

Selection Effects in Auctions for Monopoly Rights*

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Abstract

We demonstrate that auctioning market licenses may result in higher market prices than assigning them via more random allocation mechanisms. When future market profit is uncertain, winning an auction is like winning a lottery ticket. If firms differ in risk attitudes, auctions select the least risk averse firm, which, in turn, set a higher price (or a higher quantity, in case quantity is the decision variable) in the marketplace than an average firm.

Key Words: Aftermarkets, Auctions, Risk Attitude

JEL-codes: D43, D44, D82

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1 Introduction

In recent years, governments throughout the world have extensively used auction formats to allocate licenses to operate in the marketplace. Among the many examples that could be mentioned, the allocation of UMTS-frequencies in mobile telephony markets in different countries around the world probably has attracted most attention. One element these auctions have in common is that after the auction is conducted, winning firms compete in a market with considerable uncertainty about (future) consumer demand.

Another element these auctions have in common is the heated debates about whether they result in higher consumer prices. Private enterprises consistently argue that the fee that has to be paid during an auction to obtain the license, is reflected in the market prices that these same enterprises later charge to consumers.¹ The more money is paid during an auction, the higher future consumer prices are. Economic theorists, on the other hand, have consistently argued that the fees paid to obtain a license are sunk costs and should have no effect whatsoever on the prices that are later charged in the marketplace, cf. [2], [3]. In the same vein, they argue that the views expressed by these enterprises may simply stem from the firms' own interests not to have to bid (and pay) in auctions.² Nevertheless, there is now experimental evidence that auctions may have a positive impact on market prices, [13].

In this paper, we look at the relation between auctions and prices in the after-market more closely. We will argue by means of a theoretical model that the sunk cost argument need not hold if bidders differ in their risk attitudes. Of course, the usual assumption made in the literature is that firms are all risk neutral, but recent empirical studies in finance indicate that firms may indeed be risk-averse, or at least that their behavior is such that it is as if they were risk averse. Nance *et al.* [12] and Geczy [5], among others, argue that firms hedge against different types of exogenous uncertainties such as the volatility of exchange rates. In a study on the behavior of the gold mining industry [14], it is argued that delegation of control to a risk-averse manager 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 firm to firm, firms may very well act as if their attitude towards risk differs 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.

It is well-known that under general forms of risk aversion, the sunk cost argument does not hold: players with the same utility function make different choices depending

¹Governments have also been worried about the possible effect on consumer prices; see *e.g.*, [4].

²There are some, see, *e.g.*, [11], arguing that if firms have to pay large sums of money, they may face an increase in the cost of obtaining capital, which may slow down innovation.

on how wealthy they are. The sunk cost argument continues to hold, however, if players are characterized by constant absolute risk aversion (CARA). As we want to concentrate on the *selection* aspect of auctions and not on the *wealth* aspect, we consider firms having CARA utility functions.

To make the selection argument, we focus in this note on the case where only one license is auctioned, so that the winner of the auction becomes a monopolist in the aftermarket.³ When future profit is uncertain, auctions tend to select the bidder that is least risk averse, and since this firm concentrates more on the good states of demand, this firm chooses a higher level of its decision variable than an average firm does. This is what we will call the *risk attitude effect*. Whether the aftermarket price is higher or lower depends on whether the aftermarket monopoly is a price or a quantity setter. A price setting monopolist sets a *higher* price than a randomly selected firm, whereas a quantity setting monopolist sets higher output, resulting in a *lower* expected market price. Thus, the main idea incorporated in the paper is a selection argument: auctions select the least risk-averse firm and this firm makes very different decisions concerning prices or quantities than a randomly selected firm.

The selection aspect of auctions may have long-term as well as short-term implications for the market price. If a firm's quantity choice is interpreted as a capacity choice, in the sense of Kreps and Scheinkman [9], and if capacities have to be chosen before the uncertainty is realized, then the selection effect has long-term consequences, *i.e.*, a lower price over a long period of time. If firms are price setters, and if demand remains uncertain for a long time, the selection effect also has long-term consequences.

