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## **Endogenous Sunk Costs in the Market for Mobile Telecommunications: The Role of Licence Fees**

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*Abstract:* An oligopoly model with endogenous sunk costs illustrates the trade off between ex ante extraction of oligopoly rents and market entry of firms in the mobile telecommunications industry. Competitive bidding for radio frequency licences provides scope for setting market structure endogenously: the higher the licence fee, the lower the number of competitive firms sustained by the market. High licence fees may be a signal for post-entry collusion.

### **I INTRODUCTION**

This paper presents a simple model of market structure and sunk costs to illustrate the effect of the scarcity of suitable radio frequencies on the market structure of the mobile telecommunications industry. Mobile telecommunications uses radio frequencies as an essential input for operation. However, the spectrum of suitable radio frequencies is limited and contended by alternative uses, such as broadcasting or military applications. Thus, the frequencies allocated for mobile telecommunications have a scarcity value and provide their owners with rents. Several methods of allocating spectrum have been proposed, ranging from administrative procedures to market based allocation mechanisms such as competitive auctions (e.g. McMillan, 1994, Klemperer, 2002). In the context of auctions that were organised during the last year in Western Europe, the question was asked “whether these spectrum fees have become too high” (Melody, 2001). Also the European Commission

\*The opinions expressed are those of the author and need not necessarily reflect those of the EIB.

(2001) raised concerns about the possible consequences of the allocation mechanisms adopted, among which are anticompetitive behaviour by firms and discrimination.

This paper takes the view that licence fees can be regarded as “endogenous sunk costs”, very much like advertising and R&D (Sutton, 1991; 1998).<sup>1</sup> Firms are playing a two stage game: they first have to decide on a fixed entry cost (licence fee) to pay and then they compete *à la* Cournot in quantities. The model presented shows that an inverse relationship between number of firms in the industry and licence fee paid may lead to “overbidding”. This occurs when the licence fees paid are too high compared to the number of firms in the industry that is compatible with non-negative profits. If the entry cost is determined by “market based” mechanisms (e.g. auctions), policy makers may not be able to credibly pre-commit themselves to a given market structure, since firms could have an incentive to “overbid” licence fees. If overbidding has taken place, the industry profits have to be increased. This could be achieved either through exit or through collusion. Other ways of increasing industry profits consist in slowing down the build-up of infrastructure and in concentrating on the most profitable regions only, or by sharing infrastructure with competitors.

The mobile telecommunications industry has already seen cases of bankruptcies because firms were unable to pay the licence fees. This happened, for instance in the US during the PCS (Personal Communications Systems) auctions in 1995 (Cramton, 1995; Garrard, 1998). The issue of exit may become very relevant in Europe too in view of the extremely high prices paid for UMTS licences in some countries during the auctions (European Commission, 2001). First signs of potential collusion are emerging, with calls on regulators to allow extensive sharing of mobile telecommunications infrastructure (e.g. sharing of base stations).

The paper is arranged as follows. Section II presents the model, while Section III illustrates the role of sunk costs in this context. Section IV discusses the relationship of sunk costs and market structure. Section V provides a short description of the attribution of UMTS licences in Europe in relation with the model presented. Section VI concludes.

## II THE MODEL

Consider an industry with  $n$  identical firms. Each firm has the profit function<sup>2</sup>:

<sup>1</sup> Sunk costs are endogenous in the sense that firms have incentives to increase fixed costs if they help to raise the appeal to consumers for its products and services.

<sup>2</sup> This section relies on Gruber (2001).

$$\Pi(n,s,F) = R(n,s) - F \quad (1)$$

Let  $R$  be revenues net of marginal costs and  $F$  fixed costs.  $F$  includes fixed set-up costs for the network as well as up-front licence fees for the spectrum.  $s$  is a variable for market size and is composed of two components as follows:  $s = eW$ .  $e$  is an indicator of the spectral efficiency of the technology in use, i.e. the information transmission capacity per unit of spectrum as indicated by bits/Hertz/second.  $W$  is a measure of the amount of frequency spectrum allocated to the industry. This is indicated in Hertz.

The revenue function is assumed to have the following properties:

- Revenues increase with market size  $dR/ds > 0$ . This implies that both higher spectrum and a greater amount of spectrum allocated increase revenues ( $dR/de > 0$  and  $dR/dW > 0$ ).
- Revenues decrease with the number of firms:  $dR/dn < 0$ .

