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Strategy-proofness and efficiency for non-quasi-linear and common-tiered-object preferences: Characterization of minimum price rule ☆

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ABSTRACT

We consider how to assign heterogenous objects to agents and determine their payments. Each agent receives at most one object and has non-quasi-linear preferences over bundles, each consisting of an object and a payment. We focus on the following cases: (i) objects are linearly ranked, and if objects are equally priced, agents prefer a higher-ranked object to a lower-ranked object, or (ii) objects are partitioned into several tiers, and if objects are equally priced, agents prefer an object in the higher tier to an object in the lower tier. First, we analyze the (Walrasian) equilibrium structures in those cases. *A minimum price rule assigns a minimum price equilibrium to each preference profile. Second, on the normal-rich common-object-ranking domains and normal-rich common-tiered-object domains*, by assuming some conditions, we characterize minimum price rules in terms of agents' welfare, and by four properties, i.e., efficiency, strategy-proofness, individual rationality, and no subsidy.

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1. Introduction

1.1. Motivating examples and main results

We consider the allocation problems exemplified below, which motivate the present research.

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Example A (**Spectrum license allocation problem**). Since the 1990s, governments in many countries have conducted auctions to allocate spectrum licenses. In many cases, each firm is allowed to obtain at most one license. Because of the suitability of their technology, firms have common rankings over spectrum licenses for different frequency bands in some cases. If licenses are equally priced, firms prefer a spectrum license of the higher rank to one of the lower rank. In other cases, spectrum licenses are partitioned into several tiers. If licenses are equally priced, firms value licenses in a higher tier more than licenses in a lower tier. However, firms may have different preferences over licenses in the same tier. Spectrum license auctions often generate considerable government revenue.[1] Such large-scale auction payments generally influence a firm's ability to use the license and make firms' preferences over licenses and payments non-quasi-linear.

Example B (**House allocation problem in an Alonso-type housing market**). Central business districts are located at the city center, where households are employed and to which they commute every day using the same public transportation system. Houses are equivalent in quality and size but differ in their distances to the city center. Each household needs at most one house. As long as houses are equally priced, households prefer a house with a shorter distance to the city center to those with longer distances, as longer distances necessitate more commuting cost and time. Since purchasing a house has a considerable impact on the household's budget, each household has non-quasi-linear preferences over houses and payments.[2]

Example C (**Apartment allocation problem in condominiums**). Several apartments belonging to a condominium are to be sold. These apartments are similar in quality and size but differ in orientation and floor. Each household needs at most one apartment. If the apartments are equally priced, households prefer apartments on higher floors to those on lower floors. However, households might have different preferences over apartments on the same floor, even if they are equally priced, because they differ in orientation. Such preferences create the phenomenon called the "higher-floor premium."[3] According to this phenomenon, in a condominium, apartments on higher floors have higher prices than those on lower floors. Similar to Example B, each household has non-quasi-linear preferences over apartments and payments.

The common features of the above allocation problems are as follows: Several heterogeneous objects are assigned to a group of agents. Each agent receives at most one object, and obtaining the object requires some monetary payment. Agents have non-quasi-linear preferences over bundles, each consisting of an object and a payment. Non-quasi-linearity describes the environment in which payments are sufficiently high such that income effects are non-negligible. In addition, objects are linearly ranked, and if they are equally priced, agents prefer a higher-ranked object to a lower-ranked object. Alternatively, objects are partitioned into several tiers, and if they are equally priced, agents prefer an object in the higher tier to an object in the lower tier, but agents may have different preferences over objects in the same tier.

We investigate an object assignment model with monetary transfers that features the above-mentioned characteristics. An *allocation* specifies how the objects are allocated to agents and how much each agent should pay. A *rule* is a mapping from a class of agents' preference profiles (called the "domain") to the set of allocations.

A *common-object-ranking domain* is a class of preference profiles such that an object-ranking is prespecified, and for each preference profile, an individual preference satisfies money monotonicity, object monotonicity, the possibility of compensation, and continuity, and more importantly, it ranks objects according to a prespecified ranking. A *common-tiered-object domain* is a class of preference profiles such that objects are partitioned into several tiers in a prespecified manner, and for each preference profile, an individual preference satisfies the first four conditions above and ranks objects according to the prespecified tiers.

We consider subdomains of common-object-ranking domains and those of common-tiered-object domains. A preference is *normal* if, as payments for objects decrease, objects that are preferred in the beginning become more preferred. A subdomain of a *common-object-ranking domain* is a *normal-rich common-object-ranking domain* if the subdomain includes all normal preferences of the common-object-ranking domain. A *normal-rich common-tiered-object domain* is defined similarly. Since normality is a natural assumption in the above-mentioned allocation problems, we focus on normal-rich common-object-ranking domains and normal-rich common-tiered-object domains.

An allocation is *efficient* if no one can be made better off without reducing others' welfare or reducing the total amount of the payments. *Efficiency* describes the property of a rule that for each preference profile in its domain, the rule always selects an efficient allocation. *Strategy-proofness* states that for each agent and each preference profile, revealing one's true preference is a weakly dominant strategy. *Individual rationality* states that for each agent and each preference profile, everyone should be no worse off than receiving and paying nothing. This property guarantees the agents' voluntary participation. *No subsidy* states that the payment for each object is non-negative. *No subsidy for losers* states that for each preference profile, agents who receive nothing cannot receive any subsidy.

[1] In the 2000 British 3G spectrum license auctions, each bidder receives at most one license. Moreover, some licenses are valued more highly than others. The total revenue from one auction represented 2.5% of the UK's GNP (Binmore and Klemperer, 2002).

[2] See Subsection 1.2.2 for details.

[3] See Subsection 1.2.3 for empirical works that document this phenomenon. It has also been reported in newspapers (e.g., The New York Times, "The Stratospherians," May 10, 2013).

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