The paper borrows from the early literature on price and quantity setting behavior of a risk-averse monopolist (cf., [1] and [10]). The paper is, of course, also related to the growing literature studying the strategic interaction between bidding in auctions and firms' behavior in the aftermarket (see, *e.g.*, [2], [6], [7]). This paper is the first, however, to consider the importance of differences in risk attitudes for the interaction between auctions and aftermarkets.

The rest of this note is organized as follows. Section 2 describes the model. In Section 3 we present and discuss the main results. Section 4 provides some further discussion and concludes.

2 The Model

Consider a monopolistic market with uncertain demand, where the monopoly profit $\pi(s, \theta)$ depends on the monopolist's choice of the strategic variable s , $s \geq 0$, and the uncertainty variable θ . The strategic variable s can be interpreted in many different

³Auctioning multiple licenses is extensively studied in [8].

ways, but two common interpretations are that of a price choice and of a quantity, or capacity, choice. If the firm chooses price, then $s = p$, and the firm fulfills a random demand $q(p, \theta)$. If the firm chooses quantity, then $s = q$, and the price consumers pay for this quantity is $p(q, \theta)$, and the firm accepts to sell its pre-determined quantity q at this random price. The uncertainty is represented by a random variable θ . Since we make no specific assumptions about the function $\pi(s, \theta)$, without loss of generality we assume that θ is uniformly distributed over $\sigma = [0, 1]$. Access to the market is limited to the firm that has obtained a license. The government considers an auction where the highest bidding firm wins this license. To fix attention, we think of the auction as being an English auction, or a second-price auction.

Firms have CARA utility functions and differ in their risk attitudes. We denote the measure of absolute risk aversion of a firm i as r_i , and its utility function as

$$U_i(m) \equiv U(m, r_i) = \begin{cases} \frac{1}{r_i} (1 - \exp(-mr_i)) & , \text{ if } r_i \neq 0 \\ m & , \text{ if } r_i = 0 \end{cases}$$

The following lemma states that $U_i(m)$ decreases with the measure of absolute risk aversion r_i .

Lemma 1 $\frac{\partial U}{\partial r_i}(m, 0) = 0$ and $\frac{\partial U}{\partial r_i}(m, r_i) < 0$ for all $r_i \neq 0$.

The proof of Lemma 1 is straightforward and is, therefore, omitted. We assume that the individual risk attitudes (firms' types) are drawn from a common distribution F_r with finite support $[\underline{r}, \bar{r}] \subset R$. Positive values of r_i correspond to risk averse firms whereas negative values correspond to risk seeking firms. A player's risk attitude is private information to the player in the auction stage.

The expected utility of a firm i that gets a license to operate in the market at the auction price w , has a risk type r_i and sets a level s of the strategic variables, is denoted by $W^i(s, w)$. It follows that

$$W^i(s, w) \equiv E_\theta(U_i(\pi(s, \theta) - w)) = \int_\sigma U(\pi(s, \theta) - w, r_i) d\theta. \quad (1)$$

As usual, we assume that $W^i(s, w)$ is twice differentiable and strictly concave in s , *i.e.*, $W_{s,s}^i < 0$, so that the profit-maximizing strategy choice always exists and is unique for any values of the auction price w and a firm's risk attitude r_i . With respect to the uncertainty parameter θ we assume the single-crossing property $\pi_{s,\theta} > 0$. This property in this context is sometimes referred to as the Principle of Increased Uncertainty (*cf.*, [10]) and states that the marginal profit π_s is monotonically increasing in θ . We also assume that $\pi(0, \theta) = 0$, *i.e.*, the profit function is continuous in the sense that the market profit of not winning the auction, which is equal to 0 by definition,

equals to the pay-off of winning the auction and setting the strategic variable equal to zero. Together with $\pi_{s,\theta} > 0$, this assumption $\pi(0, \theta) = 0$ implies that $\pi_\theta > 0$, *i.e.*, not only the marginal profit π_s but also the profit π itself is increasing in θ . Thus, θ represents a positive demand shock that positively affects both the profit and the marginal profit of a firm.

