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Auctions, aftermarket competition, and risk attitudes ☆

Maarten C.W. Janssen [a,b,c], Vladimir A. Karamychev [b,*]

[a] Department of Economics, University of Vienna, Hohenstaufengasse 9, 1010 Vienna, Austria
[b] Department of Economics, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
[c] Tinbergen Institute, The Netherlands

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ABSTRACT

With the experience of the sequence of UMTS auctions held worldwide in mind, we consider a situation where firms participate in license auctions to compete in an aftermarket. It is known that when a monopoly right is auctioned, auctions select the bidder that is least risk-averse. This firm will choose a higher value of the aftermarket strategic variable than any other firm will do, thereby implying a higher market price under price setting behavior and a lower price due to higher quantity under quantity-setting behavior. This paper extends the analysis to oligopoly aftermarkets and analyzes whether the monopoly result carries over to oligopoly settings. We argue that with multiple licenses and demand uncertainty auctions actually perform even worse from a welfare point of view than the monopoly case would suggest. A strategic effect strengthens the monopoly result with respect to prices, but weakens the result with respect to quantities.

1. Introduction

In many markets around the world, governments use auctions to allocate licenses to interested parties. A characteristic feature of these auctions is that after the auction is held, the winning firms compete with each other in an aftermarket where the revenues and profits depend not only on the market strategies that the licensed firms choose, but also on uncertainty concerning important market features, such as demand or cost. Winning a license is very much like winning a lottery ticket where the value of the ticket is uncertain. Important examples that share these features are the UMTS auctions that have been held in the past years all around the world. Other examples include the selling of radio frequencies for commercial radio and the selling of licenses to exploit gasoline stations on certain locations.

If firms were completely risk-neutral (an assumption often made for analytical tractability), this uncertainty would not affect firms' behavior in a crucial way. However, as we will briefly argue below, there are good reasons to believe that firms are not necessarily risk-neutral and, in fact, that firms differ in their risk attitudes. In this paper, we analyze how firms' risk attitudes affect their bidding behavior in an auction followed by an aftermarket.

Janssen and Karamychev (2007) ask a similar question in case governments decide to allocate only one license, thereby creating a monopoly in the aftermarket. They identify a risk attitude effect and show that the least risk-averse firm has the highest certainty equivalent for the aftermarket game (lottery) and, therefore, will win the license in any standard auction format. This firm chooses a higher value of its strategic variable, *e.g.*, price or quantity, than any other firm would choose. Thus, if the strategic variable is price, auctions select the firm that sets the highest aftermarket price, leading to a welfare loss relative to any other allocation of licenses. On the other hand, if the strategic variable is quantity, auctions select the firm that sets the highest quantity, resulting in a lower aftermarket price (and a welfare gain). We refer to this selection aspect of auctions as to the "monopoly result".

A crucial assumption in the present paper and in Janssen and Karamychev (2007) is that firms are not necessarily risk-neutral. Empirical studies in finance indicate that firms may indeed be risk-averse, or that their behavior is as if they were risk-averse. Nance et al. (1993) and Geczy et al. (1997), among others, argue that firms hedge against different types of exogenous shocks such as exchange rate volatility. In a study on the gold mining industry, Tufano (1996) argues that delegation of control to a risk-averse manager, whose renumeration is linked to the firm's performance, may cause the firm to take actions in a risk-averse manner. As delegation of control differs between firms, and as the payment structure of managers differs from

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* Corresponding author. Department of Economics, Erasmus University Rotterdam, Burg. Oudlaan 50, NL-3062 PA Rotterdam, The Netherlands.
E-mail address: karamychev@few.eur.nl (V.A. Karamychev).

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firm to firm, firms may very well act as if their attitudes towards risk differ significantly from one to the other. On the other hand, liquidity constraints and prospects of bankruptcy may force managers to undertake risky actions. Therefore, firms' managers can be both risk-averse and risk-seeking. In an experiment that they conducted with 224 managers, Laughhunn et al. (1980) showed that there are indeed large individual differences in risk attitudes between managers.

It is well-known that under a general form of risk aversion, the action price, which is sunk at the market stage, affects firms' aftermarket behavior. In particular, firms with identical utility functions make different choices in risky environments depending on how wealthy they are. McMillan (1994) argues that as auctions force firms to pay considerable amounts of money for licenses, auctions may force firms to behave differently in the marketplace. This wealth effect, however, disappears when firms are characterized by constant absolute risk aversion (CARA). As we want to concentrate on the selection aspect of auctions and not on the wealth effect, we assume that firms have CARA utility functions.

The main question we address in this paper is whether the monopoly result discussed above carries over to a situation where governments auction multiple licenses. This question is relevant in most applications (UMTS, radio frequencies, *etc.*) as governments often create oligopoly markets by auctioning off more than one license. We will say that the monopoly result generalizes to the oligopoly context if the auction has an equilibrium in which the most risk-seeking (least risk-averse) firms make the highest bids. We refer to such an equilibrium as a "risk-seekers' equilibrium", and we analyze the conditions under which it exists. To avoid complications arising from the possibility that players would like to signal their type through their bids, we analyze this question in a private information scenario, where firms are neither informed about each other bids, nor about the risk attitudes of each other in the aftermarket.[1]

This private information scenario arises in a sealed-bid uniform-price multi-unit auction where winning firms are the firms with the highest bids, and they pay a license fee which is equal to the highest non-winning bid. This is the auction format we adopt in this paper and the main features of this format were used, for example, in the Danish UMTS auction in 2001, see National Telecommunications Agency Denmark (2001). Qualitatively similar (although more complicated) results can, however, also be obtained for other formats, for example a pay-your-bid multi-unit auction, see, *e.g.*, Janssen and Karamychev (2005). Using this auction format, we consider both demand and cost uncertainty, and distinguish between differentiated Bertrand (strategic complements) and Cournot (strategic substitutes) oligopolies.

