Radio spectrum fees as sunk costs in the market for mobile telecommunications: The aftermath of European 3G licensing.

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Abstract

The relationship between market structure and sunk cost is illustrated in an oligopoly model. When market structure is exogenous, questions of time consistency of regulatory measures may arise if there is also scope for setting sunk costs endogenously. The relevance of this result in practice is illustrated with reference to the regulatory design of market structure in the European mobile telecommunications industry. Auctioning the spectrum may lead to too high license fees, inducing some firms to exit or calling for leniency in enforcing regulatory commitments.

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1. Introduction

This paper provides a theoretical framework for looking at the interplay between market structure and endogenously determined fixed costs. This approach has similarities with the endogenous sunk cost literature (Sutton, 1991, 1998). It is moreover extended to an industry with entry regulation, such as the mobile telecommunications industry. This industry is interesting to look at, because it is relatively young with a market structure evolving from monopoly to three or more firm oligopoly as different generations of technologies are adopted (Gruber, 1999). This gives scope for studying the determinants of the evolution of market structure (Gruber and Verboven, 2000, 2001) and provides options for the future design of market structure.

Market entry is based on a licensing process for scarce spectrum resources. Whereas initially the assignment of licenses was based on administrative procedures (e.g. "beauty contests"), there is a trend to make this increasingly dependent on market-based mechanisms such as auctions (Mc Millan, 1994; Cramton, 2002). This paper argues that spectrum auctions could lead to an evolution of market structure that is different from what was anticipated by regulators. Spectrum auctions in mobile telecommunications started at a large scale in the US in 1994 by the US Federal Communications Commission (1995). In the auctions taking place over the years 1994-2001 the auctions yielded more then $40 billion for the US treasury. From this point of view the spectrum auctions in Europe for third generation (3G) mobile services were even more successful, with total spectrum fees exceeding €100 billion (European Commission, 2002a). From a public finance point of view, auctions therefore seem to be an extraordinary success as

up-front license payments provide governments with tax revenues, which are considered particularly valuable because of their mostly lump-sum nature and thus not susceptible to distorting prices. This paper abstracts from these public finance considerations and looks at the implications of high license fees for the evolution of market structure. The principal question is whether the chosen market structure, as given by the number of licenses to be auctioned, is consistent with the license fee raised. If there is "overbidding", problems of time consistency of or regulatory policy emerge between the regulatory commitment to enforce competition and the call for relaxation of regulatory and antitrust obligations. For this purpose a close look is taken at the actions of governments and firms in the aftermath of the 3G auctions in Europe.

The paper is arranged as follows. Sections 2 and 3 present a the theoretical model within which to analyse the evolution of market structure in function of the size of license fees. Section 4 presents background information on the mobile telecommunications industry in Europe. Section 5 describes the design of market structure for the 3G markets across European countries and the results of the licensing procedures. Section 6 makes a critical assessment of the outcomes and comments on the developments successive to the auction. Section 7 concludes.

2. A model

Consider a homogenous goods industry with Cournot competition has the following inverse demand function $p(Q)=s/Q$. s is parameter for market size and Q are total quantities sold at market price p. Assume constant marginal costs c. It can be shown that

in a Cournot equilibrium with n identical firms (where quantity supplied by each firm is q=Q/n) the equilibrium price is p=nc/(n-1).

As typical for a Cournot model, price is above marginal cost and declining with the number of firms. The fixed entry cost F sets an upper bound on entry. At a Cournot equilibrium the profits for each firm are

$$\Pi(n,s,F)=(p-c)q-F=s/n^2-F. \quad (1)$$

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

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

Neglecting the integer problem, from equation 1 one can derive the following expression:

$$n^*=\sqrt{\frac{s}{F}} \quad (3)$$

Thus one can derive relationships between equilibrium number of firm, market size and entry costs: $dn^*/ds>0$ and $dn^*/dF<0$. The equilibrium number of firms thus increases with market size and decreases with fixed costs.

Let us now relate these findings to an industry such as mobile telecommunications. To start with, suppose there were no spectrum constraint. If the regulator would not regulate entry, the Cournot outcome would be n* firms and zero profits[1]. If however entry is regulated and the regulator would set the number of firms at ñ, then three cases are possible:

1. ñ>n* : this case implies excessive entry and negative profits.
2. ñ=n* : this case corresponds to the free entry outcome with zero profits.

