frequency distribution of proposals sent to players on the opposite side

(a) balanced markets: wave1 & wave2

	EA6			NA6		
	w1	w2	w3	w1	w2	w3
m1	(52%,56%)	(28%,6%)	(19%,0%)	(35%,32%)	(32%,61%)	(33%,81%)
m2	(4%,26%)	(54%,49%)	(42%,12%)	(63%,34%)	(30%,34%)	(7%,15%)
m3	(0%,18%)	(10%,45%)	(90%,88%)	(9%,15%)	(14%,5%)	(3%,4%)
	EM6			NM6		
	w1	w2	w3	w1	w2	w3
m1	(1%,2%)	(49%,53%)	(50%,18%)	(65%,30%)	(32%,46%)	(3%,29%)
m2	(2%,40%)	(12%,43%)	(87%,81%)	(94%,68%)	(4%,7%)	(2%,21%)
m3	(62%,58%)	(15%,4%)	(23%,2%)	(38%,3%)	(49%,47%)	(14%,50%)

(b) unbalanced markets: wave 1 & wave 2

	EA7				NA7			
	w1	w2	w3	w4	w1	w2	w3	w4
m1	(32%,57%)	(17%,10%)	(17%,3%)	(34%,56%)	(53%,35%)	(12%,50%)	(20%,78%)	(15%,77%)
m2	(7%,30%)	(50%,54%)	(37%,23%)	(7%,29%)	(61%,31%)	(31%,42%)	(4%,19%)	(3%,19%)
m3	(4%,13%)	(20%,36%)	(75%,74%)	(1%,15%)	(75%,34%)	(20%,8%)	(3%,3%)	(2%,4%)
	EM7				NM7			
	w1	w2	w3	w4	w1	w2	w3	w4
m1	(2%,5%)	(48%,48%)	(48%,28%)	(2%,5%)	(58%,33%)	(37%,47%)	(3%,14%)	(2%,16%)
m2	(7%,34%)	(9%,48%)	(80%,69%)	(4%,35%)	(92%,61%)	(6%,7%)	(2%,13%)	(0%,15%)
m3	(36%,61%)	(4%,4%)	(23%,3%)	(36%,60%)	(35%,6%)	(42%,46%)	(13%,73%)	(10%,69%)

Notes. In each table, the first number in each cell indicates the percentage of proposals sent from the row player to the column player, the second number in each cell indicates the percentage of proposals sent from the column player to the row player.

Table B16: Determinants of logged number of proposals in balanced markets: wave 1

	(1)	(2)	(3)	(4)
	log proposals	log proposals	log proposals	log proposals
assortative	-0.0682	-0.109*	-0.124*	-0.124*
	(-1.27)	(-2.18)	(-2.57)	(-2.57)
ESIC	-0.257***	-0.297***	-0.305***	-0.305***
	(-6.14)	(-4.35)	(-4.87)	(-4.87)
assortative*ESIC		0.0810	0.0964	0.0964
		(0.80)	(1.14)	(1.14)
round			-0.0293**	-0.0150
			(-3.22)	(-1.72)
order			-0.0996***	
			(-5.38)	
period				-0.0142***
				(-5.38)
constant	2.607***	2.627***	3.001***	2.901***
	(46.51)	(44.01)	(40.21)	(43.45)
observations	728	728	728	728
clusters	26	26	26	26

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B16': Determinants of logged number of proposals in balanced markets: wave 2

