European telecom licences

SUMMARY

This paper analyses the procedures used by different European countries for awarding spectrum licences to potential operators of third generation (3G) mobile telephone networks. We contrast market-based methods, such as auctions, with bureaucratic methods, such as 'beauty contests'. They have been used for decisions about two major questions: (1) How many licences should be awarded, and how much spectrum should each licence give access to?; (2) Which companies should receive which licences, and how much should they pay for their licences? Most countries used a bureaucratic process to answer the first question. However, Germany, Austria and Greece were different, and constructed auctions in which the number and size of licences were determined by the auction itself. As for the second question, there was much variation between countries, and both auctions, and 'beauty contests' were popular methods. We have four main findings. First, the bureaucratic procedure used by most countries to answer the first question led to companies concealing relevant information from the authorities. Second, while firms may have tried to manipulate the procedures used in Germany, Austria and Greece to deter entry to their markets, they were surprisingly unsuccessful in this. Third, the traditional economic criticisms of beauty contests seem to apply to some, but not to all those that were conducted. Finally, the bidding strategies adopted by the telecom companies were often more complex than those predicted by economic theory.

— Tilman Börgers and Christian Dustmann

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Awarding telecom licences: the recent European experience

Tilman Börgers and Christian Dustmann

University College London

1. INTRODUCTION

When awarding spectrum licences to potential operators of third generation (3G) mobile telephone networks, European governments have had to make decisions about two major questions:

(1) How many licences should be awarded, and how much spectrum should each licence give access to?
(2) Which companies should receive which licences, and how much should they pay for their licences?

Different European countries have adopted very different methods for making these decisions: market-based methods, such as auctions, or bureaucratic methods, such as 'beauty contests'. In this paper we compare the evidence regarding the behaviour of economic agents when these different methods were used to the predictions of

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economic theory. We proceed in four steps. In the first two steps, we analyse evidence regarding market-based and bureaucratic methods for the first of the above two issues, that is, the number and size of licences. In the third and fourth steps, we perform a similar analysis for the two methods used to resolve the second issue, that is, the choice of licence holders and prices. We restrict attention to the 15 member states of the European community. The evidence we use includes the publicly available data on bidding in the European third generation spectrum auctions, but also evidence on bureaucratic decisions processes, such as consultants' reports, industry publications, and minutes of meetings between government officials and industry representatives.

To answer the first of the above questions most countries have used a bureaucratic process. This took the form of consultation meetings and exchange of documents between government officials and the industry. In this paper we shall view these bureaucratic consultations as 'cheap talk' games, that is, games in which there are no intrinsic costs associated with making one statement or the other, and we shall ask to which extent firms revealed the full information to which they had access. To address this issue, we compare the information provided to governments in the cheap talk phase to the information implicitly revealed in auction outcomes. We find that cheap talk led to incomplete information revelation.

Germany, Austria and Greece deviated from the bureaucratic procedures used by the other states of the European community, and constructed auctions in which it was endogenous how many licences would be awarded, and of which size these licences would be. One key prediction of economic theory regarding these auctions is that firms will use them to buy up spectrum primarily with the intention of stopping others from entering the market. We show that somewhat surprisingly this happened only to a very limited extent.

The remainder of the paper analyses the two methods used to address the second of the above questions – which firms should receive licences and at what price. We shall examine whether bidding behaviour in auctions, as far as it was publicly observable, was in agreement with the predictions of auction theory; we find some significant deviations. We shall also examine whether the beauty contests have suffered from the drawbacks commonly attributed to them by economists, and find that this was sometimes, but not always the case.

Overall, the licensing process was not an occasion for economists to boast about. Some of what was expected ahead of the licensing process did not actually happen, or happened only in some countries, but not in others. Some theories turned out to be more relevant than others. The licensing process provided a learning opportunity for economists, and should be motivation for new theory development.

Understanding the 3G licensing process in Europe is important for two reasons. First, this process shaped the future of an important European industry. Secondly, similar licensing processes will occur again, for example when it comes to licensing television stations, issuing pollution rights, or allocating railway franchises, or selling state-owned production facilities. Issues such as how to package assets, whether to use

beauty contests or auctions, how to induce information revelation, the impact of lobbying, endogenous market power, and the possibility that firms bid to raise the prices paid by others, potentially affect those applications as they have affected 3G licensing. Two points are perhaps special about 3G licensing though. The first is the scale. Firms' futures were at stake. The second is the high level of uncertainty over the value of the licences. One can speculate over how these factors affect our results. In particular, the first point implies the potential importance of endogenous market power, an issue raised in the paper by Jehiel and Moldovanu in this issue. The second point might have made it easier to induce information revelation, simply because not much really valuable information was present.

Our work differs from other surveys of the European spectrum auctions (Jehiel and Moldovanu, 2001; Klemperer, 2002a, b, e) in three ways: First, we consider the licensing process in *all*, rather than some member states of the European Community. Second, whereas previous work has focused on the assignment of licences to firms, and the determination of licence prices, we also emphasize the earlier step in which the number and size of licences is determined. Third, our concern is not only with auctions, as in previous studies, but also with beauty contests and other bureaucratic methods.

Our paper differs from previous work also because our concern is not primarily with the 'success' or 'failure' of different countries (Klemperer, 2002e). The German UMTS auction, for example, was 'successful' in raising large revenue, but bidders' behavior was hardly what economic theorists had predicted ahead of the auction. Indeed, had bidders behaved as predicted, the auction would have been much less 'successful'. This example indicates that the question whether a licensing method succeeds or fails is very different from the question whether agents behave as predicted by economic theory. If successes occur for reasons that are not well understood by economic theory, then it is difficult to build good advice on these successes. This motivates our focus on the extent to which theories have been verified.

This paper is organized as follows. Section 2 describes choice variables, constraints and objectives of the European governments, and introduces a classification of licensing methods. Sections 3, 4, 5 and 6 contain the four key steps in our analysis where we investigate the empirical performance of economic theory in predicting governments' and agents' behaviour. Section 7 summarizes our conclusions.

2. DECISION PROBLEM AND METHODS

2.1. Choice variables, constraints and objectives

We now describe the three components of the decision problem faced by the member states of the European Community: the choice variables, the constraints and the objectives. The choice variables were the number of licences, the amount of spectrum assigned to each licence, the precise location of that spectrum in the available spectrum bands, the assignment of licences to operators, and the prices which operators had to pay for their licences.

For simplicity, we shall ignore the precise location of licences in the spectrum band. The first two choice variables together can then be referred to as 'the number and size of licences'. As regards the 'size of a licence' (the amount of spectrum covered by a licence) it must be kept in mind that there are two types of spectrum: 'paired', and 'unpaired' spectrum. Paired spectrum provides separate ('paired') frequencies for communication from the base station to the mobile telephone, and for communications from the mobile telephone to the base station. With unpaired spectrum the same frequency is used for both directions.[1]

The first constraint concerned the available spectrum. There were 60 MHz of paired spectrum, and 25 MHz of unpaired spectrum that had been designated for 3G services in international and European decisions. These decisions were binding for all member states of the European Union.[2]

The second constraint was technological in nature. Among the available 3G technologies, the European Community had made a (limited) commitment to the so-called UMTS technology. To establish a functioning UMTS network operators needed a certain minimum of spectrum. It seems that this minimum was at least 2×10[3] MHz of paired spectrum. As evidence that the technologically required minimum was no smaller than 2×10 MHz paired spectrum we offer the observation that no licence has been issued that does not give at least access to this amount of paired spectrum, as Tables 3 and 4 below indicate. Also, we are not aware of any advisor who has indicated in the consultation processes which preceded the licensing process, and which we review in Section 3, that a licence with less than 2×10 MHz of paired spectrum was technologically viable.

While the minimum of required spectrum was certainly not lower than 2×10 MHz of paired spectrum, it may have been larger. The 'UMTS Forum', a lobby group for mobile telephone operators, has advocated licences of the size 2×15 MHz plus 5 MHz of unpaired spectrum (Recommendation 1 of UMTS Forum, 1998). At times, the UMTS Forum has claimed that smaller licences would not be technologically viable.[4] However, there is some uncertainty whether this is actually true, as we argue in Section 3 below. We shall discuss the UMTS Forum's comments in more detail in Section 3.