[1] Let us abstract here from the integer problem.

3. ñ<n* : in this case regulated entry is less than the free entry outcome with positive profits. These "oligopoly rents" decrease with the number of firms.

3. The role of license fees

To make the issue of license fee explicit, it may be useful to redefine the fixed cost F as follows: F=I+L. This means that the fixed cost is split into network investment costs I and license fee L. Equation 3 can therefore be rewritten as

$$\hat{n}^* = \sqrt{\frac{s}{I+L}} \qquad (4)$$

i.e. $\hat{n}^*$ defines the equilibrium number of firms when a license fee $\hat{L}$ is involved. Abstracting again from the integer problem, we have $\hat{n}^*<n^*$ for $\hat{L}>0$, i.e. with license fees we should have a smaller equilibrium number of firms than with zero license fees, as license fees are equivalent to increasing fixed entry costs.

ñ is fixed by the regulator and L could be decided either by the regulator or jointly with the firm. It is important that the license fee L is consistent with the total number of firms that are supposed to coexist in the market. According to the "policy" variables L and ñ, the a series of relationships between variables n*, $\hat{n}^*$ and ñ are possible. The most interesting cases are as follows:

Case 1. Excessive entry: ñ>n*>$\hat{n}^*$. Here the regulator provides more licenses than the equilibrium number of firms even without license fees. This is a case of excessive entry and thus not a stable market structure even with zero license fees.

Case 2. Excessive license fees: n*>ñ> $\hat{n}^*$. In this case the license fees have been set at such a high level that an otherwise viable market structure becomes unstable.

Case 3. Excessive profits: n* > $\hat{n}^*$>ñ. In this case license fees are low enough that all

firms can coexist with non-negative profits. In this case license fees have extracted some of the oligopoly profits.

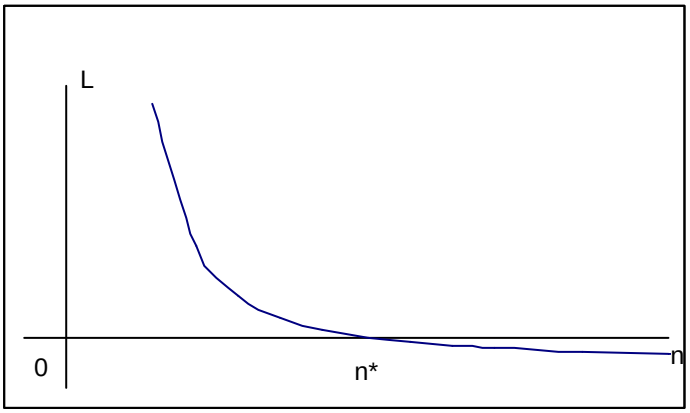
Endogenous license fees

Assume now that firms can decide themselves about the license fee to pay. In this sense sunk costs can be considered as an endogenous variable. Equation 3 can be rewritten as

$$\hat{L}^*=s/n^2-F. \qquad (5)$$

where $\hat{L}^*$ is level of license fees that drives industry profits to zero. The iso-profit relationship between market structure and license fee can be illustrated as in figure 1. Right from the curve profits are negative and left from the curve profits are positive. Thus for any ñ chosen by the regulator, $L=\tilde{L}$ to have a stable competitive market structure. Otherwise license fees have post-entry effects: if $L>\tilde{L}$ we have excessive entry, and with $L<\tilde{L}$ excessive profits. Both cases impair the efficient working of the market.

Figure 1. The iso-profit relationship between license fee and market structure



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 licenses 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" and thus the highest probability that actually some firms may exit after having been allocated a licence (e.g. winner's curse).

By fixing the number of licences at the outset the government sets exogenously the market structure. The traditional argument in favour of an auction is that it allocates the spectrum to the most efficient firm should value it most. The validity of this proposition is however based on two premises. First, the government does not license too many firm (i.e. avoids case 1). Second, firms do not collude once entered in the market. Let me explain this second point in more detail.

Suppose that the number of licences is set at ñ, which is compatible with a license fee of at most $\tilde{L}$, given the technology. If firms bid $L>\tilde{L}$, 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 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. Given 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. For UMTS instead, the expressed values of the licence fees discount a very rapid market

growth, with firms being far more optimistic than government[2].