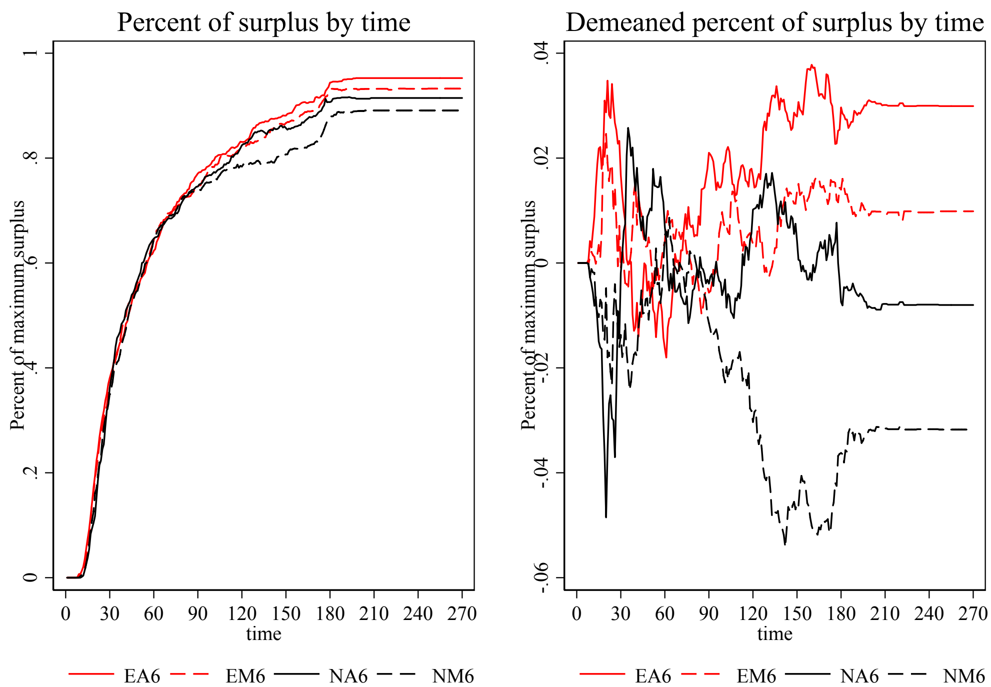
	(1)	(2)	(3)	(4)
	log proposals	log proposals	log proposals	log proposals
assortative	-0.212	-0.266	-0.266	-0.266
	(-1.57)	(-2.26)	(-1.98)	(-1.98)
ESIC	-0.870***	-0.923**	-0.941**	-0.941**
	(-4.83)	(-3.86)	(-4.04)	(-4.04)
assortative*ESIC		0.107	0.143	0.143
		(0.45)	(0.62)	(0.62)
round			-0.0891**	-0.0712*
			(-3.33)	(-2.76)
order			-0.0891	
			(-1.42)	
period				-0.0178
				(-1.42)
constant	3.114***	3.141***	3.631***	3.542***
	(18.48)	(19.64)	(16.42)	(19.24)
observations	200	200	200	200
clusters	10	10	10	10

t statistics in parentheses; standard errors clustered at the group level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B4: Percent of surplus achieved by time: wave 1