We finally turn to the objectives. Note first that our concern here is not what government objectives *ought* to have been, but what they *really* were. What the objectives

[1] Appendix A of Rothschild (1999).

[2] The relevant decisions were made by the 1992 World Radiocommunications Conference of the International Telecommunication Union and by the European Radiocommunications Committee (ERC) of the European Conference of Postal and Telecommunications Administrations. The member states of the European Union belong to both organizations and are bound by their decisions. The most important decisions are ERC Decision (99)25 and ERC Decision 00(01). The process by which these decisions were reached, and the economic rationale behind these decisions, are interesting and important subjects in their own right. An investigation of these issues is beyond the scope of this paper.

[3] In this paper, notation of the form $2 \times A$ MHz will always refer to two paired spectrum bands of size A MHz each. By contrast, if we simply write A MHz, then we always mean unpaired spectrum.

[4] See the UMTS Forum's comments on the licences issued in the UK mentioned in House of Commons (2001).

really were is important for our investigation because we want to focus on those aspects of the licensing process that were relevant to actual government objectives.

There is some ambiguity regarding government objectives, as not all governments have explicitly formulated objectives for the 3G licensing process, and those governments that have stated their objectives have not been very precise. However, some information can be obtained from these statements of objectives. What we can infer from them is which variables mattered. Sometimes, we can also infer which variables were more important than others. But typically we cannot infer how precisely variables were aggregated.[5]

Most governments seem to have sought to allocate the spectrum so that consumers benefited, both in terms of low prices and in terms of quality and variety of services offered. In economic terms one can interpret the first objective to be the maximization of consumer surplus. Companies' profits appear to have entered governments' objectives as well. Profit should at least be sufficient to allow the concerned firms to raise equity or debt when needed. Lastly, revenue maximization appears to have been important for some governments, although it appears to have been less important than the other objectives.

Many governments have mentioned further objectives of their licensing process, such as the promotion of competition in telecommunications, or wide participation in the licensing process. These objectives seem to have been *subsidiary* goals, that is, goals that were pursued because it was hoped that their achievement would help to promote the primary goals. Consumer surplus, profits and revenue seem to have been the primary objectives.

2.2. Licensing methods

We consider first the choice of the number and size of licences. All European governments conducted consultations regarding this question. In some countries the number and size of licences was then simply chosen by the government. For these countries we shall say that they used a 'bureaucratic' method to determine the number and size of licences.

Other countries subsequently to consultations conducted auctions in which the number and size of licences was determined endogenously. In this case we shall say that the respective countries used 'auction' methods. One way of implementing an auction method was, for example, to divide the available spectrum into blocks, and to let companies choose for how many blocks of spectrum they wanted to bid for. This was done in Austria and Germany.

[5] The description of government objectives in the following two paragraphs relies on the following sources: Statement by Telecommunications Minister Barbara Roche to the House of Commons on 18 May 1998, reproduced in N.M. Rothschild & Sons (1999, p. 5); § 2(2) of the 'Telekommunikationsgesetz' in Germany; Irish Office of the Director of Telecommunications Regulation (2001, p. 9); and Hubert (2000).

Table 1. Classification of licensing methods

	Method I	Method II	Method III
Mechanism by which the number and size of licences is determined	Bureaucratic	Bureaucratic	Auction
Mechanism by which the licence holders and prices are determined	Bureaucratic	Auction	Auction

Turning now to methods for determining the assignment of licences to potential operators and of licence prices, we note that the 'bureaucratic' method for this aspect of the decision problem is the 'beauty contest'. In a 'beauty contest' the government invites bidders to submit business plans, and then government officials examine these business plans using pre-announced criteria. The companies whose bidding plans look most attractive are allocated licences at a price fixed by the government. By contrast, 'auction' methods allocate licences to the bidders who bid most, and payments are some function of bids.

Every country that used auction methods to determine the number and size of licences also used auction methods to determine the licence holders and prices. Therefore, we are left with three different types of methods used in the licensing process in Europe. These are listed in Table 1.

In Table 2 we then indicate for each member state of the European Union which of the three methods in Table 1 was used to award 3G licences, as well as some details of format and timing.

In Table 2 the boundary between Methods II and III is somewhat fluent. Italy, which is assigned to Method II in Table 2, offered a fixed number of licences for sale, but indicated that if the number of bidders in the auction was equal to, or smaller than, this fixed number, the number of licences could be reduced by one (Italian Ministry of Communications, 2000, item 20). This was indicated as a possibility, not as a certain event. Greece, which we have assigned to Method III, indicated, by contrast, exactly how the number of licences would be reduced if there were fewer bidders than licences (see Section 4 below). We have assigned Greece to Method III rather than Method II because the Greek government's pre-commitment was much stronger than the pre-commitment of the Italian government.

The Italian licensing process also involved a first stage in which company documentation, and technical and commercial plans had to be submitted. Only bidders who were considered satisfactory in the first stage were admitted to the auction stage. This procedure thus included an element of a beauty contest.

Three further points seem noteworthy in Table 2. First, a surprising variety of licensing methods was used. Second, however, it is also true that most countries chose the number and size of licences by bureaucratic methods, and the most popular formats to award these licences were beauty contests and simultaneous ascending auctions. Third, the licensing process was spread out over a considerable amount of

Table 2. Licensing methods used by the member states of the European Community

Method	Country	Auction method	Beginning of the licensing process
Method I (Beauty contest for Licences of Government-determined Size)	Finland	N/A	15.02.99
	Spain	N/A	31.12.99
	Sweden	N/A	01.09.00
	Portugal	N/A	29.09.00
	France	N/A	31.01.01
	Ireland	N/A	27.03.02
	Luxembourg	N/A	29.03.02
Method II (Auction of licences of Government-determined Size)	United Kingdom	Simultaneous ascending	06.03.00
	Netherlands	Simultaneous ascending	05.06.00
	Italy	First stage: Simultaneous ascending auction; Second stage: Auction of two additional blocks of 2 × 5 MHz paired spectrum.	11.09.00
	Belgium	Simultaneous ascending	08.02.01
	Denmark	Sealed bid	05.09.01
Method III (Auction of licences of variable size)	Germany	2-stage auction. Both stages were simultaneous ascending auctions. Stage I: 12 blocks of 2 × 5 MHz paired spectrum. Successful bidders must acquire at least 2 and at most 3 blocks. Stage II: All blocks of 2 × 5 MHz paired spectrum that remained unsold in Stage I, plus 5 blocks of 1 × 5 MHz unpaired spectrum. Bidders can acquire in this stage at most one block of paired and one block of unpaired spectrum.	31.07.00
	Austria	Approximately as in Germany.[a]	02.11.00
	Greece	2-stage auction. Both stages were sealed bid auctions. Stage I: 4 licences are offered. If there are not 4 valid bids, then 3 licences are offered. If there are no 3 valid bids, then 2 licences are offered. Stage II: Winning bidders from stage I can bid for additional paired spectrum.	11.07.01

Notes: [a] Some differences between the Austrian and the German auction are explained in Section 4 below.

Sources: www.mintc.fi (Finland), www.cmt.es (Spain), www.pts.se (Sweden), www.anacom.pt (Portugal), www.art-telecom.fr (France), www.odtr.ie (Ireland), www.etat.lu/IRL/tele/3g (Luxembourg), www.radio.gov.uk and www.spectrumauctions.gov.uk (United Kingdom), www.dgtp.nl and www.opta.nl (Netherlands), www.comunicazioni.it (Italy), www.umts.bipt.be (Belgium), www.itst.dk (Denmark), www.regtp.de (Germany), www.rtr.at (Austria), www.eett.gr (Greece).

time. The European Community had set January 2002 as the target date for the award of UMTS licences. They had also added that in case of technical difficulties an extension of one year could be granted.[6] This extended target has been met by all EC member states.