Post-entry effects

Any specific licensing policy for the underlying services needs to be justified. The policy maker typically wants to assign the licenses to the firms that are best at diffusing the associated services in question. There are two major decisions to be taken: the number of licences to be allocated and the price to be paid for the license. If prices are driving market growth, then the effect of the number of licenses essentially depends on the type of competition. If Bertrand competition were prevailing, then two firms would be enough to establish competitive prices. If Cournot competition were prevailing instead, then the price is a decreasing function of the number of firms. If price were a determinant for market growth, this would increase with the number of firms. Empirical studies on strategic interaction suggest that Cournot competition is a better description of what is actually happening in the mobile telecommunications industry (Parker and Röller, 1997).

The second question relates to the post-entry effects of licence fees. 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 license 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.

[2] The Economist, 6 May 2000.

High licence fees therefore could lead to higher prices than what would happen 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 competitive auctions for licences provide incentives to establish excessive licence fees. Put in another way, can auctions for licences induce credible signalling for collusion at 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. License 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.

International aspects

In the light of the previous discussion let us describe countries with two different policies. A country that establishes small licence fee benefits from the fact that firms have little incentive to collude. If there were Cournot competition, the largest possible number of licences should be granted to have low prices and highest levels of diffusion. Oligopoly rents would not go to the government, but rather be shared among consumers

and producers. Prices would be low and market penetration high.

In country that chooses high licence fees, possibly determined through competitive auctions, there may be an inherent incentive for firms to collude. Hence monopoly prices would be charged. Most of the rents would go to the state via the license fee. However, there would be high prices and therefore lower market penetration.

Differences in the licensing regimes across countries can have implications for firm performance. To illustrate this point, consider the following simple framework. Suppose two identical countries denominated 1 and 2. Each country has one firm, called firm 1 and firm 2 respectively, but each firm can reciprocally operate in both countries. Finally suppose that each firm has a cost advantage when operating on the domestic market compared to when operating in the other country (e.g. lower marginal costs due to information advantages). With Cournot competition, this leads to higher market shares for the domestic firm on the domestic market.

Assume now that country 2 establishes a licence fee and thus extracts some oligopoly profit. This puts firm 2 at a disadvantage because it has a larger market share in a low profit market (country 2) and a small market share in a high profit market (country 1). For firm 1 the reverse holds: it has low market share in a low profit market and a high market share in a high profit market. Hence firm 1 has higher total profits than firm 2. Not asking for licence fees could also be seen as a subsidy to firm 1, especially from country 2's perspective. Legitimate questions now arise on whether the two firms are now forced to compete on unequal terms, whether the absence, or in any case inequality, of license fees are distorting subsidies and whether coordination of the regulatory frameworks within countries participating in a common market is desirable.

Finally, there are also issues concerning lump sum transfers of rents. Firms active in country 2 pay a higher license fee than in country for 2 reasons: first, because there is an auction which drives up the license fee; second, because there is no license fee in country 1, firms have more funds available to spend for a license in country 2. Thus firms active in country 1 could employ some of the forthcoming rents from country 1 in country 2 for receiving the license.

4. The mobile telecommunications sector in Europe

The mobile telecommunications industry became the first major laboratory of competitive supply of telecommunications services in a sector where the natural monopoly paradigm was prevailing. However in many countries this opportunity of competition was picked up only after some delay. Initially most countries viewed cellular telecommunications as just an additional new business of the state-owned telecommunications monopoly. The development of the cellular network was a means of honing the innovative capabilities of national equipment suppliers. Analogue cellular mobile telecommunications (first generation mobile technology or 1G) started during the first half of the 1980s in most European countries. In the early days of mobile telecommunications, licenses were often granted on a first-come-first-serve basis if not automatically to the incumbent fixed line telecommunications operator. A few countries granted a second license, which was assigned through an administrative tender procedure (or “beauty contest”).

On the occasion of the introduction of the digital technology (second generation mobile technology or 2G), based on the GSM standard, the European Commission started to

actively promote a co-ordinated approach with more competition. Member countries were instructed to grant at least three licenses for digital services. Entry in GSM was typically of the sequential type, with the 1G incument typically entering first. As Gruber and Verboven (2000) have shown, the heterogeneity in the timing of the licenses had important implications for the diffusion path of technologies. There are generally 3 or 4 firms in each national market with a relatively stable market structure[3].