(a) Balanced markets



(b) Imbalanced markets

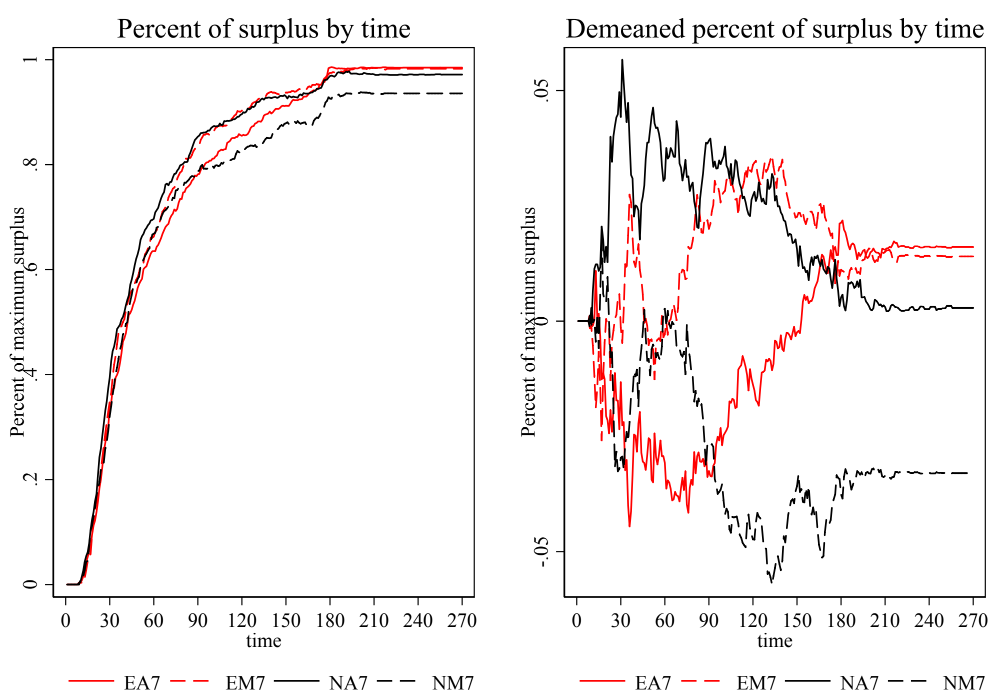
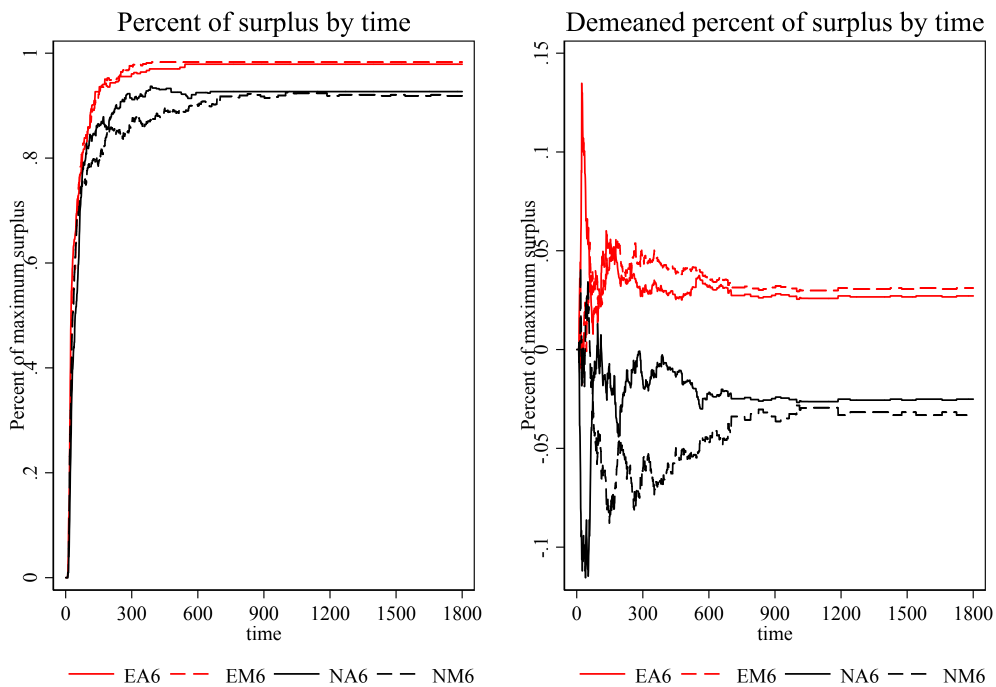