[6] See Article 3 of Decision No 128/1999/EC of the European Parliament and of the Council.

3. CHOOSING THE NUMBER AND SIZE OF LICENCES THROUGH CONSULTATION

3.1. Overview

We show in Table 3 the decisions reached by the countries that used a bureaucratic method for determining the number and size of licences. Table 3 indicates some variability in outcomes. Some countries issued licences that covered 2×15 MHz paired spectrum and 5 MHz unpaired spectrum. In other countries, licences were offered which gave access to only 2×10 MHz paired spectrum and 5 MHz unpaired spectrum. Still others designed licences that did not have any unpaired spectrum attached to them. The fact that outcomes differed in this way indicates that countries had indeed a non-trivial choice over the number and size of licences. This is reinforced by Table 4 in the next section that shows similar information for those countries that determined number and size of licences in an auction. If one takes Tables 3 and 4 together the range of licence sizes becomes larger.

The bureaucratic processes adopted by the countries listed in Table 3 were consultation processes in which various companies and organizations were asked to provide comments to the government, and the government decided on the basis of the information received. These consultations therefore constitute *lobbying*, meaning an attempt by interested parties to influence government decisions. Economic models of lobbying reflect two different interpretations of what lobbyists do.[7] One view is that lobbyists offer governments bribes with the goal of influencing decisions. Another view is that lobbyists provide potentially valuable information for governments, but that they will seek to manipulate this information, and that they won't necessarily disclose all the information available to them. We shall focus on the second view because we have more evidence that is relevant for this view of lobbying than for the alternative view. However, at the end of this section, we shall also briefly touch on the first of the two views of lobbying.

If we adopt the view that lobbyists communicated information to the governments, we first need to ask which information governments needed when choosing the number and size of licences. As explained in Section 2, to a first approximation, most governments sought to maximize some combination of consumer surplus, profits and government revenue. To form beliefs about the consumer surplus for any given number and size of licences, governments needed to have beliefs about the products which would be offered, about the demand for these products as a function of their prices, and about the prices which would prevail in the market. Beliefs about the prices would presumably need to be derived from beliefs about the firms' variable cost functions, and about the nature of competition among the firms. The same

[7] See Grossman and Helpman (2001).

Table 3. Number and size of licences determined by bureaucratic methods

Method	Country	No. of incumbent 2G operators[a]	Number and size of licences[b,c]
Method I (Beauty contest for licences of government-determined size)	Finland	9[d]	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.[c]
	Spain	3	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Sweden	3[e]	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Portugal	4	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
	France	3	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Ireland	3	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum (one A and three B licences)[f]
	Luxembourg	2	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
Method II (Auction of licences of government-determined size)	United Kingdom	4	5 licences; A: 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum; B: 2 × 15 MHz paired spectrum; C, D and E: 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Netherlands	5	5 licences; A and B: 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum; C, D and E: 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Italy	4	5 licences; A and B: 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum; C, D and E: 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Belgium	3	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.
	Denmark	4	4 licences; each 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum.

Notes:

[a] We indicate the number of network operators, not the number of service providers. The number of network operators seems more relevant because UMTS licences are licences to operate a network.

[b] We indicate how many licences were *offered*. The number of licences *awarded* is sometimes different because not enough interested bidders were forthcoming. The number of licences awarded is indicated in Tables 5 and 6.

[c] Where heterogeneous licences were issued we label licences with capital letters so that we have a simple way of referring to these licences in Tables 5, 6, and 7.

[d] We have indicated the number of existing 2G licences. It should be kept in mind that in Finland these are typically regional licences, and that there is cross-ownership of regional licence holders.

[e] In Sweden a fourth 2G licence had been issued at the time of the licensing process, but no network had been rolled out at the time of the beauty contest.

[f] The A licence differed from the B licence in a number of dimensions. In particular, A licence holders were expected to provide access to Mobile Virtual Network Operators (MVNOs). If they could prove a 'demonstrable need' for additional spectrum to support MVNOs they were promised an additional spectrum allocation of 2 × 5.2 MHz paired spectrum and 5 MHz unpaired spectrum. Additional spectrum was also promised to new entrants if they had a 'demonstrable need'.

Sources: As Table 2.

variables, and the fixed costs of constructing a mobile network, needed to be taken into account when forming beliefs about profits and about government revenues.

Governments also had to think about how these variables would depend on the chosen number and size of licences. Thus, for example, it was important how the amount of paired and unpaired spectrum awarded would influence the services which companies were able to offer. Similarly, it was important how the number of licencses would affect the competitiveness of price formation in the market.

At the time the licensing process was prepared there was substantial uncertainty about a number of the relevant issues. For example, there was uncertainty regarding the question of which services could be provided with different types of licences, and what demand for these services would be. Governments conducted consultations in order to find out more about these issues.

What does the economic theory of informational lobbying predict? Unfortunately, game-theoretic models of informational lobbying have typically many equilibria. In some, all utterances of the lobbyists are ignored. In others, a significant amount of information is credibly communicated (see, e.g., Crawford and Sobel, 1982; Battaglini, 2002). What we can take from the literature is not so much an unambiguous *prediction*, but rather a *focus*, namely a focus on the question to which extent the information available to lobbyists is revealed to the government.

Notice that we are not asking whether actual decisions were biased in favour of those consulted. Biases in decision making are not a prediction of the informational lobbying literature. In particular, it would be naïve to expect that misrepresentation of information would lead to biased decision making. Decision makers understand the interests of the experts whom they consult, in a way that may allow them to make correct inferences from what they are told.

How can we tell whether the consulted parties fully revealed their knowledge? Our methodology for addressing this question is as follows. First, in Section 3.2, we ask which information governments received in the course of their consultations. Then, in Section 3.3, we ask whether subsequent auctions revealed additional information. We focus on events preceding March 2000, the date of the United Kingdom's auction, because this auction may have revealed important information to other governments.

3.2. Lobbying and information revelation

3.2.1. The UMTS Forum's report. The most important industry organization consulted was the UMTS Forum. The UMTS Forum represents telecom operators and manufacturers.[8] Its very prominent Report No. 5 (UMTS Forum, 1998) studied

[8] Regulators and other government institutions are also members of the UMTS Forum. However, reports such as the UMTS Forum's Report No. 5 come with the qualification that 'The National Administrations that are members of the UMTS Forum have actively supported the development of the report. However, the views expressed do not necessarily represent the views of the Administrations' (UMTS Forum, 1998, p. 1).

the 'minimum spectrum demand' per UMTS operator in the 15 member states of the European Union, and recommended that licences should give access to 2 × 15 MHz paired spectrum and 5 MHz unpaired spectrum. A country that followed the UMTS Forum's recommendation could thus license only four operators.

We will now investigate how the UMTS Forum arrived at its recommendation. This is interesting for our purposes because it indicates how much information governments could derive from the UMTS Forum's report. The first issue addressed by the Forum is which products UMTS network operators will offer. The UMTS Forum argued that the anticipated UMTS applications can be classified into different service classes, such as 'high interactive multimedia services', 'simple messaging' or 'speech'. For forecasting spectrum requirements, it was argued, there is no need to consider in detail what the particular applications will be.

The UMTS Forum's predictions of demand for these services took the form of 'point predictions'. The predictions were *point* predictions in two senses: first, no price dependency was indicated, and second, no uncertainty was expressed. For governments seeking to find a solution to the decision problem described in Section 2 the informational value of such demand predictions is low. Without price dependency, it is impossible to calculate consumer surplus. Moreover, if we take for granted that demand for UMTS applications is uncertain even today, it is hard to interpret forecasts that do not indicate the associated uncertainty.

The report did not discuss price formation. It also assumed that network operators would share demand equally (while pointing out that this assumption could well be false).[9] The report's focus was on how large licences had to be so that the network operators were technically able to satisfy the forecast demand, assuming that this demand would be shared equally. At this point the UMTS Forum's report did explicitly acknowledge uncertainty (p. 24). The indication provided was, however, vague, and did not make it transparent what the forecasts would be for alternative sets of assumptions. It also did not consider the costs of building a network.