It is in any case fair to say that during the first generation and also at least during a large part of the second generation technology the mobile telecommunications market was in an "excessive profit" situation. These technologies were far more successful in the market than originally expected and produced huge oligopoly rents. Table 1 lists the profitability of selected European mobile telecommunications firms in 1997, a period when the mobile telecommunications market was in full expansion. It shows that for some, such as TIM profitability in terms of returns on capital employed can be well above 100%. But also other firms such as Telecel, Vodafone and Mannesmann have a return of capital employed several multiples of typical industry average.

Table 1 Profitability (ROCE*) of selected European mobile telecommunications firms in 1997

Firm	Country	ROCE %
TIM	Italy	137.1
Telecel	Portugal	65.5
Vodafone	UK	54.0
Mannesmann	Germany	41.9
Comviq	Sweden	17.9
Netcom	Norway	14.2

* ROCE= return on capital employed
Source: Company accounts, listed in Warburg Dillon Reed (1998).

[3] The exceptions are the Netherlands with 5 firms and Luxembourg and Ireland with 2 firms each.

Regulatory activity in the mobile telecommunications industry is more reduced compared to the fixed telecommunications industry as the sector is considered as liberalised and "competitive". Thus regulatory action in most cases is limited to market segments where there is scope for abuse of market power, such as interconnection. Firms with "significant market power", i.e. with market shares in excess of 25%, are subject to separate accounting in order to establish cost based pricing in interconnection. There is the presumption that regulatory action or entry would drive profitability towards the average level of the economy. There are indeed signs that later entrants in the market have much lower rates of return[4]. There even was a case of exit in Italy, where in 2002 the smallest and latest (fourth) entrant left the market[5]. It has also to be said that in most of the European countries license fee were either zero or relatively modest, especially when compared to what would be paid for 3G licenses[6]. The struggling for survival of 4th entrants in some countries would suggests that a 3 or 4 firms market structure has come close to the zero profit entry condition in the industry.

Whereas the first and second generation of mobile telecommunications systems were mainly designed for voice transmission, the next technological step is the development of systems for data transmission. Third generation systems are therefore being developed

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[4] On the advantages of early entry see for instance Oftel (2001) for the UK industry. It shows that the early entrants BT and Vodafone have a big advantage because they can operate a less expensive GSM network at the 900 MHz frequency range compared to the later entrants One2One and Orange, which have to operate a more expensive GSM network working at 1800Mhz frequency range.

[5] The spectrum was sold in equal terms to the three remaining firms.

[6] Total license fees collected in the EU for 2G licenses amounted to €10 billion, whereas for 3G licenses it was in excess of €100 billion (European Commission, 2002).

that will substantially increase data transmission rates and should ultimately allow also for sending moving images. The International Telecommunications Union (ITU) has established that these services will be provided with one of the 5 technology standards defined by the ITU. The member states of the European Union committed themselves to introduce this under the heading of Universal Mobile Telecommunications System (UMTS), a concept developed by the European Telecommunications Standard Institute (ETSI) and based on one of the ITU standards. The European interest was in making UMTS backward compatible with the existing GSM installed base. The first adoptions of third generation systems were expected to occur in 2002 in Europe and Japan. Whereas in Japan this actually happened, though with a slower than expected pick-up of 3G services by the users, in Europe launch dates were delayed by more than one year[7]. The US are delaying the development of third generation systems, also because of the slow development of the second generation systems which have been introduced late and using a range of different, non-compatible technologies (ITU 1999). European policy makers are very keen on introducing early third generation systems, also for reason of industrial policy[8]. Early adoption of UMTS is seen as key for preserving the worldwide lead in mobile telecommunications technologies established with GSM (see European Commission, 1997). Thus member states of the EU were instructed to provide 3G licenses in order for first 3G technology-based services to become available by 2002. The spectrum was assigned to firms over the years 1999-2002 but with different policies

[7] New entrants such as the firm Hutchinson claim that their network is ready, but handsets are still missing. This is expected to be solved during 2003.

[8] See Decision No. 128/1999/EC as well as European Commission (2001).

pursued across the member states with respect to the assignment method, number of licenses and overall timing on service provision and coverage obligation, as will be seen in the following.

