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An experimental study of house allocation mechanisms

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Abstract

We report an experiment on three house allocation mechanisms under complete information: random serial dictatorship with squatting rights, and two variants of the top trading cycles mechanism. Results show that the latter two are significantly more efficient than the former.

Keywords: House allocation; Mechanism design; Experiments

JEL classification: C78; C91; D83

1. Introduction

A house allocation mechanism assigns a set of houses to a set of agents, allotting at most one house to each agent. Rents are exogenously given and there is no medium of exchange, such as money. The canonical examples are dormitory room allocation for college students and public housing. In general, some houses have existing tenants, some houses are empty. Some applicants will be new, for example, freshmen.

Many universities in the United States employ some variant of a mechanism called the *random serial dictatorship with squatting rights* (RSD) to allocate dormitory rooms. Each existing tenant can either keep her house or enter the applicant pool. Each applicant is randomly given a priority and each is assigned, in priority order, her top choice among the houses that remain. This mechanism is strategy-proof: for each applicant, reporting her true preferences is a dominant strategy. An existing tenant who enters the lottery may end up with a house less preferred than her current house and therefore this

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mechanism is not individually rational. Consequently, not every existing tenant will join the applicant pool and potential gains from trade is lost. Therefore RSD is not Pareto efficient.

Abdulkadiroğlu and Sönmez (1999) propose a simple alternative, the top trading cycles (TTC) mechanism. Applicants are again prioritized and are given their top choice in priority order. This continues until someone requests an existing tenant's house. In this case, the existing tenant is moved to the top of the priority queue, directly in front of the requester. This is repeated any time an existing tenant's house is requested. If a cycle of requests is formed (e.g., I want John's house, John wants your house, and you want my house), all members of the cycle are given what they want, and their new houses are removed from the system. The key innovation is that an existing tenant whose current house is requested is upgraded to the first place at the remaining of the line before her house is allocated. As a result the TTC mechanism is individually rational. It is also strategy-proof and Pareto efficient.

In theory, TTC has better efficiency properties than RSD when all agents are perfectly rational. However, it is not clear whether it remains superior in practice with boundedly rational agents. We use laboratory experiments to evaluate the performance of the mechanisms.

Since the solution concept is dominant strategy, it is robust to the information specifications. In a companion paper, Chen and Sönmez (2002) implement RSD and a variant of TTC under *incomplete information*. This paper serves as a robustness check, where we conduct a series of experiments to evaluate the performance of RSD, TTC, and a variant of TTC called TTC-opt under *complete information*. The latter environment is important, as in some real world applications, agents might know each other's preferences well.

2. Experimental Design

We design the simplest possible environment which captures the key aspects of the house allocation problem. We consider an environment with three agents: an existing tenant and two newcomers. There are two houses to allocate: House A and House B. The existing tenant currently occupies House A. House B is vacant. Preferences are induced by the following payoff table:

	A	B	No house
Existing Tenant	\$10	\$15	\$3
Newcomer 1	\$10	\$4	\$3
Newcomer 2	\$10	\$15	\$3

These payoffs are chosen for the following considerations. First, there are four Pareto efficient house allocations for the chosen problem. In general, the aggregate utility can differ at different Pareto efficient allocations. In our case, however, the aggregate utility is 28 at each of these allocations. This conveniently gives us a reference point for full efficiency. Second, the environment slightly favors the RSD mechanism. If the existing tenant is an expected payoff maximizer, then she has a slight preference for entering the lottery. Since the inefficiency of RSD results from the possibility that the existing tenant opts out, this design choice is favorable for RSD. Our results suggest that RSD causes significant efficiency loss even under this preferential treatment.

In this environment, we test three mechanisms: RSD and two versions of TTC. In the first version, the existing tenant is explicitly given an option to keep her house and not enter the lottery (TTC-opt). In the second version, the existing tenant is not given such an option, but of course she can rank her house as her top choice and receive it with certainty (TTC). Since TTC guarantees each existing tenant a house that is no worse than her current house, in theory, the outcomes of TTC and TTC-opt should be the same.