Based on the considerations described, the UMTS Forum then arrived at its recommendation of four 2 × 15 MHz UMTS licences, each with 5 MHz unpaired spectrum. The report described this solution as the 'scenario with full functionality that occupies the least amount of spectrum per operator' (p. 35). The alternative of 2 × 10 MHz paired spectrum with 5 MHz of unpaired spectrum was described as feasible too: 'This scenario can handle all traffic' (p. 34). But the report went on, saying, 'There may be problems delivering high data rate services in some areas' (p. 34). The same comment was also made regarding 2 × 15 MHZ licences that do not have unpaired spectrum. The UMTS Forum commented: '5 MHz [unpaired spectrum] may be required to give satisfactory capacity for asymmetric traffic' where traffic is called 'asymmetric' if the amount of information transmitted 'down-link' is

[9] Page 29. In this and the next paragraph page numbers refer to UMTS Forum (1998).

very different from (for multimedia services typically: larger than) the amount of information transmitted 'up-link'.

The UMTS Forum pointed out some uncertainty associated with its recommendation. The Forum mentioned in particular that it had not taken the costs of building a network into account. It pointed out that these costs may depend on the size of licences, because licences with more spectrum may make a less dense, and therefore cheaper network possible.

Our conclusion from the discussion so far is that governments could deduce some, but by far not all relevant information from the UMTS Forum's report. The report left large uncertainty about the size of demand for UMTS applications and its price elasticity. It was also almost silent about the nature of competition in future UMTS markets. Finally, it did not attempt to quantify entry costs.

The UMTS Forum's recommendation was not the only source of information for governments in the lobbying process. Other sources of information were the responses to consultation documents, oral discussions in groups that brought governments and industry together, and reports from telecom consultancy companies. We next review what governments could learn from these sources, focusing on two countries (Sweden and the United Kingdom) whose consultations are particularly well documented, and led the governments to modify their plans.

3.2.2. Sweden. The Swedish government commissioned in 1999 two consultancies to provide reports as part of its preparation for UMTS licensing, Communicator (1999) and Questus (1999). Communicator was commissioned to forecast market demand for UMTS services. Communicator gave more emphasis to demand uncertainty than the UMTS Forum did. Also, Communicator tried to use survey data to determine price responsiveness of demand for UMTS services. The number of consumers surveyed was low (500), and the questions asked were vague and qualitative. Communicator concluded, 'early users [of broadband mobile data communications] will be relatively insensitive to cost' (Communicator, 1999, p. 6). It then provided demand forecasts as *point* forecasts in the sense described above, and found that its 'assessment of traffic development is roughly similar to that developed by the UMTS Forum' (Communicator, 1999, p. 7).

Questus was asked by the Swedish government to consider what needed to be done to attract a new entrant into the Swedish mobile telephone market. Interestingly, unlike the UMTS Forum, Questus did try to quantify the effect of additional competition in the mobile telephone market. It concluded that there was some evidence of price falls as the consequence of the introduction of a new competitor. However, there were also exceptions, and Sweden was one of them, where 'the apparently strong levels of competition have still not driven tariffs down to the same levels [as in other countries]' (Questus, 1999, p. 25). Questus did not seek estimates of the costs of rolling out networks, but it asked market players whether they thought there 'was room for a fifth network operator in Sweden'. Questus found that industry players

answered this positively. Industry players presumably considered the costs of building such a network in their responses.

Questus came to the conclusion that Sweden should offer five licences. It cited the UMTS Forum's finding (though not recommendation) that even $2 \times 10 + 5$ MHz licences would be adequate, and then recommended that Sweden should issue two $2 \times 15 + 5$ MHz licences, and three $2 \times 10 + 5$ MHz licences. The Swedish government issued a press release on 22 February 2000 announcing that 'up to five licences will be issued' (source: www.pts.se). It appears that industry players, in particular Ericsson, objected to this decision. Ericsson seems to have argued that technically $2 \times 10 + 5$ MHz licences would not be able to handle anticipated UMTS traffic.[10] Ericsson's argument seems to have been that 2×10MHz of paired spectrum was not sufficient for UMTS services, and that the value of the unpaired spectrum was very uncertain. A further study commissioned by the government (Omnitele, 2000) disputed the need for more paired spectrum. However, as regards unpaired spectrum, Omnitele acknowledged that there was large uncertainty about its value. Finally, Omnitele also acknowledged that larger licences would reduce operators' costs. A press release of 19 April 2000 (source: www.pts.se) indicated that the government had changed its mind. It was announced that only four UMTS licences would be issued. This was the final decision.

Our conclusion is that the Swedish consultation process indicated that major uncertainty remained concerning these factors: (1) the size and price elasticity of demand for UMTS services; (2) the amount of paired spectrum required to carry the required service; (3) the extra value of unpaired spectrum; (4) the impact of additional competition on prices; (5) the costs of the roll-out of networks.

3.2.3. United Kingdom. Like Sweden, the United Kingdom had a public change of mind regarding the optimal number and size of licences. It made exactly the opposite move from that made in Sweden. In September 1998 the UK government indicated that it planned to make four licences available. The government did not say how large these licences were supposed to be, but the government's statement pointed very strongly towards $2 \times 15 + 5$ MHz licences (UMTS Auction Consultative Group, 1998a). In November 1998 the government announced that it was considering issuing five licences instead (UMTS Auction Consultative Group, 1998b), and in May 1999 the government confirmed that five licences would be offered, where the size of the licences would be as indicated in Table 3. On what information were the government's preliminary announcement and its final decision based?

The initial announcement was based on a report by Ovum Ltd and Quotient Communications Ltd (1998). Like other reports, the Ovum–Quotient report also forecast demand as a quantity without incorporating price dependency. The report

[10] We have inferred the content of Ericsson's objections from Omnitele (2000), which contains a partial response to Ericsson's critique.

acknowledged the uncertainty regarding demand levels by presenting an 'optimistic' as well as a 'pessimistic' scenario. The report focused on the 'optimistic' scenario. In order not to underestimate demand, the report also focused on likely traffic in London, the UK's largest city. It assumed that operators would share the market equally. No assessment of the impact of competition was made. The report calculated how much spectrum an individual licence holder would need to be technically able to cover the traffic. The report indicated major uncertainty regarding the extent to which unpaired spectrum could be used for data-services in buildings. The report provided an estimate of the required investment to build up a network, but emphasized the need for further research into this subject. For the case that unpaired spectrum could be used for data-services in a building, the Ovum–Quotient report concluded, 'up to 5 operators could be accommodated if a means were agreed whereby all operators shared use of a common block of unpaired spectrum' (Ovum Ltd and Quotient Communications Ltd, 1998, p. 46).

Note that the Ovum–Quotient report left uncertainty in similar areas as the documents that we have examined so far: the size and price sensitivity of demand, the value of unpaired spectrum, and the effect of competition on prices. In comparison to previous documents, the Ovum–Quotient report suggested reduced uncertainty concerning one important point: the costs of constructing a network.

The Ovum–Quotient report was dated February 1998. In November 1998 the UK government advocated four licences, arguing that five licences 'could also compromise the ability of all licencees to run effective UMTS networks' (UMTS Auction Consultative Group, 1998a, p. 1). It is unclear which information led to this conclusion. The government invited the industry to express views regarding its proposal. A potential bidder indicated that with smaller licences it might be technically feasible to roll out a full UMTS service (UMTS Auction Consultative Group, 1998b, p. 1). Moreover, one of the government's original consultants, Quotient, identified delay times in indoor services as a crucial variable, and with additional work showed that $2 \times 10 + 5$MHz licences would be viable (UMTS Auction Consultative Group, 1998b, p. 1). The potential bidder's advice, and the Quotient advice, induced the government to change its position.

Our conclusion is that overall the UK experience indicates that there was major uncertainty in particular regarding the demand side. On the technology side, the value of unpaired spectrum seems to have been particularly uncertain.