5. The design of market structure for 3G markets in Europe

The entry pattern for the 3G market had a completely different design from previous technology generations. With 1G and 2G markets the evolution of the market structure emerged from a sequential licensing of new entrants, typically starting either with a monopoly (for most 1G services) for with a duopoly (for 2G services). For the 3G service industry the design of the market structure entailed simultaneous entry of a relatively large (4-6 firms) number of firms. One has to underline that little attention was devoted to the zero profit entry condition in the design of market structure. The n+1 rule of thumb (with n being the number of incumbent 2G firms) was typically applied for determining the number of 3G licenses. This rule of thumb had a twofold purpose; to create more competition both at the pre-entry as well as at he post-entry stage. At the pre-entry stage, new entry would be encouraged to enter the competition for the market; at the post-entry stage, new entry should increase competition in the market. In this game the incumbents were presumed to have a strategic advantage. Without increasing the number of licenses, pre-entry competition would have been weak. Thus the additional license would have given the new entrants incentives for competing for a license. This would also help to increases licence receipts when combined with an auction process. For the post-entry stage it was expected that additional entry would increase competition leading to lower prices and better service.

Concerning the allocation method, one half of the EU countries have opted for a market-based mechanism such as auctions and the other half has opted for a beauty contest. Italy adopted a hybrid approach, using a beauty contest first, followed by an auction (see table 2). In general the multiple round ascending auction was chosen, with the exception of Denmark, which opted for a sealed bid auction. On of the most remarkable feature of the outcome was the enormous heterogeneity of the outcomes across countries, only in part explained by the to the different assignment method used. The most striking differences can be observed within the auction method. Figure 2 shows the evolution over time of the auction receipts as they unfold over time across the different countries. It shows a pattern of decline over time. There is an growing literature trying to rationalise these results, with explanations relying on arguments of bad auction design, collusion and political interference (see Klemperer 2002a, 2002b, and Cramton,2002). There is however the indisputable fact that auctions have yielded much more than beauty contests. On a per capita basis, the highest receipt from beauty contests (i.e. Spain) is equivalent to only the lowest receipts from beauty contests. Thus auctions were in any case much more effective in raising revenues for the government. Auctions turned also out in being much better at attracting foreign firms: with beauty contests 28% of the winning bidders were majority-owned foreign firms, whereas with auctions this was 68% (European Commission, 2002a). Moreover, beauty contests were much more prone to political interference. For instance in countries like Spain and France the license fee was modified repeatedly following the success and non-success of auctions in other countries, with the French government rising the license fee proposed by the regulator by a factor of 3, to cut it to one ninth after the poor success in attracting bidders.

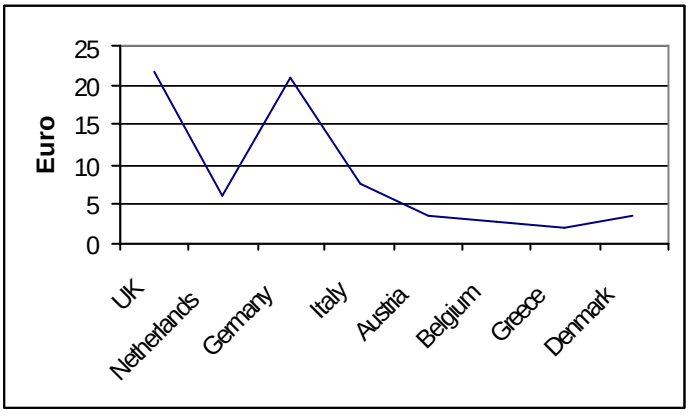
Table 2. The 3G license assignment in the European Union

Country	Date	Method	License fee EUR/pop	Number of incumbents n	Number of licenses planned	Number of licenses granted	
UK	Apr-00	A	634	4	n+1		5
Germany	Aug-00	A	615	4	n+0,1,2		6
Italy	Oct-00	BC+A	212	4	n+1		5
Netherlands	Jul-00	A	186	5	n		5
Austria	Nov-00	A	101	4	n+0,1,2		6
Denmark	Oct-01	A	96	4	n		4
Ireland	Jun-02	A	92	3	n+1		3
Greece	Jul-01	BC	45	3	n+1		3
Belgium	Mar-01	A	44	3	n+1		3
Portugal	Dec-00	BC	40	3	n+1		4
France	May-01	BC	21	3	n+1		2*
Spain	Mar-00	BC	13	3	n+1		4
Finland	Sep-99	BC	0	3	n+1		4
Sweden	Dec-00	BC	0	3	n+1		4
Luxembourg	May-01	BC	0	2	n+2		3

* a third license was awarded to the third incumbent during a second tendering in 2002.