Figure B4': Percent of surplus achieved by time: wave 2

(a) Balanced markets



(b) Imbalanced markets

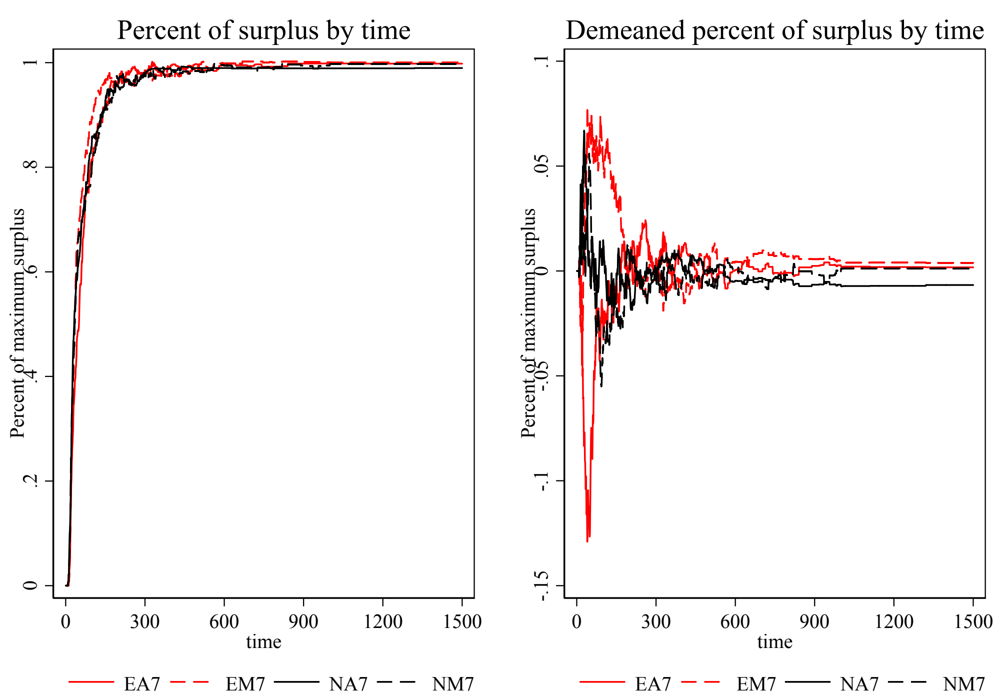


Table B17: Individual characteristics determinants of outcomes in balanced markets: wave 1

(a) Being matched

	AE6	AN6	ME6	MN6
	Log Matches	Log Matches	Log Matches	Log Matches
Age	0.013	0.003	0.009	-0.006
	(1.08)	(0.13)	(0.41)	(-0.39)
Male	-0.015	-0.050	0.014	0.060^{*}
	(-0.65)	(-1.27)	(0.36)	(2.58)
Grade of study	-0.019	0.013	-0.012	0.012
	(-1.20)	(0.45)	(-0.36)	(0.59)
Econ/Business	0.004	0.062^{*}	-0.035	-0.018
	(0.18)	(2.02)	(-0.82)	(-0.71)
Constant	1.626^{***}	1.678^{***}	1.535^{***}	1.879^{***}
	(8.22)	(5.08)	(4.05)	(7.15)
Observations	1,092	1,092	1,092	1,092

t statistics in parentheses
clustered at individual level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Payoffs

	AE6	AN6	ME6	MN6
	payoff	payoff	payoff	payoff
Round (1-7)	-0.433	-0.082	0.030	-0.021
	(-1.44)	(-0.32)	(0.11)	(-0.08)
Age	0.706	0.856	0.283	-0.564
	(1.03)	(1.24)	(0.41)	(-0.91)
Male	-0.331	-1.468	-0.763	2.325^{*}
	(-0.28)	(-1.14)	(-0.59)	(2.17)
Grade of study	-0.517	0.042	0.018	0.938
	(-0.58)	(0.04)	(0.02)	(1.09)
Econ/Business	-0.315	1.643	-2.015	0.186
	(-0.28)	(1.43)	(-1.67)	(0.18)
Constant	18.99	12.04	22.21	37.85^{***}
	(1.63)	(1.04)	(1.91)	(3.57)
Observations	1,092	1,092	1,092	1,092

t statistics in parentheses
clustered at individual level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B18: Individual characteristics determinants of outcomes in unbalanced markets: wave 1

