International Journal of Industrial Organization 53 (2017) 63–98

Contents lists available at ScienceDirect

International Journal of Industrial Organization

www.elsevier.com/locate/ijio

Auctioning the Digital Dividend: A model for spectrum auctions

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ARTICLE INFO

Article history:
Received 28 January 2015
Revised 17 April 2017
Accepted 19 April 2017
Available online 4 May 2017

JEL Classification:
C61
C73
D44
L13
L96

Keywords:
Clock auction
Spectrum auction
Telecommunications market
Equilibrium bidding
Capacity constraints

ABSTRACT

We model a spectrum auction where firms purchase units to participate in a constrained, multi-product, downstream market. We use dynamic programming techniques to numerically solve for the optimal bidding strategy in a clock auction. Firms value constraining competitor market power, so incumbents often bid aggressively to shut out entrants. We find that high cost firms may hold up the market, so the auction may be inefficient and generate zero revenue. An auction may be optimal for a regulator maximising total surplus. A regulator maximising auction revenue sets reserve prices high enough to restrict spectra sold, effectively behaving as a monopolist.

1. Introduction

In most modern economies, the "Digital Dividend" represents a substantial technological and financial windfall. Developments in television broadcasting allow the

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http://dx.doi.org/10.1016/j.ijindorg.2017.04.004
0167-7187/

transmission of digital video and sound that require only one-sixth the bandwidth of inferior quality analog transmissions. Therefore, replacing analog transmissions with digital transmissions frees up a large quantity of spectrum frequencies, which can be employed to transmit wireless data, used by mobile phones, laptop computers, and other devices.

These unallocated new spectra offer opportunities for consumers, producers, and government. First, wireless telecommunications companies can expand their services. Firms that have access to the new spectra can effectively provide superior data services. Second, consumers can enjoy a wider range of services. Third, the government benefits from the unallocated spectra in two ways. On the one hand, the government, as an auctioneer, can earn revenue from the auction. On the other hand, the government, as a regulator, can affect the degree of competition in the telecommunications market to increase total surplus. A common policy tool adopted by governments to achieve social optimum is to conduct an auction with a reserve price and caps on firms' winnings to prevent one firm from winning all units and becoming a monopolist; see Cramton et al. (2011).

Spectrum auctions are potentially an efficient way to allocate the new spectra across firms and do not represent new phenomena in most countries.[1] A spectrum auction is an example of a *multi-unit auction*. The auctioneer is selling a collection of relatively homogeneous goods to multiple firms.[2] Our aim in this paper is to examine the equilibrium properties of a Digital Dividend auction where participants compete for market power in the telecommunications market. Our model consists of a downstream market, in which firms play a Cournot game with capacity constraints, similar to Laye and Laye (2008). Specifically, firms produce two goods: low and high data use plans, and are constrained in their ability to produce data plans by the amount of spectra they have available. Having projected their potential profits in the downstream market, firms enter into a simultaneous uniform-price clock auction to increase their production capacity.

It is worth noting that although we consider the spectrum auction as the motivating example, our model can be generalised to investigate other problems with an interaction between a downstream market and an upstream auction/competition. Examples include procurement auctions (to obtain market access) for medical drugs in third-world countries and competition by airlines for landing slots; see Eső et al. (2010).

Given the complexity of solving multi-unit auctions (see Cramton, 2013), we first investigate a special case where only 2 firms compete for 2 units. For our subsequent results, we use a numerical technique to solve for the bidders' optimal strategies, and the resulting allocations.

[1] The United States began its auctions for spectrum licences during the 1990s, and have since assessed their efficiency. For example, see Cramton (1997), Cramton (1998), Cramton (2013), Kwerel and Rosston (2000), Bush (2010) and Cramton et al. (2011). Meanwhile, the GSM (second generation mobile telecommunication) and UMTS (third generation) auctions in Europe from 1999 to 2001 attracted a lot of attention from the public for their interesting outcomes. For example, see van Damme (2002), Klemperer (2005), and Grimm et al. (2003). Economists have also been surprised by the huge revenues the British government realised from the sale of its 3G telecom licences (Binmore and Klemperer, 2002).

[2] In reality, spectrum frequencies are not truly homogeneous because technology-dependent synergies from having access to adjacent frequencies exist. In addition, regional standards, technological limitations, and device manufacturers' decisions may make certain segments of a given band more or less desirable.