Source: European Commission (2002)

Figure 2. License fees in 3G auctions in chronological order (€/head/5 MHz)



Source: European Commission (2002a)

To come back to the n+1 firm rule of the thumb, this rule was not so much the outcome of a careful assessment of whether the 3G market would be able to sustain so many firms, but rather essential ingredient to create competition in the auction. Some countries such as Germany and Austria added also a feature of endogeneity in the market structure by auctioning frequency blocks instead of single licenses. By using frequency blocks any market structure up to the maximum of six firms becomes possible. It is however striking how different the market structures were designed in the different countries, with markets with the number of firms ranging from 3 to 6 firms (see column 5 in table…). In four countries (i.e. Netherlands, Denmark, Greece and Sweden) the regulator did not contemplate an increase in the number of licenses. This means that in those countries an increase in the number of mobile telecommunications firms would only occur if at least one of the incumbents would not receive a 3G license. It turned out that in all cases, except Greece, one incumbent did not receive a license. What is also striking that in 3 cases of administrative procedures (France, Ireland and Luxembourg), the number of licenses eventually granted was smaller than the planned number. With the auctions always the maximum number of licenses granted were achieved, both when the number was fixed or when endogenous (Germany, Austria).

6. The aftermath of 3G licensing

With hindsight, the 3G auctions delivered mixed results. Taking license fees as a parameter of success, some auctions were very successful but some others were complete failures (Cramton 2001, Klemperer 2002b). Moreover, there is also agreement that "successful" auctions were delivering license fees that were far too high for the revenues

expected to be generated by 3G services. However, the observed renegotiations of license conditions from license assignments achieved by beauty contests suggest weaknesses of this assignment method (as well as of governments) too. The European Commission has however criticised the non-coordinated licence allocation mechanisms adopted across the EU (European Commission, 2002b). However, the Commission could not do very much about this as licensing is prerogative of member states and the only aspects it could enforce were transparency of the process and non-discrimination. But what became more worrying was the perception by the firms that managed to acquire, possibly very expensively, a license. There was not only the burst of the speculative bubble in the financial markets, but also the sobering thought the of whether the whole market potential for 3G services would be much lower than expected, while both investment and operating costs would be much higher. Gruber and Hoenicke (2000) elaborate on the question of whether the speed of adoption proposed and the size of required investments are warranted by a sufficiently high level of demand. A simulation exercise shows that revenues from data services have to increase substantially to make 3G a profitable undertaking, but firms are exposed to very market high risk of introducing the new technology too early. Detailed technical surveys suggest that the investment for 3G infrastructure is much higher than it was in comparison to 2G infrastructure, and operating costs are likely to be higher as well (European Commission, 2002a). If this were so, then a less concentrated market structure than with 2G services may not be supported in the 3G market and exit would be necessary to make the 3G industry viable[9].

[9] The study for the European Commission (2002a) reports also findings from a simulation exercise that the market structures in Germany, the Netherlands, Sweden and the UK are unlikely to be able to support all

In principle, there are alternatives to exit. They are either collusion, softening the terms of licensing conditions (e.g. softer conditions for license fee payments and network investment) and in sharing costs. However these ex-post changes in the license terms could only be accommodated to a very limited extent as otherwise the attribution decision of the regulators could be challenged by firms that did not win licenses or did not apply in the first place. The reputation and credibility of governments thus got also at stake. These examples show that high license fees may undermine the time consistency of regulatory policies.

In the aftermath of the auction several events happened that are consistent with the "overbidding" hypothesis according to the model of section 3.[10] There is a general trend towards delaying the build-out of networks and the supply of 3G services. The main purported reasons are technical difficulties and non-availability of equipment, in particular handsets. Moreover, increasing scepticism was raised about the market potential of 3G services.Several firms that have received a license have decided to postpone the building of the network infrastructure, thereby not respecting the regulatory commitments. Other firms decided even to hand back the license to the regulator foregoing the license 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 cooperate in building out the networks (see Frankfurter Allgemeine Zeitung of 14 March 2002).

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firms.

