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Frontiers in spectrum auction design

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ABSTRACT

Spectrum auction design has seen number innovations in the recent years. Regulators have used various types of combinatorial auction formats including simple ascending combinatorial clock auctions and first-price sealed-bid combinatorial auctions. The Simultaneous Multi-Round Auction (SMRA) and the two-stage Combinatorial Clock Auction (CCA) are the most wide-spread auction formats for spectrum sales to date. We provide an accessible overview of strategic problems in these auction formats and summarize research challenges in this field for a broader audience of readers in industrial organization.

1. Introduction

The 1994 sale of radio spectrum for *personal communication services* (PCS) marked a sharp change in policy by the US Federal Communications Commission (FCC). Before turning to auctions the FCC had allocated valuable spectrum on the basis of comparative hearings (also known as *beauty contests*) and lotteries. Nobel laureate Ronald Coase long advocated that market-based mechanisms would improve the allocation of scarce spectrum resources, but his early insights were ignored for decades (Coase, 1959). While there were significant successes in the award of spectrum licenses via auction, there is

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still no consensus about the best way to auction off spectrum licenses, and many new requirements became known in the last 20 years.

Economic theory provides a well-known solution to the sale of multiple objects in a model with independent and private values and quasi-linear utility functions: the celebrated Vickrey–Clarke–Groves (VCG) mechanism. It is the unique mechanism to provide dominant strategies to bid truthfully. The result is beautiful, but the mechanism is rarely if ever used (Ausubel and Milgrom, 2006).

There has been a long discussion about appropriate auction mechanisms for the sale of spectrum rights (Porter and Smith, 2006). Since 1994, the Simultaneous Multi-Round Auction (SMRA) has been used worldwide (Milgrom, 2000). The SMRA design was very successful, but also led to a number of strategic problems for bidders (Cramton, 2009b). The *exposure problem* is central and refers to the risk for a bidder to make a loss due to winning only a fraction of the bundle of licenses (or blocks of spectrum) he has bid on at a price which exceeds his valuation of this subset. This has led to the design of combinatorial auctions. The Combinatorial Clock Auction (CCA) is the most wide-spread combinatorial auction design for spectrum sales. The auction format has led to some new issues and currently there is an ongoing debate among regulators, telecoms, consultants, and academics about the future of spectrum auction designs.

In this paper we briefly revisit SMRA and the CCA and some of the known strategic challenges in these auction formats. For this we draw on a new edited volume on spectrum auction design, which covers these and other auction formats in great depth (Bichler and Goeree, 2016). Then we discuss assumptions in game-theoretical models which should be revisited to better reflect requirements of regulators and preferences of bidders in the field.

2. The simultaneous multi-round auction

Let us first discuss the SMRA, which has been used for selling spectrum licenses for more than 20 years.

2.1. Auction rules

The SMRA is an extension of the English auction to more than one license. All the licenses are sold at the same time, each with a price associated with it, and the bidders can bid on any one of the licenses. The auction proceeds in rounds, which is a specific period of time in which all bidders can submit bids. After the round is closed, the auctioneer discloses, who is winning and the prices of each license, which coincide with the highest bid submitted on each license. There are differences in the level of information revealed about other bidders' bids. Sometimes all bids are revealed after each round, sometimes only prices of the currently winning bids are published.

The bidding continues until no bidder is willing to raise the bid on any of the licenses any more. In other words, if in one round no new bids are placed, the bidders receive

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