3.3. Information revealed by auctions with exogenous licence structure

In order to assess whether important information was missed out in the consultation processes that preceded auctions, we now ask which information was revealed by auctions that immediately followed. We focus on auctions in which licences of exogenous size were offered, and in which not all licences were of the same size. The implicit value of different licence sizes can be deduced from bidding behaviour in

these auctions. This information then has implications for the variables in which governments were interested.

We focus on auctions with *exogenous* licence size because the auctions with *endogenous* licence size are harder to interpret, since valuations of additional spectrum may reflect considerations of market power. The only two countries in which licences of exogenous and heterogeneous size were auctioned were the United Kingdom and the Netherlands. The UK offered licences of three different sizes, and the Netherlands offered licences of two different sizes (see Table 3). Both countries used simultaneous ascending auctions. All licences were offered simultaneously for sale. In each round each bidder who was not the currently leading bidder for a licence had to pick some licence and place a bid for that licence which overbid the currently leading bidder by a certain minimum increment. Leading bidders were committed to their bids. A bidder who didn't want to overbid any leading bidder had to withdraw.[11] The auctions closed when all bidders except the leading bidders had withdrawn.

We shall interpret the observed bidding behaviour in these auctions assuming *straightforward* bidding. This is a bidding strategy for simultaneous ascending auctions which is analysed in Milgrom (2000). The bidding strategy relies on the assumption of private values. This means that a bidder enters a simultaneous, ascending auction with fixed expected values for each licence, and does not change these expected values throughout the auction. Straightforward bidding then means that in every round bidders bid for that licence where the value of the spectrum minus the minimum required bid is largest. This bidding strategy is naïve, and one might think of many reasons to pursue other strategies. However, as we explain below, we do find that some bidders' behaviour in the UK and Dutch auctions is well explained by straightforward bidding.

If we assume that bidders bid straightforwardly, then every bid which a bidder places tells us something about that bidders' values for different licences. In particular, if a bidder bids for some licence X rather than some licence Y, it must be that: $v_X - p_X \geq v_Y - p_Y$ where v_X and v_Y are the bidders' values for the two licences, and p_X and p_Y are the minimal admissible bids for the two licences. The inequality is equivalent to: $v_X - v_Y \geq p_X - p_Y$. Thus successive bids for different licences, with observed prices, allow us to narrow down the range in which the value difference $v_X - v_Y$ must lie. For interesting valuation differences to emerge, licences X and Y must, of course, be different.

Why are valuation differences of interest? The value difference between a licence with paired and unpaired spectrum, and a licence with the same amount of paired, but no unpaired spectrum, indicates how companies value unpaired spectrum. The value difference between a 2×15 MHz licence and a 2×10 MHz licence indicates how valuable it was for bidders to have the more paired spectrum. Companies'

[11] Both auctions offered the possibility of a limited number of 'waivers' where a bidder could not bid, but did not have to withdraw.

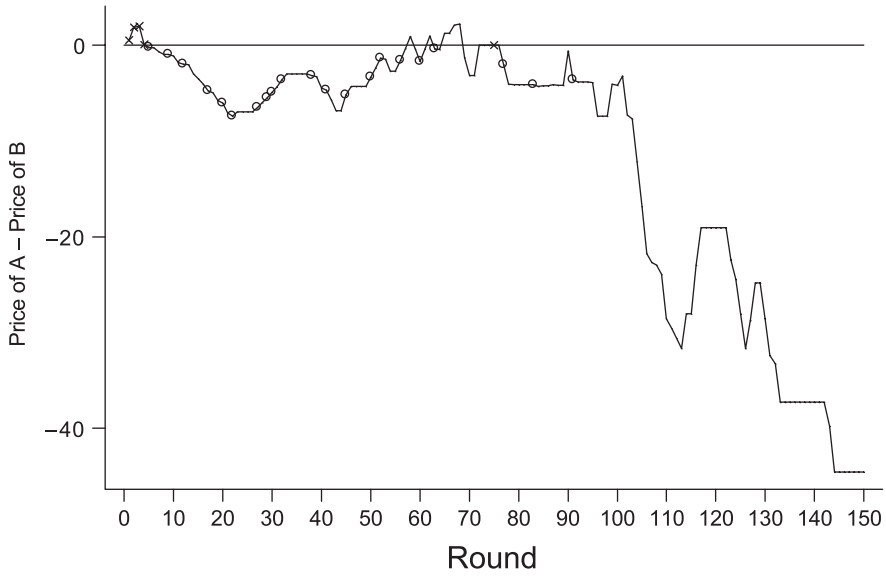

Figure 1. Spectrumco's bids on licence A and B in the UK auction

Notes: Prices are expressed in € per head of the population. Bids for licence A are marked with a circle (○) and bids for licence B are marked with a cross (×).

Source: Data available at www.spectrumauctions.gov.uk.

valuations reflect these companies' assessment of the spectrum requirements for different types of services, of the demand, of costs, and of the competitiveness of the market. These variables are of interest, but, of course, they are confounded in a companies' valuation.

We now consider first the UK auction, and focus on the comparison between licences A and B. These licences were both endowed with 2 × 15 MHz of paired spectrum, but licence A had 5 MHz of unpaired spectrum attached to it, whereas licence B had no unpaired spectrum. Incumbents were not allowed to bid for licence A, so we focus on outsiders. In Figure 1 we show the difference between A's and B's 'price' – that is, minimum admissible bid – for each of the 150 rounds of the UK auction. Licence B was typically more expensive than licence A, although it didn't offer access to unpaired spectrum, because competition for B was more intensive than competition for A, as incumbents were not allowed to bid for A.

Among the outsiders in the UK auction who showed interest in a large licence, a few bid only for A, and never for B.[12] Three bidders switched between A and B. One of these was Spectrumco, whose bids we have indicated in Figure 1. Figure 1 shows that Spectrumco switched to licence A whenever B was more expensive than A. Thus, Spectrumco's bids reveal that the value of unpaired spectrum to them was approximately zero. Telefonica's bids for A and B showed that their value of unpaired

[12] The information in this paragraph is taken from Börgers and Dustmann (2002a).

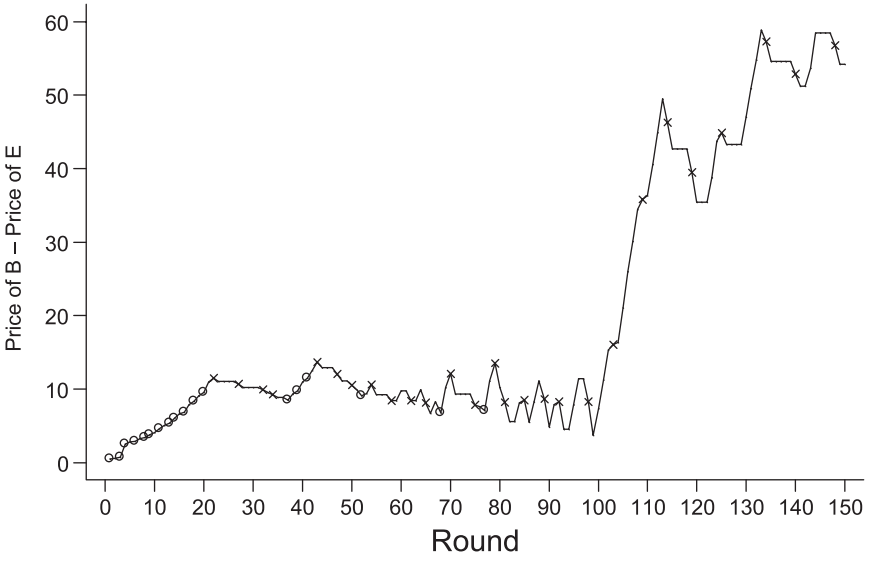

Figure 2. Orange's bids in the UK auction

Notes: Prices are expressed in € per head of the population. Bids for the large licence B are marked with a circle (○) and bids for the small licence E are marked with a cross (×).

Source: Börgers and Dustmann (2002a).

spectrum was positive, but very small. The third bidder who bid for A and B, TIW, bid somewhat inconsistently. But overall the bids in the UK auction suggest that the value of unpaired spectrum was small. This impression is reinforced by the results of the three auctions with endogenous licence size, which we discuss in the next section. In these three auctions bidders paid only reserve prices for unpaired spectrum.