[10] Such events are regularly reported in the trade press and on specialised websites such as www.totaltele.com

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. In Italy the terms of the licenses were renegotiated too, with the length being extended from 15 to 20 years.

These events precipitated also situations that were initially not considered. For instance, the scenario of what would happen if a firm does not want to exercise the rights entailed by the licence. Can such a license be entirely sold to another new entrant or can the spectrum be sold only. In the first case market structure would be maintained, but in the second case we would have a higher level of concentration with an increase of the inequality of the spectrum distribution. In some countries firms already made official statements that they would forego the license. In Germany for instance the firm Mobilkom decided to abandon the building of a 3G infrastructure. It sold the 3G infrastructure it had already in place to existing 3G firms, but it was unable to sell the license because of lack of interest. There was no firm interested in acquiring the license because of its attached network build-out obligations. At the same time existing 3G license holders were not entitled to buy the spectrum. Spain had chosen another policy by allowing the trading of spectrum. In Spain, the spectrum can be traded, and in principle the whole license can be sold to another firm. The new entrant firm Xfera decided to sell part of its spectrum which it has been assigned to one of the other 3G firms (Börgers and Dustmann (2002).

The auction mechanism has produced an interesting result in Germany and Austria. They have chosen a mechanism of determining market structure endogenously, settling for the maximum number of firms. Apart from the consistency of the bidding behaviour in

Germany, where some firms seemed to have adopted irrational strategies, this poses also the question of overall rationality of the auction process per se as efficient allocation mechanism of a scarce resource (Grimm et al., 2001). There is a large consensus about the advantage of auctions in allocating scarce public resources, but it may lead to irrational outcomes because of irrational behaviour of agents.

The large license fees derived from the auctions in the UK and Germany had left countries without later assignment dates in an unfavourable position, as several firms and otherwise potential bidders were running out of money. For instance the French beauty contest had to be deferred because only two firms were interested in the beauty contest for the four licenses, which however came with a relatively large minimum license fee. The Belgian auction attracted modest attention as only three bidders participated in the auction for four licenses. This sequential licensing process across European countries was thus criticised by governments, in particular those who selected beauty contests.

7. Conclusions

This paper has proposed a theoretical framework for illustrating the regulatory challenges in designing market structure for "natural oligopolies". Regulatory designs can be overridden by firm behaviour when entry costs can be determined endogenously. Using the endogenous sunk cost approach it is shown how firms may have an incentive to "overbid" for licenses to ensure more relaxed competition in the post-entry stage. The empirical relevance of the approach is illustrated with reference to the assignment of third generation mobile telecommunications licenses in the European Union and by contrasting the outcomes derived from beauty contests and auctions. The auction receipts varied

hugely across countries. In some countries they were far above expectations and are becoming increasingly likely to be incompatible with economically viable operations in the industry. The already observed exit of new entrants from the 3G market supports the hypothesis of excessive license fees. Likewise, there are increasing calls for leniency in antitrust enforcement, softening of regulatory obligations and outright calls for subsidies. All this suggests that the design of the market structure prior to the assignment of the licenses was inadequate. The widely adopted n+1 rule for 3G licenses, while effective in creating competition for entry into the 3G market, seems not conducive to fostering competition in the 3G market. Also endogenous determination of market structure seems not have achieved a stable outcome, as the cases in Austria and Germany show. These cases have let to the in principle least concentrated market, but where some firms already have officially announced their exit from the market.

This paper sheds some doubts on the widely accepted proposition that license assignment 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 is most efficiently. The success of an auction used to be assessed by the revenues raised. However, 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, and in any case impair the regulator's ability to enforce the terms of the licenses Given the highly uncertain long-term market environment the rapidly developing mobile telecommunications industry is faced with, economic valuation of spectrum rights may display huge variations across the industry.

This gives scope for disputes on the policies to adopt on the re-use of spectrum rights formerly belonging to bankrupt firms. A further source for friction is the existence of huge regulatory heterogeneity across national markets that belong to an integrated economic region. This diversity may create situations of unfair competition and hence trigger off litigation.

The lesson to be drawn for the design of market structure is that the choice of the license allocation mechanism has crucial importance for the post-entry performance. The issue can be put boldly as the regulator having to determine whether there should be competition for the market or competition in the market. This may also require a rethinking on the recourse to “market-based” allocation mechanisms for public goods.

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