The equilibrium number of firms  $n^*$  is determined by the following zero entry condition:

$$\Pi(n^*,s,F) > 0 > \Pi(n^* + 1,s,F) \quad (2)$$

This means that with  $n^*$  firms profits are still positive but have reached such a low level that the entry of a further firm induces negative profits in the industry. The solution to Equation (2),  $n^*$ , can be expressed as the following function:

$$n^* = \phi(s,F) \quad (3)$$

with the following characteristics  $dn^*/ds > 0$  and  $dn^*/dF < 0$ . These characteristics can be obtained by totally differentiating Equation (2) and by applying the assumed signs on the partial derivatives. Thus the equilibrium number of firms increases with market size (due to greater spectral efficiency and/or more spectrum) and decreases with fixed costs.

From this emerges that market structure,  $n^*$ , is determined by factors belonging to three different categories.

1. Technology. Spectral efficiency  $e$  is determined by technological development. Technological progress leads to better spectral efficiency and thus, *ceteris paribus*, to a more fragmented market structure.
2. Regulation. The main regulatory variable relevant for the market structure is the amount of spectrum allocated to the industry. The greater this amount, the more fragmented is the industry. A second tool of the

regulator concerns the decision on whether to impose a technical standard or not. The standard selected may not be the most efficient. It is an open question whether the market or the regulator is better at selecting the technology that is using spectrum most efficiently.<sup>3</sup> Finally, governments can decide on levying a licence fee for the use of the spectrum. The typical mechanism is an up-front fee which can be determined by various mechanisms.

3. Endogenous sunk costs. Suppose that the government decides to charge a licence fee for the spectrum. There are many ways for determining the size of the fee. If there is competition among firms for the licence, the size of the fee offered by an individual firm becomes a determinant for spectrum allocation. Competition for spectrum licences increases the licence fee and thus may endogenously affect market structure. In principle, a higher licence fee tends to reduce the equilibrium number of firms in the industry. The government typically determines how many licences will be granted and thus sets exogenously the number of firms in the industry. But the endogenously determined licence fee might become incompatible with the exogenously set market structure if, for instance, firms are paying too high licence fees. In that case, exit of some firms may be necessary to re-establish non-negative profits. Among the several allocation mechanisms, auctions are most likely to produce “excessive licence fees”<sup>4</sup> and thus the highest probability that actually some firms may exit after having been allocated a licence (winner’s curse).

### III LICENCE FEES AS ENDOGENOUS SUNK COSTS

The traditional argument in favour of an auction is that it allocates the spectrum to the most efficient use by the firm who values it most. By fixing the number of licences at the outset (as happened for instance for UMTS licences in the UK), the government sets exogenously the market structure. Suppose that the number of licences is set at  $n^*$ , which is compatible with a fixed cost

<sup>3</sup> For instance, GSM has been selected as the standard for digital mobile telecommunications in Europe. GSM however is not the best solution from the point of view of spectral efficiency. CDMA technology is more efficient. CDMA did emerge in the US, where there is no standard for digital mobile telecommunications. However, digital mobile telecommunications technology is slow at spreading in the US. The problem boils down to a problem of static efficiency (single standard helps to boost diffusion, but may be slow at adapting to technological innovation) versus dynamic efficiency (competition among systems inhibits diffusion, but it furthers the development of new technologies). For a discussion of the issues see Gruber and Verboven (2001).

<sup>4</sup> Throughout the paper the term “excessive” licence fees is referred to fees that exceed the level consistent with non-negative profits in the industry with (exogenously) given number of firms.

of at most  $F^*$ , given the technology. If firms bid  $F > F^*$ , then there are negative profits in the industry, unless some exit occurs. Reiterating this argument to the limit, one can show that a monopoly would pay the highest licence fee as a monopoly has the highest rents to dissipate. A well-known tension therefore emerges between the objective of extracting the most value from spectrum allocation and having as many as possible firms in the industry.

But what would happen if excessive licence fees were actually paid? Firms would be threatened with bankruptcy. If a firm already in the industry buys the licence of a bankrupt firm, the number of total firms is reduced and industry profits may become positive. If instead the licence of the bankrupt firm were reallocated to a new entrant, the existing firms would still have negative profits. However, the new entrant would bid less than what the predecessor paid and possibly have non-negative profits. Taking this argument further, all original licence holders would exit and be replaced by new entrants paying lower licence fees. The stability of market structure that ultimately obtains depends on the government's ability to credibly precommit itself to keep the number of firms exogenously given, at any licence fee that has been offered to pay.

