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Asymptotic Existence of Fair Divisions for Groups

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The problem of dividing resources fairly occurs in many practical situations and is therefore an important topic of study in economics. In this paper, we investigate envy-free divisions in the setting where there are multiple players in each interested party. While all players in a party share the same set of resources, each player has her own preferences. Under additive valuations drawn randomly from probability distributions, we show that when all groups contain an equal number of players, a welfare-maximizing allocation is likely to be envy-free if the number of items exceeds the total number of players by a logarithmic factor. On the other hand, an envy-free allocation is unlikely to exist if the number of items is less than the total number of players. In addition, we show that a simple truthful mechanism, namely the random assignment mechanism, yields an allocation that satisfies the weaker notion of approximate envy-freeness with high probability.

1. Introduction

Dividing resources among interested parties in a fair manner is a problem that commonly occurs in real-world situations and is consequently of fundamental importance. Countries negotiate over international issues, as Egypt and Israel did in 1978 over interests in the Sinai Peninsula [7] and the U.S. and Panama in 1994 over those in the Panama Canal. Likewise, divorced couples negotiate over their marital property, airlines over flight routes, and Internet clients over bandwidth and storage space. On a smaller scale, typical everyday tasks involving fair division include distributing household tasks, splitting a taxi fare, and sharing apartment rent [13]. Given its far-reaching and often critical applications, it should not come as a surprise that fair division has long been a popular topic of study in economics [10, 12, 20, 21, 24].

To reason about fair division, we must carefully define what we mean for a division to be “fair”. Several notions of fairness have been proposed in the literature. For example, a division is said to be *proportional* if every player values her allocation at least $1/n$ times her value for the whole set of items, where n denotes the number of players. Another

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