(a) Being matched

	AE7 Log Matches	AN7 Log Matches	ME7 Log Matches	MN7 Log Matches
Age	0.006	0.006	0.002	0.009
	(0.73)	(0.45)	(0.28)	(0.77)
Male	-0.034	-0.086	0.004	0.016
	(-1.05)	(-1.90)	(0.12)	(0.32)
Grade of study	-0.002	-0.003	0.004	-0.003
	(-0.83)	(-0.54)	(1.46)	(-0.51)
Econ/Business	0.029	-0.019	0.036	0.023
	(0.65)	(-0.38)	(0.75)	(0.42)
Constant	1.620^{***}	1.620^{***}	1.640^{***}	1.423^{***}
	(8.99)	(6.29)	(10.10)	(5.44)
Observations	980	980	980	980

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Payoffs

	AE7 payoff	AN7 payoff	ME7 payoff	MN7 payoff
Round (1-7)	0.352	0.281	0.023	0.556
	(1.18)	(0.87)	(0.08)	(1.80)
Age	0.072	0.264	-0.133	0.252
	(0.22)	(0.76)	(-0.45)	(0.68)
Male	-2.125	-2.962^{*}	0.077	-0.465
	(-1.44)	(-2.15)	(0.07)	(-0.32)
Grade of study	-0.025	0.050	0.039	-0.034
	(-0.17)	(0.30)	(0.26)	(-0.23)
Econ/Business	-0.360	0.170	1.264	0.857
	(-0.20)	(0.12)	(0.93)	(0.50)
Constant	25.30^{***}	20.03^{**}	27.81^{***}	17.10^{*}
	(3.52)	(2.76)	(4.53)	(2.15)
Observations	980	980	980	980

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B5: Word cloud of responses to questions

(a) “How did you decide to make a proposal?”

(b) “How did you decide to accept or reject a proposal?”

(c) “Were you unmatched in some rounds? If so, why?”

Note. Subjects’ answers were in Chinese. We present the word clouds of their responses in Chinese and their Google-translated responses in English without correction.

C Omitted proofs

For Theorem 1, it suffices to show the following Lemmas 1, 2, and 3.

Lemma 1. *(1) There is at most one solution to the system of equations given a matching μ and a discount factor $\delta < 1$. (2) If there exists a solution given μ and δ, then there exists a solution given μ and any $\delta' < \delta$.*

Proof of Lemma 1. Fix a matching μ. Consider the system of equations for the cases in which men are the proposers at time zero:

$$U_m^p = s_{m\mu(m)} - \max\left\{\delta \cdot V_{\mu(m)}^r, \max_{m' \in M \setminus m} \left\{s_{m'\mu(m)} - U_{m'}^p\right\}\right\},$$

where

$$V_{\mu(m)}^r = s_{m\mu(m)} - \max\left\{\delta \cdot U_m^p, \max_{w' \in W \setminus \mu(m)} \left\{s_{mw'} - \left[s_{\mu(w')w'} - U_{\mu(w')}^p\right]\right\}\right\};$$

For notational convenience, we follow the notations from max algebra to define $a \oplus b \equiv \max\{a, b\}$ and $\sum_{i\in\{1,\cdots,I\}}^{\oplus} a_i \equiv a_1 \oplus \cdots \oplus a_I$. Consider the following system of $n_M + n_W$ equations with $n_M + n_W$ unknowns $U_{m_1}^p, \cdots, U_{m_M}^p, V_{w_1}^r, \cdots, V_{w_W}^r$.