The main result we obtain is as follows. Under demand uncertainty, auctions actually perform worse than what could be expected on the basis of the monopoly result. Under differentiated Bertrand oligopoly, the aftermarket externality (due to strategic interactions between firms) reinforces the risk attitude effect. This implies that indeed the least risk-averse firms are selected and they choose the highest prices. Thus, like in the monopoly setting, auctioning multiple licenses results in higher market prices than if any other allocation mechanism is used. Under Cournot oligopoly, the aftermarket externality works in the opposite direction and weakens the risk attitude effect. When the externality is sufficiently strong, a risk-seekers' equilibrium fails to exist. This implies that the least risk-averse firms do not necessarily get licenses. Thus, and contrary to the monopoly setting, auctioning multiple licenses does not necessarily result in higher quantities and, therefore, lower market price than if the licenses were allocated differently. Hence, from a consumer welfare perspective the attractiveness of using auctions relative to using any other allocation mechanism is higher in the case of a single license than in the case of multiple licenses.[2]

The reason why the aftermarket externality works in the opposite direction in Cournot competition is that in a risk-seekers' equilibrium, the winning firms compete with the least risk-averse rivals. These firms choose the highest quantities and, therefore, are the most aggressive competitors. It remains true that for a given set of other players in the aftermarket, a relatively less risk-averse firm is willing to pay more for the license than a relatively more risk-averse firm is willing to pay. However, it may well be that a set of the least risk-averse firms make less profits and, therefore, have a smaller willingness to pay for the licenses than a set of more risk-averse firms do. That is why less risk-averse firms are not willing to pay high auction prices and outbid more risk-averse firms.

Our second result for Cournot competition is that the aftermarket externality and the *ex-ante* affiliation of firms' risk types together give rise to a strategic effect that does not only cause that a risk-seekers' equilibrium fails to exist, but that creates the conditions for another, "risk-averse players' equilibrium" to exist. In a risk-averse players' equilibrium, the most risk-averse firms (or the least risk-seeking firms—depending on the risk attitudes under consideration) submit the highest bids, win the licenses, and choose the lowest production levels, which again, as in the Bertrand case, results in the highest possible aftermarket price.

Another type of uncertainty that may exist and which we analyze as well is uncertainty about production costs. Here we show that if the uncertainty is about the level of fixed cost then the monopoly result does generalize to the oligopoly situation, whereas if the uncertainty is about marginal cost then a strategic effect appears, and the monopoly result for both price and quantity setting does not generalize.

The paper is organized as follows. An overview of related literature is provided in Section 2. As the model itself and the equilibrium analysis are fairly complicated, we start off in Section 3 with an example where we make some simplifying assumptions. The example makes it intuitively clear why under demand uncertainty the monopoly result carries over under Bertrand competition, but not under Cournot. Section 4 then presents the formal model where these simplifying assumptions are not made. The main results for the general model are provided in Section 5. Section 6 derives implications of the general results in case of demand uncertainty, while Section 7 delves into the case of cost uncertainty. Section 8 concludes and the Appendix A contains all proofs.

2. Literature review

There is a relatively large, recent literature on the possibility of inefficient allocation of licenses in auctions due to the presence of interdependencies. First, there is a literature where one license is auctioned and the auction winner competes in the aftermarket with non-winners.[3] Moldovanu and Sela (2003) analyze a situation where aftermarket competition is characterized by Bertrand competition and cost is private information at the auction stage.[4] When in such a situation a patent for a cost-reducing technology is auctioned amongst the competitors, they show that standard auction formats do not exhibit efficient equilibria where bids are increasing in the firms' efficiency parameter. Goeree (2003) and Das Varma (2003) analyze a similar setting

[1] Signaling plays an important role in a different scenario where the bids of the winning firms but not their types become public so that the auction stage has to be analyzed as an N-player signaling game. Another scenario, used in Section 3 for illustration purposes, where types of all winning firms become public, does not seem to be very realistic. Nevertheless, all these scenarios can be analyzed in a similar way to the private information scenario.

[2] We compare consumer welfare for different number of licenses indirectly, *i.e.*, through its comparison with welfare generated by, *e.g.*, a random allocation. In our analysis, the main effect of the number of licenses on consumer welfare is independent from firms' risk attitudes. Thus, a normative analysis of the optimal (from consumers' prospective) number of licenses does not depend on whether the licenses are auctioned or assigned randomly.

[3] Jehiel and Moldovanu (2006) provide an overview of existing work in this area and argue that in case firms' aftermarket profits depend on private information in the hands of other winning firms there is an informational externality. See, also, Jehiel et al. (1996) and Jehiel and Moldovanu (2000) for related papers where an (informational) externality may lead to inefficiency even in standard single-unit auctions.

[4] To avoid signaling issues, they consider the case where the true production costs of the bidding firms are revealed after the auction.