These conditions are satisfied in many common examples. For instance, suppose market demand is given by $q = \alpha(\theta) - bp$. Then, in a price setting case

$$\pi(p, \theta) = p(\alpha(\theta) - bp) \text{ and } \pi(0, \theta) = 0, \pi_\theta = p\alpha', \pi_{p,\theta} = \alpha'.$$

Similarly, in a quantity setting case

$$\pi(q, \theta) = \frac{1}{b}q(\alpha(\theta) - q) \text{ and } \pi(0, \theta) = 0, \pi_\theta = \frac{q}{b}\alpha', \pi_{q,\theta} = \frac{1}{b}\alpha'.$$

Thus, if $\alpha'(\theta) > 0$ and $b > 0$ then $\pi_{s,\theta} > 0$ and $\pi_\theta > 0$ in both price and quantity settings.

An important property of the expected utility function (1) is that it is strictly decreasing in w :

$$W_w^i(s, w) = -E_\theta(U_i'(\pi(s, \theta) - w)) < 0.$$

This property allows us to implicitly define a firm's valuation $v(r_i)$ as the maximum willingness to pay for the license:

$$W^i(s_i^*, v(r_i)) \equiv \max_s W^i(s, v(r_i)) = 0. \quad (2)$$

As a firm that has not been successful in obtaining a license will make zero profit in the aftermarket, the firm's valuation $v(r_i)$ for the license is the certainty equivalent of the random profit $\pi(s^*, \theta)$, where s_i^* is the optimal choice of the firm's i decision variable s , *i.e.*, $s_i^* = s^*(r_i, w)$.

3 Results

Using the above notation and assumptions, we prove the claim that auctions lead to either higher market prices (in case of price setting) or to lower market prices (in case of quantity setting) in two steps. First, we show that in the aftermarket, a less risk-averse firm will set a higher value of s . Second, we show that a less risk averse firm has a higher willingness to pay for the license, so that an auction selects the firm that is least risk averse (or, more risk seeking) among the firms that participate.

Proposition 1 *Under CARA, $\pi_\theta > 0$ and $\pi_{s,\theta} > 0$, the less risk averse the monopolist is, the higher the value of s^* it will choose, *i.e.*, $\partial s^*/\partial r_i < 0$. An auction price w that a winning firm paid for the license does not affect s_i^* , *i.e.*, $\partial s^*/\partial w = 0$.*

Proof. Maximizing $W^i(s, w)$ with respect to s yields the necessary first-order condition

$$0 = W_s^i(s^*, w) = E_\theta(\pi_s(s^*, \theta) U_i'(\pi(s^*, \theta) - w)), \quad (3)$$

which is also sufficient due to $W_{s,s}^i < 0$. Differentiating this equation with respect to w yields the following expression for $\partial s_i^*/\partial w$:

$$\frac{\partial s^*}{\partial w} = -\frac{W_{s,w}^i(s^*, w)}{W_{s,s}^i(s^*, w)} = \frac{-xW_s^i(s^*, w)}{W_{s,s}^i(s^*, w)} = 0,$$

as, $W_{s,w}^i(s^*, w) = -xW_s^i(s^*, w)$ because of CARA utility function, and $W_{s,s}^i(s^*, w) < 0$ by our assumption.

In order to show that $\partial s^*/\partial r_i < 0$ we first evaluate $W_{s,r_i}^i(s, w)$:

$$W_{s,r_i}^i(s, w) = E_\theta\left(\pi_s \frac{\partial U_i'(\pi - w)}{\partial r_i}\right) = -\int_{\sigma} \pi_s(\pi - w) U_i'(\pi - w) d\theta,$$

which directly follows from CARA. Then, $W_{s,r_i}^i(s^*, w)$ can be written as:

$$\begin{aligned} W_{s,r_i}^i(s^*, w) &= -\int_{\sigma} \pi(s^*, w) \pi_s(s^*, w) U_i'(\pi(s^*, w) - w) d\theta \\ &= \int_{\sigma} \pi_\theta(s^*, w) J(\theta, r_i, s^*, w) d\theta < 0, \end{aligned}$$

where

$$J(t, r_i, s^*, w) = \int_0^t \pi_s(s^*, w) U_i'(\pi(s^*, w) - w) d\theta.$$

The first equality for $W_{s,r_i}^i(s^*, w)$ is obtained by integrating in parts. Then, it is easy to see that $J(0, r_i, s^*, w) = 0$ and $J(1, r_i, s^*, w) = W_s^i(s^*, w) = 0$. Since $U_i' > 0$ and $\pi_{s,\theta} > 0$, it follows that $J(t, r_i, s^*, w) < 0$ for all $t \in (0, 1)$, which, together with $\pi_\theta > 0$ implies the last inequality.

Differentiating (3), but now with respect to r_i yields the desired inequality

$$\frac{\partial s^*}{\partial r_i} = -\frac{W_{s,r_i}^i}{W_{s,s}^i},$$

which together with $W_{s,r_i}^i < 0$ and $W_{s,s}^i$ implies $\partial s^*/\partial r_i < 0$. ■

In accordance with Proposition 1, the optimal level of the strategic variable can be written as $s_i^* = s^*(r_i)$ with $ds^*/dr_i < 0$. If the strategic variable is price, the proposition says that less risk averse firms will set higher prices. If the strategic variable is quantity, the proposition says that less risk averse firms will set higher

quantities, leading to lower market prices. We next analyze which risk type will win the auction.

Proposition 2 *A firm's valuation is a strictly decreasing function of its risk attitude, i.e., $dv/dr_i < 0$.*

Proof. $v(r_i)$ is defined by (2). Differentiating it with respect to r_i yields

$$v'(r_i) = -\frac{1}{W_w^i} \left(W_{r_i}^i + W_s^i \frac{ds^*}{dr_i} \right).$$

Taking into account the F.O.C. (3) and Lemma 1 leads to $W_s^i = 0$, $W_w^i < 0$ and $W_{r_i}^i < 0$. Thus, $v'(r_i) < 0$. ■

Proposition 2 shows that the least risk averse firm has the highest valuation. Risk attitude negatively affects a firm's valuation, because for a given market behavior, a less risk averse (or more risk seeking) firm gets a higher expected utility than a more risk averse (or less risk seeking) firm. As a firm's risk attitude is the only determinant of the *ex-ante* expected utility of winning the auction, the auction stage can be analyzed just like a standard Independent Private Valuation auction if signals (risk types) are independently distributed. As in any common auction format players with higher valuations bid higher, the firm that is least risk averse will win the auction.

4 Discussion and Conclusion

We have considered a selection argument in order to connect auctioning licenses with aftermarket prices. Crucial to the argument is that firms differ in their attitude towards risk. We have shown that firms with different risk attitudes behave differently in the marketplace and get different expected utility from the uncertain market profit. Accordingly, such firms behave differently in an auction where the right to operate in the aftermarket is allocated. When a single license is auctioned, we have shown that auctions select the least risk averse player, which is what we call the risk attitude effect, and that this player chooses higher prices, or quantities, than a randomly chosen player will do.

In many real-world cases, governments do not allocate a single license, but, instead, also rely on competitive forces in the marketplace by allocating multiple licenses. In [8], we also consider oligopoly extensions of the present note. It is clear that the risk attitude effect will also play a role in auctioning multiple licenses. Moreover, since the risk attitude effect always works in favour of less risk averse firms, these firms will continue to win licenses when oligopoly interaction in the marketplace is

considered *provided that the strategic effects are relatively small*. When strategic effects are strong, they tend to strengthen the risk attitude effect in case the strategic market variables are strategic complements (as in the heterogeneous Bertrand competition model). If the strategic market variables are strategic substitutes (as in the Cournot model), strategic effects and the risk attitude effect work in opposite directions, making the final outcome less clear.

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