

Research on the Best Way to Allocate Spectrum Resources: Perspective from Auction

Wanjun Chen^{1, †}, Hanwen Liu^{2, †}, Mingxin Liu^{3, *, †}, Chenyang Zhang^{4, †}

¹Ulink college of Shanghai, Shanghai, China

²Hefei No. 10 High School, Hefei, China

³St.Francis' college, Letchworth Garden city, UK

⁴Jilin University of finance and economic, Changchun, China

*Corresponding author: 17mliu@st-francis.herts.sch.uk

†These authors are contributed equally.

Abstract. The context of this paper's research is spectrum auctions, and talk in detail about the spectrum auction that took place in the UK in the spring of 2000, as well as other ways of allocating spectrum, comparing them, and classifying the advantages and disadvantages. The reason why this study spectrum auctions is that to compare other methods and choose the best way to allocate spectrum so that both firms and the government can benefit the most. The research method is a case study, by reading the literature and investigating the data, we will analyze the research problem from an objective point of view. Finally, by analyzing several advantages of spectrum auctions, this article find that auctions are indeed the most efficient way to allocate spectrum rather than beauty pageants. The significance of the research is that the allocation of the spectrum can make a large amount of money for the government and at the same time, firms will pay a large amount of money, so the goal of the research in this paper is to find a method that can satisfy both firms and government needs.

Keywords: Spectrum auction; game theory; high price.

1. Introduction

1.1 Research Background

Nowadays, lots of countries around the world are using auctions to allocate scarce spectrum resources, which is called spectrum auction. The spectrum auction is a kind of English auction, government can sell licenses that can operate 3G mobile telephone networks through an auction system. A specific auction that I will talk about in the following paragraph is the UK 3G spectrum auction that happened in 2000.

The 3G spectrum auction that happened in the spring of 2000 in the UK was held as a simultaneous ascending auction. Simultaneous ascending auctions are those in which all relevant licenses are sold simultaneously, and there are multiple rounds of auctions. Each round can have new bids, and the auction only ends when bids for all licenses have stopped. The licenses sold by the UK government in 2000 were called UMTS licenses. There are five licenses labelled A-E sold by radio communications, and each of them has different minimum opening bids of 125, 107.1, 89.3, 89.3 and 89.3 million respectively. The auction format is as follows. All five licenses are auctioned at the same time. The auctions are conducted in rounds. In each round, bidders who are not current price bidders for a license may bid on the license, raising the price to at least the minimum bid increment for the license. At the end of the round, all bids and bidders are confirmed, along with the highest bid and bidder for every license and the lowest bid for the next round. The auction will only conclude when no bidders are willing to bid higher for any license, otherwise, it will continue. The auction winner for that specific spectrum auction is T/W, Vodafone, BT, 121 and orange, and won licenses A-E at the price of £4385 £ 5964, £4030, £4004 and £4095 million respectively. All in all, the UK 3G spectrum auction was raising £22.5 billion in revenue for the government, and it was recorded as the largest auction in history.

However, because of the spectrum auction in 2000 that raised £22 billion for the British government that many countries began to follow this way of allocating spectrum, in order to be able to seek sufficient funds to help balance national budgets. Therefore, the problem arose because, in the following German spectrum auction, the government set the minimum price so high that many companies could not afford to take part in it. Even if some companies successfully get the license, they will find a way to make the money back. The way to earn it back is to increase the selling price, so consumers have received a huge impact. Subsequently, more and more countries are realizing that a successful spectrum auction is not about bringing the largest revenue to the government, but about effectively allocating spectrum resources. However, whether spectrum auction is the most efficient way to allocate spectrum? Is there any other way not only for firms to get licenses at a cheaper price but also without the loss of interests of the consumers, at the same time, the government can maximum their utility?