$$\begin{cases} U_{m_1}^p = s_{m_1\mu(m_1)} - \delta V_{\mu(m_1)}^r \oplus \sum_{m' \neq m_1}^{\oplus} \left[s_{m'\mu(m_1)} - U_{m'}^p\right], \\ \ddots \\ U_{m_{n_M}}^p = s_{m_{n_M}\mu(m_{n_M})} - \delta V_{\mu(m_{n_M})}^r \oplus \sum_{m' \neq m_{n_M}}^{\oplus} \left[s_{m'\mu(m_{n_M})} - U_{m'}^p\right], \\ V_{w_1}^r = s_{\mu(w_1)w_1} - \delta U_{\mu(w_1)}^p \oplus \sum_{w' \neq w_1}^{\oplus} \left[s_{\mu(w_1)w'} - \left[s_{\mu(w')w} - U_{\mu(w')}^p\right]\right], \\ \ddots \\ V_{w_{n_W}}^r = s_{\mu(w_{n_W})w_{n_W}} - \delta U_{\mu(w_{n_W})}^p \oplus \sum_{w' \neq w_{n_W}}^{\oplus} \left[s_{\mu(w_{n_W})w'} - \left[s_{\mu(w')w} - U_{\mu(w')}^p\right]\right]. \end{cases}$$

Consider and rearrange the equation for U_m^p, for any $m \in M$:

$$U_m^p + \delta V_{\mu(m)}^r \oplus \sum_{m' \neq m}^{\oplus} \left[s_{m'\mu(m)} - U_{m'}^p\right] = s_{m\mu(m)}.$$

Then, by using the slack variable methods, we can rewrite this nonlinear equation as a set of n_M linear equations and one nonlinear condition with n_M additional unknowns $x_{mm_1}, \cdots, x_{mm_{n_M}}$:

$$\begin{gathered} U_m^p + \delta V_{\mu(m)}^r + x_{mm} = s_{m\mu(m)}, \\ U_m^p + \left[s_{m'\mu(m)} - U_{m'}^p\right] + x_{mm'} = s_{m\mu(m)} \qquad \text{for any } m' \neq m, \\ x_{mm} \cdot \prod_{m' \neq m} x_{mm'} = 0. \end{gathered}$$

We can rearrange the equation for V_w^r and apply the slack variable method to it for any $w \in W$ in a similar fashion, Then we can rewrite the entire problem as a linear programming problem with $n_M^2 + n_W^2 + n_M + n_W$ variables

$$\min \quad \sum_{m' \in M} \sum_{m \in M} x_{mm'} + \sum_{w' \in W} \sum_{w \in W} x_{ww'},$$

subject to the following $n_M^2 + n_W^2$ main constraints:

$$
\begin{aligned}
U_m^p + \left[s_{m'\mu(m)} - U_{m'}^p\right] + x_{mm'} - s_{m\mu(m)} \geqslant 0, &\qquad \forall m' \in M\backslash m, \forall m \in M, \\
U_m^p + \delta V_{\mu(m)}^r + x_{mm} - s_{m\mu(m)} \geqslant 0, &\qquad \forall m \in M, \\
V_w^r + \left[s_{\mu(w)w'} - \left[s_{\mu(w')w} - U_{\mu(w')}^p\right]\right] + x_{ww'} - s_{\mu(w)w} \geqslant 0, &\qquad \forall w' \in W\backslash w, \forall w \in W, \\
V_w^r + \delta U_{\mu(m)}^p + x_{ww} - s_{\mu(w)w} \geqslant 0, &\qquad \forall w \in W;
\end{aligned}
$$

and $n_M^2 + n_W^2 + n_M + n_W$ nonnegative constraints:

$$
\begin{aligned}
U_m^p \geqslant 0 \quad \forall m \in M, &\qquad V_w^r \geqslant 0 \quad \forall w \in W, \\
x_{mm'} \geqslant 0 \quad \forall m, m' \in M, &\qquad x_{ww'} \geqslant 0 \quad \forall w, w' \in W.
\end{aligned}
$$

First, we argue that there is at most one solution to the minimization problem. Note that the constraints are noncolinear, because each of the main constraints contains a different $x_{mm'}$, x_{mm}, $x_{ww'}$ or x_{ww}. If the constraints are satisfied, then there exists a solution. If there exists a solution, there is a unique solution, because of the following argument. All the main constraints will be binding and not all $x_{mm'}$'s and $x_{ww'}$'s will be zero, so the optimal value—if it exists—is not zero. By Dantzig's sufficient uniqueness condition that for a linear program in canonical form the optimal value is positive, the solution is unique.