Whereas governments' consultation exercises had indicated large uncertainty over the additional value of unpaired spectrum, and had left open the possibility that unpaired spectrum was very important to bidders' business plans, we thus find that the bids in the subsequent auctions indicated that the value of unpaired spectrum to firms was actually small.

We now turn to the comparison between licences with 2×15 MHz paired spectrum, and licences with 2×10 MHz paired spectrum, neglecting for the moment the unpaired spectrum. We explain in Börgers and Dustmann (2002a, b) that the UK auction data indicate that some firms had clear views of the value difference, whereas other firms' behaviour is hard to understand. To illustrate this we include two figures, one showing the behaviour of a bidder whose valuation of an extra 2×5 MHz of paired spectrum is clearly revealed during the auction, the other showing the behaviour of a bidder whose valuation of an extra 2×5 MHz of paired spectrum is unclear.

The first bidder is Orange. In Figure 2 we show on the horizontal axis the rounds of the UK auction. On the vertical axis we display the price difference between the 2×15 MHz licence B, the only large licence for which Orange as an incumbent was

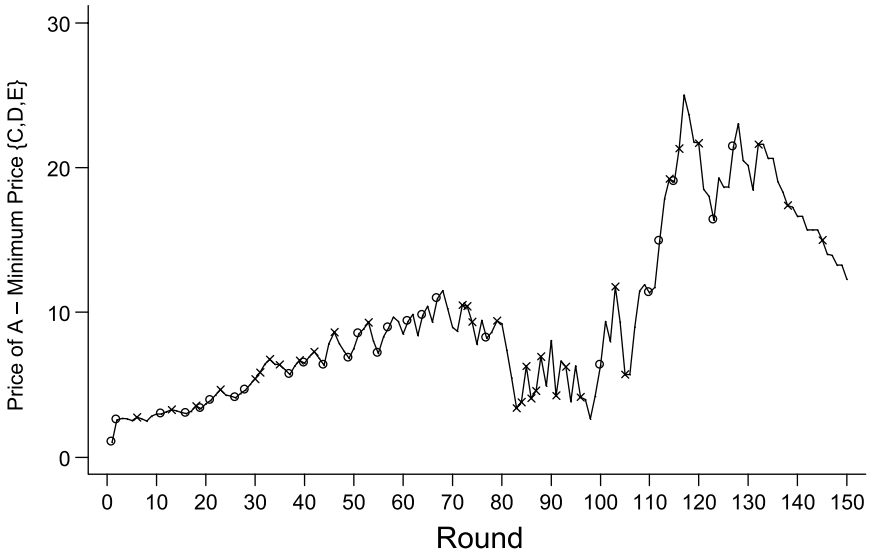

Figure 3. NTL Mobile's bids in the UK auction

Notes: Prices are expressed in € per head of the population. Bids for the large licence A are marked with a circle (○) and bids for the small licences C, D and E are marked with a cross (×).

Source: Börgers and Dustmann (2002a).

allowed to bid in the UK auction, and the 2 × 10 MHz licence E, which is the only small licence for which Orange bid in the UK auction.

Figure 2 indicates that Orange switched to licence E whenever the price difference between B and E was approximately €10 of the population. This thus seems to be Orange's estimate of the value of the additional spectrum. As the final price of licence E in the UK auction was approximately €117 per head of the population, and Orange was the winner of this licence, one can argue that Orange revealed 'decreasing returns to scale' with respect to spectrum. Orange's valuation of a third block of 2 × 5 MHz of spectrum was less than 10% of its valuation of the first two blocks of 2 × 5 MHz of spectrum. This may have been due to technology considerations, market demand considerations, or competition considerations. It certainly indicated that, unlike what some of those who had been consulted before the auction had said, a licence of 2 × 10 MHz paired spectrum seemed a viable option.

However, there seems to have been a large variety of views about the value of extra spectrum among UK operators. For example, Vodafone, the company that won in the UK the large licence B, was willing to pay approximately 50% more for this licence than for a small licence. Vodafone's behaviour could be interpreted as saying that a 2 × 10 MHz licence could not form the basis of a viable UMTS business.

Some UK companies' behaviour seems to indicate that they were genuinely uncertain about the value of extra spectrum. In Figure 3 we show a graph that is analogous to the graph in Figure 2, but now we consider the bidder NTL Mobile. The vertical axis now focuses on the difference between the price of the large licence A and the

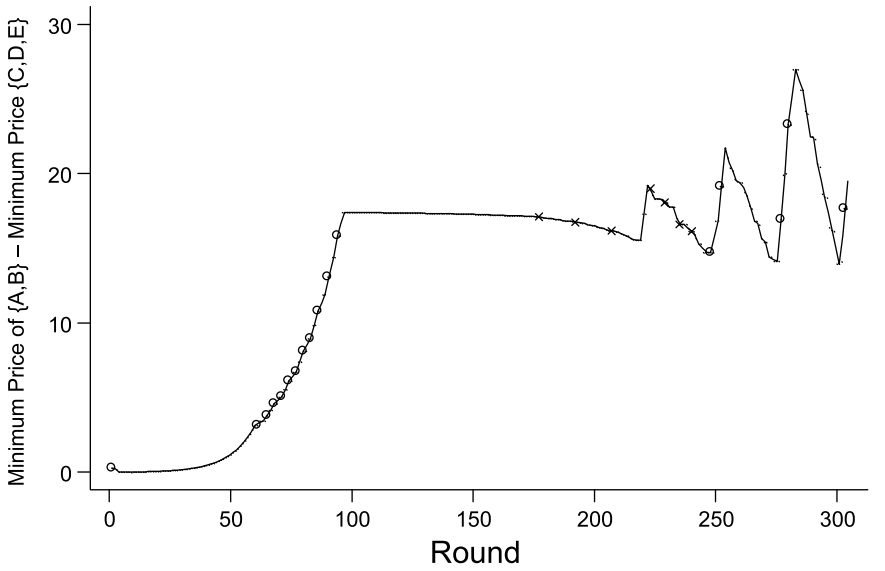

Figure 4. Libertel's bids in the Dutch auction

Notes: Prices are expressed in € per head of the population. Bids for licences A, B are marked with a circle (○) and bids for the small licence C, D, E are marked with a cross (×).

Source: Data provided by Eric van Damme.

minimum of the prices of the small licences C, D and E. This is because NTL Mobile only bid for licence A, but never for B.

Figure 3 is different from Figure 2 in that we cannot draw a horizontal line through the graph that separates the bids for large licences from the bids for small licences. This suggests that NTL Mobile had significant uncertainty about the value of incremental spectrum, and that it changed its mind about this value during the auction. Indeed, it appears that NTL Mobile gradually raised its estimate of the value difference. Perhaps it was learning from the observed bidding behaviour of other bidders.

We now turn to the Dutch auction. The Netherlands auctioned two $2 \times 15 + 5$ MHz licences and three $2 \times 10 + 5$ MHz licences. Thus, the auction in the Netherlands could provide information about the value of additional paired spectrum, but it could not provide information about the value of unpaired spectrum. The structure of the auction in the Netherlands was similar to that in the United Kingdom. One of the differences was, however, that no licence was reserved for outsides. Thus, all bidders could bid for all licences.

There were two bidders in the Dutch auction, Libertel (owned by Vodafone) and Telfort (owned by British Telecom) that switched frequently between large and small licences. We display for these two bidders graphs that are analogous to Figures 2 and 3.