1.2 Research Motivation

According to the definition, spectrum auction means that authorized users plan a certain frequency band, conduct public auction, and transfer the right to use the frequency band to the highest bidder by means of public bidding. Since it is an effective way to allocate spectrum resources, its main advantages for the following ways. First, the spectrum auction mostly uses first-price auctions, in which the highest bidder gets the item and pays the corresponding maximum amount, also following the principle that the highest bidder wins. This auction allows for the most efficient allocation of spectrum resources because there is competition among applicants. Second, if there is a public auction, that is, open outcry. This intensifies the competition among participants and forms a competitive market structure, and the market functions. But a public auction does not reflect the true valuation of the winner and an open auction allows all participants to communicate information to each other. Such auctions are prone to collusion among participants. The intense competition in a public auction may also deter some potential bidders. However, if you have a closed auction, that is to say, you inhibit collusion to some extent. In a closed auction, all the participants only know their own bids, they don't know anything about the bids of the other players, and the highest bidder wins and pays the corresponding price. This competition would not be wasted, since it would greatly increase auction revenues, which would also make up for shortfalls in tax and other revenues. In addition, economic theory and outcomes have demonstrated that auctions are the most efficient and effective way to allocate spectrum rights. Auctions also increase aggregate competition and spectrum availability for a larger subset of potential mobile operators. The use of a variety of geographic license areas and spectrum block sizes, in particular, has enabled a wide range of interested parties to compete and to provide service across the country.

1.3 Research Contents

This paper illustrates several aspects of superiorities of the auction. To begin with, the first part is for its economic benefits. Auctions maximize the benefits of consumers by allocating licenses to parties that value licenses most and promoting efficient spectrum use. For consumers, how to maximize their own interests is what they are pursuing. Therefore, the method of auction may be the best option for these bidders. Not only that, but also auctions minimize wasteful private expenses for obtaining licenses and increase competition with existing services [1]. Secondly, auctions create a relatively level playing field. Auctions are relatively fair, objective, open and transparent processes. In contrast, comparison hearings can be subject to allegations of bias. In addition, the comparison process may be subject to political pressure, which as a result may lead to a lack of public confidence in the decisions resulting from such hearings [2]. It is clear that having a level playing field is good for both initiators and bidders. For the initiator, the auction can involve as many people as possible to obtain the most favorable price; For bidders, they can observe the real-time movements of other bidders and reduce losses by reducing the likelihood of collusion between bidders or between bidders and initiators. The third part is for income. The 32 auctions conducted by the FCC raised more than

\$32 billion for the U.S. Treasury. In contrast, comparing hearings does not increase revenue without filing fees or licensing fees, and it is not feasible to establish a set of fees that can increase as much revenue as possible without information on license values that can only be generated in auctions [3]. The method and process of auction is relatively simple, and does not require additional manpower and costs, which is why it is favored by most people.

By the way, auctions and game theory are inextricably linked. Game theoretic analysis showed free-rider issues in some proposed bidding processes, resulting in the dismissal of plans for 'combinational bidding,' in which bidders clarify prices for collections of licences rather than individual licences [4,5]. These theories standardise and make auctions more equitable. As a result, game theory is also being employed to reevaluate the closing policy for US spectrum auction houses in order to determine whether alternate solution rules can preserve the flexibility of the existing regulations while reducing the auction's vulnerability to informal collusive agreements [6].

2. Theoretical Analysis of Spectrum Auction

2.1 The analyse of the benefit and shortcoming about this spectrum auction

The spectrum auction was highly successful in achieving the efficiency and competition. At the same time it raised considerable revenues.

In this paper, it mainly talks about the 3G spectrum auction in UK, which have elaborated so many effectiveness and advantages of the spectrum auction in detail. However, in this part, the passage is going to analyze the disadvantages and the way to solve the problem: The excessive high bid price in the spectrum auctions.

First off, the first price auction is typically used in spectrum auctions. Following the rule of the highest bidder, the highest bidder wins the item and pays the matching maximum sum. Due to competition between applicants, this auction enables the most efficient distribution of spectrum resources.

Second, a public protest is held if there is a public auction. As a result, participant competition increases, creating a competitive market structure and function. The fact that the winner's value is not accurately reflected in the public auction, however, permits all participants to communicate with one another. Participants in this form of auction can easily collude. Some prospective bidders may be discouraged by the fierce competition during public auctions.

However, if your auction is closed, that is to say, you have suppressed collusion to some extent. In closed auctions, all participants only know their bids, they know nothing about the bids of other participants, and the highest bidder wins and pays the corresponding price. This competition will not be wasted, because it will greatly increase auction revenue, which will also make up for the shortage of taxes and other revenue. In addition, economic theory and results show that auction is the best way to allocate spectrum rights efficiently and effectively. The auction also provides greater spectrum competition and availability for more potential wireless suppliers. Specifically, the use of various geographically licensed areas and spectrum blocks allows various stakeholders to compete and provide services nationwide.