Dana and Spier (1994) have shown in a model of auctions and endogenous market structure that the government's incentives to increase or decrease the number of firms depend on the amount of information available to the government. Incomplete information induces a bias toward less competition relative to complete information.

#### IV IMPLICATIONS FOR MARKET STRUCTURE

A frequently raised policy question concerns the effect of licensing policies on market growth for (broadband) services. Economic theory would suggest that up-front sunk cost should not interfere with post-entry competition as pricing decisions are based on marginal costs. But what if excessive entry costs (licence fees) were paid? Suppose, for example, that in a duopoly framework the duopoly profit is less than the licence fee paid. In that case there are two options for the firm: exit or collusion. With the exit of one firm, the remaining firm could reap monopoly profits and thus break even. If on the other hand the government can credibly precommit a duopoly structure, then firms need to collude to reap monopoly profits to repay the licence fee.

High licence fees therefore could lead to higher prices than would be the case without a licence fee. As such, licence fees could be seen as an inducement for collusive behaviour. Moreover, market growth would be lower.

As a result of the previous discussion, the question arises whether com-

petitive auctions for licences provide incentives to establish excessive licence fees. In other words, can auctions for licences induce credible signalling for collusion in the post-entry stage.

Suppose the case of an auction for two licences. If post entry collusion is ruled out, auctioning with firms with identical cost structures would lead to licence fees that drive profits to zero. Licence fee  $L$  would be equal to the duopoly firms profit  $\Pi(2) = L$ . In other words, licence fees extract perfectly all oligopoly rents. But we know also from the previous discussion that the duopoly firm's profit is less than half of the monopoly profit:  $\Pi(2) < \Pi(1)/2$ . From this one can derive an excessive licence fee that would be profitable with collusion as long as it is in the range  $\Pi(2) < L < \Pi(1)/2$ .

In other words, spectrum allocation through auctions could lead to extraction of monopoly profits with collusion, and not necessarily to the allocation of the scarce resource to the socially best use.

## V THE EXPERIENCE WITH UMTS LICENCES

Since the inception of mobile telecommunications industry there is an ongoing fight for allocation of adequate portions of the radio frequency spectrum which has to be subtracted from alternative uses (see Calhoun, 1988, for a description of the historical milestones). During the 1950s and 1960s the mobile telecommunications industry (when in the pre-cellular phase of the technology) was struggling to get any frequencies at all. Spectrum for first generation (or analogue) cellular mobile telecommunications networks was allocated only at the beginning of the 1980s. The frequencies for second generation (or digital) cellular networks such as GSM were made available much quicker at the end of 1980s. In the meantime the mobile telecommunications market was developing very rapidly. In several countries, the mobile telecommunications market even overtook the fixed line telecommunications market both in terms of users and revenues (OECD, 2001). The eagerness to provide spectrum to the mobile telecommunications industry therefore has increased. European policy makers have allocated licences for third generation mobile (UMTS) networks well ahead of the availability of equipment to provide UMTS services.<sup>5</sup>

Most Western European countries allocated UMTS licences during the years 2000-2001. There were expectations of fat fiscal revenues from licence fees, given the large value of the mobile telecommunications market and the high profitability of the firms in the market. The declared policy objectives in

<sup>5</sup> See Gruber and Hoenicke (1999) for a description of the 3 G market.

allocating the licences were multiple: first, to increase competition by increasing the number of firms with respect to the status quo; second, to promote the development of new services; third, and especially for those countries selecting auctions, to cream skim oligopoly rents expected from exclusive access to scarce spectrum.

Although UMTS was heavily promoted the European Commission, the individual EU member states were left free to determine the number of firms and the allocation method for the licences. Generally, each national regulator gave at least one more licence than the number of firms in the GSM market. The licensing methods adopted can be summarised by the two categories beauty contest and auction, although within each category there can be substantial variation. Table 1 lists the approaches by the different countries and the total amount of the licence fees paid, in particular when calculated on a per capita basis. They can range from zero to more than Euro 600 per head. In some countries such as UK and Germany these valuations went far above the expectations of the regulator. The auction method has typically produced the highest amounts. It is also striking that the amount paid increases with the number of firms. In Germany, market structure was endogenous to the bidding process: the government auctioned 12 frequency blocks, with each bidder able to bid for 2 or 3 blocks. This means that there could be 4 to 6 firms in the market as a final outcome. The eventual outcome was 6 firms in the market, along with the second highest licence fees in Europe. This and other results from the European auctions run counter to the intuition of the endogenous sunk cost model presented in this paper. This would rather suggest that the licence fee should decrease with the number of firms. One rational explanation of this counterintuitive result would be overbidding.