The proof for the system of equations when women are the proposers in period zero is identical. This establishes part (1) of the lemma.

Second, let C^δ be the constrained set for the minimization problem when the discount factor is δ. Then for $\delta' < \delta$, $C^{\delta'}$ is a closed subset of C^δ because the parts containing δ in the main constraints are nonnegative, which makes the constraints tightened as δ decreases. Since the objective function of the minimization problem is linear, we have that when there is a solution with δ, there will be a solution with $\delta' < \delta$.[18] This establishes part (2) of the lemma. □

Lemma 1 shows that fixing a matching μ and a discount factor δ, if a solution exists, it is unique and for any discount factor smaller than δ, there exists a unique solution given μ. Lemma 1 leads to the main result on surplus division:

Lemma 2. *For any $\delta \in (0, 1)$, there exists a solution to the system of equations with μ^*.*

Since we already know that there exists a solution with efficient matching when $\delta = 1$, by Lemma 1 part (2), we must have a solution with efficient matching for any $\delta < 1$. This directly gives us Lemma 2.

Lemma 3. *Any inefficient matching μ cannot be supported by the system of equations.*

[18] When the objective function is linear, then every indifference surface is a hyperplane with the normal vector being the gradient of the objective function. Now we use this gradient vector as an axis going through the origin. That is, moving in one direction on the axis is going in the same direction as the gradient, and the other going in the opposite direction. Then every point in the entire space lies on some indifference surface of the objective function and all points on the same indifference surface can be projected to a single point where this surface intersects the gradient axis. Hence, if a minimum occurs in the set C^δ, then it is necessarily the case that a lower bound is realized on projection of C^δ on the gradient axis (with lower bound being oriented according to the direction of lower objective values). Since $C^{\delta'}$ is a closed subset of C^δ, its projection on the gradient axis is a closed subset of the projection of C^δ on the gradient axis, which continues to have a lower bound. This immediately implies that a minimum continues to exist when restricted to $C^{\delta'}$. We thank Van Kolpin for the suggestion.

Proof of Lemma 3. Suppose μ is an inefficient matching: The total surplus s^{μ} from this inefficient matching is less than the total surplus s^{μ^*} from the unique efficient matching μ^*. Suppose there is a solution to the system of equations for μ. Then since for any man $m \in M$,

$$U_m^p = s_{m\mu(m)} - \max\left\{\delta V^r_{\mu(m)}, \max_{m' \in M \setminus m} \{s_{m'\mu(m)} - U^p_{m'}\}\right\},$$

we must have that and for any $m' \in M \setminus m$,

$$U_m^p \leq s_{m\mu(m)} - (s_{m'\mu(m)} - U^p_{m'}).$$

In particular, the inequality holds for the man $\mu^*(\mu(m))$ that woman $\mu(m)$ would have matched with in the efficient matching μ^*:

$$U_m^p \leq s_{m\mu(m)} - \left(s_{\mu^*(\mu(m))\mu(m)} - U^p_{\mu^*(\mu(m))}\right). \tag{Um}$$

By the same logic, we have the following for each woman in W:

$$V_w^p \leq s_{\mu(w)w} - \left(s_{\mu(w)\mu^*(\mu(w))} - V^p_{\mu^*(\mu(w))}\right). \tag{Vw}$$

Sum all (Um) and (Vw) for all $m \in M$ and $w \in W$, we get

$$\begin{aligned}\sum_{m \in M} U_m^p + \sum_{w \in W} U_w^p \leq \sum_{m \in M} s_{m\mu(m)} - \sum_{m \in M} \left[s_{\mu^*(\mu(m))\mu(m)} - U^p_{\mu^*(\mu(m))}\right] \\ + \sum_{w \in W} s_{\mu(w)w} - \sum_{w \in W} \left[s_{\mu(w)\mu^*(\mu(w))} - V^p_{\mu^*(\mu(w))}\right],\end{aligned}$$

which can be simplified as follows:

$$2s^{\mu^*} \leq 2s^{\mu}.$$

This is impossible. We conclude that μ cannot be supported by the system of equations. □