We conducted a total of 26 independent sessions in February and March 1999 at the University of Michigan. These include 9 sessions for RSD, 9 for TTC and 8 for TTC-opt. All sessions are conducted by hand. Our subjects are undergraduate students from introductory economic principles' class at the University of Michigan with one exception. Newcomer 2 in Session 3 of RSD is a graduate student. No subject is used in more than one session. This gives us a total of 78 subjects.

Each session consists of one round only. All three mechanisms are implemented as one-shot games of complete information. Subjects know the complete payoff table as well as the mechanisms used to allocate the houses. The sessions last for about half an hour, with the first 15 min being used for instructions. The conversion rate is $1 for all sessions. Each subject also receives a participation fee of $3 in addition to their earnings from the experiments. The average earning (including participation fee) is $11.70 for 30 min.

3. Results

Two questions are important in evaluating the mechanisms. The first is the efficiency of the mechanisms. The second is whether individuals play their dominant strategies.

To evaluate the aggregate performance of the mechanisms, we compare the efficiency generated by the three mechanisms. Efficiency is calculated by taking the ratio of the sum of the actual earnings of all subjects in a session and the Pareto-optimal earnings of the group. The qualitative result stays the same if expected efficiency is considered instead of observed efficiency.

Result 1 (Efficiency): The efficiency of either TTC or TTC-Opt is significantly higher than that of RSD.

Support: All sessions of TTC and TTC-opt generate 100% efficiency. Under RSD, five sessions generate 100% efficiency, while four sessions generate 61% efficiency. Permutation tests show that the efficiency of TTC (or TTC-opt) is significantly larger than the efficiency of RSD ($p=0.0147$, one-tailed).

The reason for the loss of efficiency in RSD is the existing tenants who opt out. For RSD, participation is not a dominant strategy for the existing tenant although our choice of parameters slightly favors participation for risk neutral agents. For TTC-opt, however, opting out is a dominated strategy.

Result 2 (Participation): Existing tenants under TTC-opt are significantly more likely to participate than those under RSD.

Support: The existing tenants' participation rate is 100% under TTC-opt, but only 33.3% under RSD. A t-test of proportions yields $z=3$, $p<0.01$ (one-tailed).

Once the existing tenant decides to participate, then truthful preference revelation is a dominant strategy for each of the three mechanisms considered. However, as many experiments have shown that subjects do not always play dominant strategies.

Result 3 (Truth Preference Revelation): The differences in the proportions of truthful preference revelation under each of the three mechanisms are not statistically significant.

Support: Under RSD, 100% of the subjects revealed their preferences truthfully. Under TTC, 100% of the existing tenants and newcomer 1's revealed their preferences truthfully, while 78% of the newcomer 2's revealed their preferences truthfully. Under TTC-opt, 89% of the existing tenants (newcomer 1's), 75% of the newcomer 2's revealed their preferences truthfully. Let T_i be the probability that agents reveal their preferences truthfully under mechanism i. T-tests of proportions yield the following statistics: H_0: $T_r = T_t$ against H_1: $T_r > T_t$ yields $z = 1.27$ ($p > 0.10$); H_0: $T_r = T_y$ against H_1: $T_r > T_y$ yields $z = 1.41$ ($p > 0.05$); and H_0: $T_t = T_y$ against H_1: $T_t > T_y$ yields $z = 0.92$ ($p > 0.10$).

4. Conclusion

In theory, TTC has better efficiency properties than RSD whether the environment is complete information or incomplete information. Chen and Sönmez (2002) show that even with boundedly rational agents, TTC remains more efficient provided that the environment is incomplete information. This experiment completes this program by showing that all qualitative results of Chen and Sönmez (2002) remain the same in a complete information environment as well. We now have added reason to believe that replacing RSD with TTC in practice might significantly improve allocation efficiency.

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