2.2 Problem discovery and analysis

The bid price in the spectrum auctions was so high.

Consider the conclusion of the UK auction as an illustration. The UK 3G auction lasted 150 rounds and seven weeks, ending on April 27, 2000.

For the five licenses, thirteen bidders competed. Phase 2 of the qualification process saw the start of the bidding after all disputes with connected bidders had been settled. The auction generated 22.5 billion in revenue, making it the greatest auction ever. Given that the US is 4.5 times larger than the UK, this figure exceeded the total earnings of all US spectrum auctions held over the six years prior. The cost comes to 650 euros per person or 1100 euros per subscriber who is currently paying.

The final winners and prices paid are shown in table 1, and the prices exceeded the expectations of everyone.

Table 1. Auction Winners and Winning Bids

	A	B	C	D	E
MHz spectrum	2×15	2×15	2×10	2×10	2×10
MHz spectrum	5	0	5	5	5
Price bidder	T/W	Vodafone	BT	121	Orange
Price Bid	4385	5964	4030	4004	4095

3. Suggestion

The exploration of spectrum auction in Germany also began with the 3G spectrum auction in 2000. It took 19 days from July 31 to August 18, 2000, with a total of 173 rounds of bidding, raising 50.8 billion euros. The operators who finally won the spectrum license were E-Plus Hutchison, Group 3G, Mannesmann Mobilefunk, MobileCom Multimedia, T-Mobile and VIAG Interkom.

Like the 3G auction in the UK, the 3G auction in Germany has a huge amount of money, and the purpose of the auction has been achieved only in terms of income. However, this also made the operators who won the spectrum license have to pay a huge amount of money in the next time. And because of the huge amount of money needed to build the network, after the 3G auction in Germany, the operation conditions of all operators were not particularly ideal. Some operators were forced to go bankrupt and withdraw their capital from Germany, and the other operators also experienced a long time of losses. It can be seen from this that there is a reasonable price range for the spectrum license fee, which is too low to reflect the value of the spectrum and is not conducive to promoting the efficient use of the spectrum; Too high is too much economic pressure for operators, which is not conducive to market stability and normal development of telecom operators [7]. The German structure has the advantage of determining the licencing market and size structure endogenously. The bidding strategies, on the other hand, are more complicated. The auction in Germany was not completely transparent. After each round, only the current price bidder and bidders were mentioned, rather than all bidders. This made it harder for bidders to notice when other bidders reduced their bids from three locks to two blocks. This may allow the entrant to bid and provide a more precise price. And the roll-out will be less affected, then the spectrum resources will be well-used and have a worry-free-construction.

It is worth noting that it is not easy to allocate spectrum with spectrum auction mode, which requires better combination of theory and practice. Even every time spectrum is allocated through spectrum trading, it needs to go through a lot of research, solicit opinions from all parties and evaluate economic value before entering the implementation stage. Through accumulating experience for many times, we have slowly transformed from the current single administrative approval mode to the mode combining the spectrum trading mode with the administrative approval mode. The whole transformation process may last for 10 years or even longer, but its significance for the entire radio industry is enormous [8-11].

4. Conclusion

All in all, this paper describes the methods used to allocate spectrum, with a focus on spectrum auctions. Through different aspects of the study, we found that spectrum auctions are indeed the best way to allocate spectrum, as they are transparent and allow for maximum benefits for firms, and the government receives a very large amount of profit. However, there are also some limitations to this method, such as the price being so high that firms have to pay a very high price because if they do not participate in the spectrum, and don't bid in the spectrum auction, the company's shares will fall significantly, so the company's investment becomes less and less, and the consumer has no confidence to continue using the company's services. This would give lots of pressure on the firms. Spectrum

auctions also have limitations because the government always wants to raise the starting price because they can get more revenue from the government. However, if the price is extremely high, firms can't afford it, so they have to take out a loan from the bank, but there is no guarantee that the company's turnover will be able to repay the high loan. Therefore, the government needs to consider carefully when setting the starting price, and analyse it in such a way that the starting price can satisfy the government's profitability while not putting too much pressure on the companies.

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