In the Dana and Spier (1994) model, incomplete information induces a bias towards less competition relative to complete information. Considering the fast technological change and the high uncertainties on the market prospects for mobile telecommunications, market valuations by firms and governments may diverge strongly. For GSM services both firms and governments initially made cautious market growth assumptions, but actual growth exceeded vastly initial expectations (Gruber, 1999). For UMTS instead, the expressed values of the licence fees discount a very rapid market growth, with firms being far more optimistic than government (see *The Economist*, 6 May, 2000).

In the aftermath of the auction several events happened that are consistent with the “overbidding” hypothesis.<sup>6</sup> Several firms that have received a licence have decided to postpone the building of the network

<sup>6</sup> These events are periodically reported in the trade press and on specialised websites such as [www.totaltele.com](http://www.totaltele.com).



Table 1: *UMTS Licence Fees in Western Europe*

<i>COUNTRY</i>	<i>Allocation Mechanism</i>	<i>Number of Firms</i>	<i>Total Country Licence Fees Per Population (in Euro)</i>
UK	Auction	5	634
Germany	Auction	6	615
Italy	Auction	5	212
Netherlands	Auction	5	168
Austria	Auction	6	101
Denmark	Auction	4	96
Greece	Auction	3	45
Belgium	Auction	3	44
Portugal	Beauty Contest	4	40
Norway	Beauty Contest	4	32
France	Beauty Contest	2	21*
Switzerland	Auction	4	19
Spain	Beauty Contest	5	13
Finland	Beauty Contest	4	0
Sweden	Beauty Contest	4	0

\* After renegotiation. Originally the total licence fee was set at EUR 55.

Source: European Commission.

infrastructure, thereby not respecting the regulatory commitments. Other firms decided even to hand back the licence to the regulator foregoing the licence fee paid (such as in Norway). With the justification of reducing costs, several firms have also started to build networks on a shared basis with their competitors. For instance, the German Chancellor called on operators to co-operate in building out the networks (see *Frankfurter Allgemeine Zeitung*, 14 March 2002). National regulators are observing such schemes with close interest and also with apprehension. The EU Commission (2001) was expressing concerns about them as they may be potential means for collusion.

But it is not just auctions that can produce high licence fees. The French government tried to set high licence fees through administrative procedures by setting a high minimum entry fee for a beauty contest. Guided by the auction results in the UK and Germany, the fee was set at such a high level that only two firms participated in the contest for four licences. After having granted a licence to each bidder and the payments were already arranged, the government had to reduce the licence fees substantially during renegotiations of the terms of the licences. In Italy the terms of the licences were renegotiated too, with the length being extended from 15 to 20 years. These examples show that high licence fees may undermine the time consistency of regulatory policies.



## VI CONCLUSIONS

This paper proposes a simple theoretical framework illustrating the trade-off that may arise between furthering competition in the industry (by giving an appropriately high number of licences) and the attempt of extracting oligopoly rents through up-front licence fees. Using the endogenous sunk cost approach it is shown that firms may have an incentive to “overbid” for licences to ensure more relaxed competition in the post-entry stage. The empirical relevance of the approach is illustrated with reference to the allocation of mobile (UMTS) licences in Western Europe. The approach can, however, be used for a much broader range of industry where policy has to design market structure. The lesson to be drawn for the design of market structure is that the choice of the licence allocation mechanism has crucial importance for the post-entry performance. The issue can be put boldly as the regulator has to determine whether there should be competition for the market or competition in the market. This may also require a rethinking of “market-based” allocation mechanisms.

Licence fees determined by auctions have traditionally been justified as an efficient means for putting an economic value on the scarce resource and for allocating it to the firm that uses it most efficiently. An alternative interpretation of auctions could be that they identify firms most likely to collude in the post-entry stage (Offermann and Potters, 2000). The present paper suggests that auctions may also become a way of letting endogenous sunk costs determine the market structure in a way that could contrast with the policy maker’s ex ante objectives for market structure and performance. High licence fees could either force the exit of firms or signal post-entry collusion. Moreover, they may in any case impair the regulator’s ability to enforce the terms of the licences.

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