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Journal of Economic Theory 153 (2014) 428–458

JOURNAL OF Economic Theory

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Identifying combinatorial valuations from aggregate demand ☆

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Received 14 June 2013; final version received 3 July 2014; accepted 7 July 2014

Available online 14 July 2014

Abstract

We study identification of combinatorial valuations from aggregate demand. Each utility function takes as arguments subsets or, alternatively, quantities of the multiple goods. We exploit mathematical insights from auction theory to generically identify the distribution of utility functions. In our setting, aggregate demand for each item is observable while demand for bundles is not. Nevertheless, our identification result allows us to recover the latter.
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JEL classification: C14; D11; D44

Keywords: Combinatorial valuations; Identification; Distribution of utility functions; Submodularity; Gross substitutes; Combinatorial auctions

☆ We are grateful to Patrick Bajari and Jeremy Fox for comments and conversations relating to the paper. We would also like to thank the organizers and participants at the conference on "Bounded Rationality, Revealed Preferences and Consumer Demand" at UCL, the 2012 North American Summer Meetings of the Econometric Society, and the Applied Micro Seminar at the University of Minnesota.

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http://dx.doi.org/10.1016/j.jet.2014.07.009
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1. Introduction

This paper studies identification of the distribution of combinatorial valuations from aggregate demand. The paper is relevant to the concerns of several literatures. First our exercise is in the tradition of the classic literature on the integrability of demand (Antonelli [1], Samuelson [29], Houthakker [14], Hurwicz and Uzawa [15], Mas-Colell [21]). This literature seeks to uncover a single consumer's utility function from her demand correspondence. However, our analysis occurs in the context of a more recent literature on Walrasian equilibrium with discrete goods and combinatorial auctions (Kelso and Crawford [16], Gul and Stacchetti [12], Lehmann, Lehmann, and Nisan [18], Cramton, Shoham, and Steinberg [6]). This literature deals with complex resource allocation problems involving bundles of discrete goods. By exploring the link between preferences and demand, our results contribute to an understanding of consumer or bidder behavior in such settings. Accordingly, our work departs from the classic integrability literature by identifying valuations from demand when goods are discrete. A further departure is allowed by the discreteness of our setting: Rather than identifying a single utility function from individual demand, we are able to identify the distribution of utility functions in a finite population from aggregate demand. In this respect our exercise is thematically related to the invertibility results for continuous demand systems (e.g. Brown and Matzkin [3,4], Lewbel [19], Beckert and Blundell [2]) that concern recovering distributions of stochastic demand functions or of unobserved consumer heterogeneity. Yet our paper deals with a very different environment – that of discrete goods and combinatorial preferences – and hence necessitates methods and arguments that are very different from those employed in the literature on continuous demand systems. In particular we employ various substitutes notions particularly adapted to the combinatorial setting.

Our results ultimately have relevance to the empirical literature on discrete choice models of demand. A common simplifying assumption in this literature is that a consumer is allowed to purchase only one alternative in a given period. There has been some work, of both a theoretical and an empirical nature, on discrete choices with multiple purchases, going back to Manski and Sherman [20] and Train, McFadden, and BenAkiva [31]. See also Hendel [13], Dube [8], and Gentzkow [11] for more recent works. These studies have relied on parametric functional forms for both distributions of heterogeneity and the class of underlying utility functions. This literature has restricted attention to data schemes where demand for bundles are available. In contrast, our approach studies identification in the situation where 1) individual goods are priced separately, so there are no bundle-specific prices, and 2) only demand for each product is available, not demand for bundles. However, our analysis is conducted in a very different setting than those in the empirical discrete choice literature. While we do not expect our results to transfer directly to the models in that literature, we believe that our arguments and the conditions we identify and study would be relevant to partial identification in such settings. Further discussion of this point can be found in Section 6.2.

We now describe our environment and results a bit more precisely. We assume that there is a finite number of goods and a finite number of consumers. (We can also handle the case of finitely many consumer types, as discussed in the Online Appendix.) Each consumer has a utility for every package of goods. Utility is assumed to be quasi-linear, so that there is a money good that enters linearly into the utility function. At every price vector, we observe aggregate demand. That is to say, we only observe the total number of units of each good demanded; we do not observe how many consumers demand any given package. For example, if one unit of good 1 and one unit of good 2 are demanded, we do not observe whether these two units were demanded by two separate consumers or by only one consumer. Using only the demands of each good, *generically*

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