Next, we consider what the unique solution to the system of equations looks like when equal split is or is not in the core. We present the following results:

Proof of Proposition 3. Since equal split is the core, for any $m' \in M$, we must have

$$s_{m'\mu^*(m)} - \frac{1}{2} s_{m'\mu^*(m')} \leq \frac{1}{2} s_{m\mu^*(m)}.$$

This implies that

$$\begin{aligned} s_{m'\mu^*(m)} - U^p_{m'} &= s_{m'\mu^*(m)} - \frac{1}{1+\delta} s_{m'\mu^*(m')} < s_{m'\mu^*(m)} - \frac{1}{2} s_{m'\mu^*(m')} \\ &\leq \frac{1}{2} s_{m\mu^*(m)} < \frac{1}{1+\delta} s_{m\mu^*(m)} = V^r_{\mu^*(m)}. \end{aligned}$$

Hence, there exists a uniform lower bound $\underline{\delta} \in (0,1)$ such that for any $\delta \in (\underline{\delta}, 1)$, $s_{m'\mu^*(m)} - U^p_{m'} < \delta V^r_{\mu^*(m)}$

for any $m' \in M \backslash m$ and any $m \in M$.[19] This implies that for any $\delta \in (\underline{\delta}, 1)$, for any $m \in M$,

$$\begin{aligned} U_m^p &= s_{m\mu^*(m)} - \max\left\{\delta V^r_{\mu^*(m)}, \max_{m' \in M\backslash m}\left\{s_{m'\mu^*(m)} - U^r_{m'}\right\}\right\} \\ &= s_{m\mu^*(m)} - \delta \cdot V^r_{\mu^*(m)}, \end{aligned}$$

which is automatically satisfied given $U_m^p = V^r_{\mu^*(m)} = s_{m\mu^*(m)}/(1+\delta)$. Similarly, we obtain the same conclusion for the case when women are the proposers.

When equal-splits is not in the core, there exist $m, m' \in M$, such that $s_{m\mu^*(m)} + s_{m'\mu^*(m')} < 2s_{m\mu^*(m')}$ or $s_{m\mu^*(m)} + s_{m'\mu^*(m')} < 2s_{m'\mu^*(m)}$ or both. Without loss of generality, assume that $s_{m\mu^*(m)} + s_{m'\mu^*(m')} < 2s_{m\mu^*(m')}$. Assume that

$$U_m^p = \frac{s_{m\mu^*(m)}}{1+\delta}, \text{ for any } m \in M; \; V_w^r = \frac{s_{\mu^*(w)w}}{1+\delta}, \text{ for any } w \in W.$$

Then we must have

$$\begin{aligned} & \delta V^r_{\mu^*(m)} \geqslant \max_{m'' \in M\backslash m}\left\{s_{m''\mu^*(m)} - U^p_{m''}\right\} \geqslant s_{m'\mu^*(m)} - U^p_{m'} \\ \Rightarrow \quad & \frac{\delta s_{m\mu^*(m)} + s_{m'\mu^*(m')}}{1+\delta} \geqslant s_{m\mu^*(m')}. \end{aligned}$$

Since $s_{m\mu^*(m)} + s_{m'\mu^*(m')} < 2s_{m\mu^*(m')}$, there exists a $\underline{\delta} \in [0, 1)$, such that for any $\delta \in [\underline{\delta}, 1)$, the above inequality does not hold, implying that it cannot be a solution. Similarly, we obtain the same conclusion for the case when women are the proposers. $\square$

[19] The existence of such a lower bound for each pair of m and m' requires $s_{m'\mu^*(m')}$ to be strictly positive. Hence, as long as we assume that $s_{mw} > 0$ for any $m \in M$ and $w \in W$, we ensures the existence of a uniform lower bound.