In the case of Libertel there is no clear valuation of the licence difference. In particular, towards the end of the auction Libertel was willing to bid much more aggressively for a large licence than in the earlier rounds of the auction. By contrast,

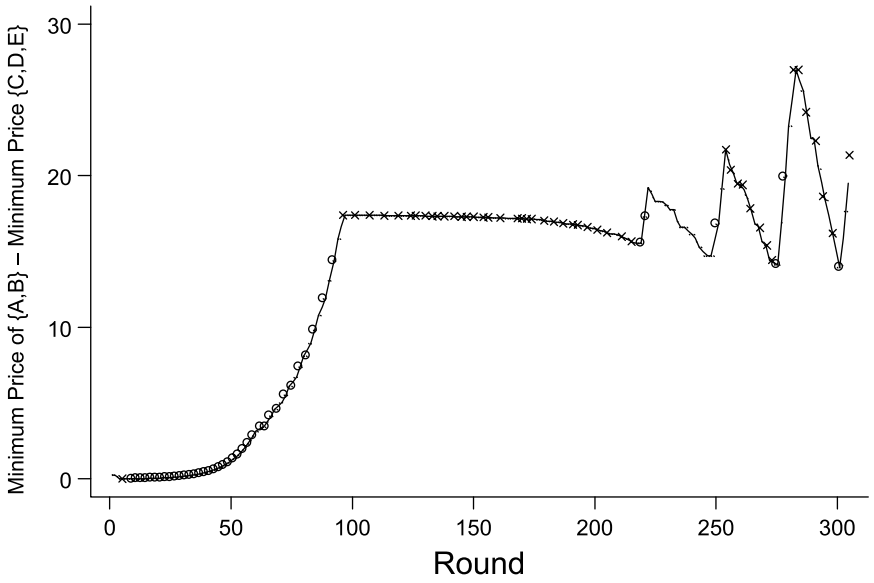

Figure 5. Telfort's bids in the Dutch auction

Notes: Prices are expressed in € per head of the population. Bids for the large licences A, B are marked with a circle (○) and bids for the small licences C, D, E are marked with a cross (×). In the data set available to us exactly one bid of Telfort, their bid in round 4, is unobservable. There is therefore no circle or cross corresponding to that bid in Figure 5.

Source: Data provided by Eric van Damme.

Telfort seems to reveal a value difference of approximately €15 per head of the population, although they do place towards the end of the auction one bid for a large licence although the price difference has grown significantly above their earlier threshold. Telfort eventually won the smaller licence D at a price of €27 per head of the population. This indicates that Telfort attached a relatively larger value to 2×5 MHz extra spectrum than Orange had done in the UK auction. On the other hand, Telfort's acquisition of the smaller licence means that in their opinion a viable business case could also be based on the smaller licence.

The auction evidence therefore suggests that most bidders, but not all, had quite low valuations of unpaired spectrum. The fact that many bidders have been willing to bid substantial amounts for 2×10 MHz licences indicates that bidders thought that viable UMTS services could also be built with this comparatively small amount of paired spectrum. These beliefs were expressed much more clearly in the auctions than in the preceding government consultations, which had left many governments distinctly uncertain as to the spectrum requirements for UMTS. Thus, we argue that the consultations preceding the licence design involved only incomplete revelation of the information available to the industry.

Observe that it would be premature that auctions with an endogenous number and size of licences would be superior. We consider such auctions in the next section, and find that they, too, have been problematic.

3.4. Lobbying as an exchange of favours

Having discussed in detail the interpretation of lobbying as an exchange of information, we now briefly turn to the more cynical view of lobbying, where lobbyists offer favours to decision makers, and decision makers in return make choices from which the lobbyists benefit. The literature has formalized this view in principal–agent models where lobbyists act as principals and decision makers as agents. If there are multiple lobbyists involved, then this game describes a *common agency* relationship (Bernheim and Whinston, 1986).

The principal–agent view of lobbying can be interpreted as a reduced form model of a more complex relationship. 'The interaction between SIG [special interest group] and policy maker need not involve any explicit discussion of a quid pro quo. Rather, influence can be bought and sold by a subtle exchange in which both sides recognize what is expected of them. The SIG can make known by its words and deeds that it supports politicians who are sympathetic to its cause. Then the policy-maker can appear to be taking actions to promote a constituent's interests while gratefully accepting the group's support' (Grossman and Helpman, 2001, p. 226). In our context, what lobbyists could offer is, perhaps, agreeable behaviour in other areas of telecommunication policy.

A 'subtle exchange' of the sort described in the previous paragraph is more likely to arise in long-term relations than in one-off interactions. Among the different lobbyists, the incumbent mobile telephone operators were clearly involved in a long-term relationship with the government agencies making the decisions. This was not so obvious for outsiders trying to enter the market. We have no direct evidence that incumbents may have benefited from this repeated relationship; the only information available is that about the ultimate outcomes of the process. This is displayed in Table 3 above. Both the countries with the largest number of licences, Germany and Austria, and the country with the smallest number of licences, Greece, did not use bureaucratic methods for making these choices (see Table 4 below). The countries that relied also for the assignment of licences to licence holders on bureaucratic methods, and which thus perhaps had the strongest lobby influence, all have the relatively low number of four licences. Table 3 does not provide evidence that would allow us to go beyond these cursory observations.

4. AUCTIONS WITH AN ENDOGENOUS NUMBER AND SIZE OF LICENCES

4.1. Overview

Two different approaches to designing an auction with an endogenous number and size of licences have been taken in Europe. The first approach is to conduct an auction in two stages: In the first stage, a larger number of small licences is offered. Some spectrum is withheld in the first stage. It is understood that not all licences

Table 4. Number and size of licences determined by auction

Method	Country	No. of incumbent 2G operators[a]	Number and size of licences[b]
Method III (Auction of licences of variable size)	Germany	4	6 licences; A: five licences with 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum each. B: one licence with 2 × 10 MHz paired spectrum.
	Austria	4	6 licences; A: two licences with 2 × 10 MHz paired spectrum plus 10 MHz unpaired spectrum. B: one licence with 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum. C: three licences with 2 × 10 MHz paired spectrum.
	Greece	3	3 licences; A: 2 × 20 MHz paired spectrum plus 5 MHz unpaired spectrum. B: 2 × 15 MHz paired spectrum plus 5 MHz unpaired spectrum. C: 2 × 10 MHz paired spectrum plus 5 MHz unpaired spectrum.

Notes:
[a] We indicate the number of network operators, not the number of service providers. The number of network operators seems more relevant because UMTS licences are licences to operate a network.
[b] Where heterogeneous licences were issued we label licences with capital letters so that we have a simple way of referring to these licences in Table 7.

Sources: As Table 2.

necessarily sell in the first stage. In the second stage, the spectrum that was withheld in the first stage, as well as all spectrum that was not bid for in the first stage, is sold. Only bidders who won a licence in the first stage can participate in the second stage. The second approach is to divide the spectrum into relatively small blocks, and to let bidders bid for a variable number of these blocks.

The first approach was chosen by Greece, the second by Germany and Austria. Interestingly, the German government initially planned to take the first rather than the second approach. The German government was later severely criticized for choosing the second approach. In a public consultation in October 1999 (Regulierungsbehörde für Telekommunikation und Post, 1999), the German government proposed to auction first in a simultaneous ascending auction five 2 × 10 MHz (paired) licences. Each bidder could acquire at most one licence. In a second stage the German government then planned to auction five 5 MHz (unpaired) spectrum blocks. All paired spectrum that was not sold in the first stage was also to be offered in the second stage, where it would be divided into blocks of 2 × 5 MHz (paired) spectrum. Only winners of the first stage were to be admitted to the second stage. Bidders were allowed to acquire an unlimited number of spectrum blocks in the second stage.

Following consultation with the industry, in February 2000 the German government opted instead for the second approach to auctions with variable number and size of licences (Regulierungsbehörde für Telekommunikation und Post, 2000a, b).

The government adopted a design that had been proposed by industry. The publicly indicated reasons for the government's change of mind were that it would not be right to limit the number of competitors in the UMTS market *ex ante*, that the government wanted to accommodate different bidders' business plans, and that the government was uncertain about spectrum requirements: 'The comments revealed radical differences between the estimated minimum amount of paired spectrum required for a licence, which ranged from 2×10 MHz to 2×20 MHz' (Regulierungsbehörde für Telekommunikation und Post, 2000a, p. 81).

Below, we shall first provide a review of the German and Austrian auctions. Then we shall briefly comment on the auction in Greece. In Table 4 we give an overview of the number and size of licences as determined by the auctions considered in this section.

4.2. Germany and Austria

Germany's and Austria's auction rules were very similar. In both countries, a two-stage auction took place. In the first stage, the items auctioned were 12 blocks of 2×5 MHz paired spectrum. A valid bid had to indicate either two or three of these blocks of spectrum, and it had to specify how much the bidder was bidding for each of these blocks. A valid bid had to exceed the previously leading bid by some minimum increment. The currently leading bidder for a block could not change to a different block. Once a bidder had reduced his demand to two blocks he could not switch back to three blocks. The first stage of the auction ended once there were no further valid bids.

In the second stage all blocks of 2×5 MHz of paired spectrum that had not been sold in the first stage, plus five blocks of 5 MHz of unpaired spectrum were sold. Only bidders who were successful in the first stage were allowed to participate. Bidders could bid for at most one block of paired spectrum. In Germany, bidders could bid for as many blocks of unpaired spectrum as they wanted, whereas in Austria they were allowed only to bid for up to two blocks of unpaired spectrum. Further bidding rules for the second stage were the same as for the first stage.

Another difference between the German and the Austrian auction was that in Germany, at the start of each round, each bidder was notified only of the currently highest bid and the identity of the highest bidder for each frequency. In Austria bidders were informed of all active bids and bidders. A consequence of this difference is, of course, that it is easier to study the Austrian than the German auction.

What does economic theory predict for the German and Austrian auctions? It seemed likely that insiders' valuations were larger than outsiders'.[13] The German and Austrian markets had each four insiders, and it thus seemed likely that each of these

[13] One reason is that second generation incumbents will most likely find it cheaper to build the physical infrastructure than new entrants, as they can re-use existing sites. Another reason might be that 2G incumbents can rely on an existing customer base whereas new entrants can't. Finally, 2G incumbents might be able to sell roaming rights to 3G entrants at a profitable price.

insiders would win at least a two block licence. Would they be satisfied with this? Their intrinsic valuation of a third block might be too low to overbid an outsider, but an additional effect was expected to tip the balance in favour of insiders: by overbidding outsiders on just one block of spectrum (assuming that outsiders would at most acquire two block licences), an insider could reduce the number of competitors in the market, and thus expect larger monopoly profits. The most plausible economic prediction was therefore that the four incumbents would each acquire a three block licence, leaving outsiders unable to compete. The pursuit of market power was thus expected to distort the auction outcome.[14]

The predictions were falsified. Considering Germany first, where seven bidders entered the auction, we note that six firms gained licences, including two outsiders. In the first stage, six of them acquired two blocks of 2×5 MHz paired spectrum. Because all paired spectrum was sold in the first stage, in the second stage only unpaired spectrum was available. Five of the six winners of the first stage acquired one block of 5 MHz unpaired spectrum each. Thus, Germany, together with Austria (see below), obtained in contrast to the predictions the most fragmented UMTS market.[15]

What had happened? The incumbents' willingness to pay for 2×5 MHz additional paired spectrum, which reflects the intrinsic value of this spectrum plus the value of a reduction in the number of competitors from six to five, was not as large as one might have thought.[16] In the light of the discussion of the previous section it is, indeed, not surprising that companies had a low assessment of the intrinsic added value of a 2×15 MHz licence in comparison to a 2×10 MHz licence. However, why did bidders not value the extra market power which they would have obtained by acquiring another spectrum block? One hypothesis starts by observing that the German 2G mobile telephone market is very asymmetric. Two large incumbents, Mannesmann (at the time of the German auction recently taken over by Vodafone) and T-Mobil (owned by Deutsche Telekom), had each about 40% subscriber shares. Two other incumbents, E-Plus and Viag, had much smaller subscriber shares (14% and 6% respectively). For the large incumbents it might not have mattered exactly how many further smaller competitors were added.

At this stage of our discussion, the natural conclusion seems to be that the outcome of the German auction was much less distorted by monopoly power than economists had predicted, and that instead the government learned what it wanted to learn: the

[14] The argument is due to Jehiel and Moldovanu (2000). They developed a formal model, and found multiple equilibria, but argued that 'equilibria where the set of licensed firms coincide with the set of 4 incumbents are very likely, while other equilibria (including those with 5 or 6 licensed firms) are not likely (or impossible). Klemperer (2000a) wrote 'Some features of the auction mitigate the bias [towards too few winners]. But the German auction risks gaining an overly concentrated market in which consumers pay more for services.'

[15] Recent developments in 2002 have indicated that Germany might still end up with a lower number of 3G operators. Among the two outsiders that won German licences, Group 3G, backed by Telefonica and Sonera, has decided not to build a network in Germany. What happens with its licence is unresolved at the time of writing. France Telecom has withdrawn its support for the second outsider, Mobilcom, and at the time of writing it is unclear whether Mobilcom will pursue its UMTS plans.

[16] See Jehiel and Moldovanu (2001).

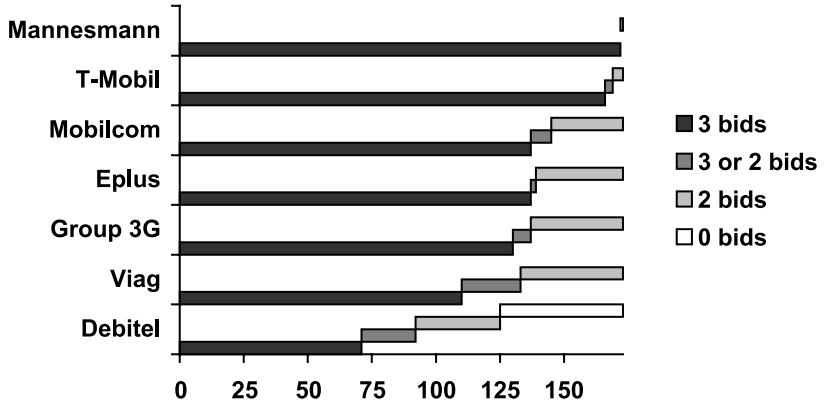

Figure 6. Bidding in the German auction

Source: Allan (2001).

intrinsic value of additional paired spectrum was low, and therefore it was feasible to offer six UMTS licences for the German market. Unfortunately, however, if one examines bidding in the German auction in more detail, one finds phenomena which are difficult to explain, and which suggest that perhaps we do not understand at all what really happened in the German auction. To explain the issue we focus on the bidders' decision to bid for three blocks, two blocks, or to withdraw. Because only limited information was disclosed, we cannot determine with certainty when a company decided to withdraw. Figure 6 shows what can be deduced from the publicly available data. From round 146 onwards only two bidders, the two larger incumbents, were bidding for licences consisting of three blocks of paired spectrum. The auction continued for 27 more rounds and closed when first, between rounds 167 and 169, T-Mobil, and then, in round 172, Mannesmann, reduced their demand to two blocks of spectrum.

The question that has been asked is 'Why did T-Mobil and Mannesmann not reduce their spectrum demands in round 147, but did reduce it at the end of the auction?' Jehiel and Moldovanu (2001, p. 16) call this behaviour 'bizarre'. This issue is of potential importance for the interpretation of the German auction because it might lead one to question whether bidding in the German auction actually revealed any valuations, or whether it was irrational.

The reason why T-Mobil and Mannesmann's behaviour is surprising is as follows: From round 147 onwards, Mannesmann and T-Mobil had two potential reasons for continuing to bid. One was that they might attach intrinsic value to extra spectrum. The other one was that by winning one more block of spectrum they could push one of the smaller competitors out of the market. However, there was a free-riding problem: each might have an interest in leaving it to the other to push the smaller competitor out of the market, preferring to acquire additional paired spectrum instead at potentially lower prices in the second stage auction. Now, if bidders' incentives to continue

bidding were sufficiently large to overcome the free-rider problem in rounds 147–172, then why were they no longer sufficiently large after that? In particular, the longer the auction lasted, the more likely it must have appeared that one of the smaller bidders would give up.

Different explanations of T-Mobil's and Mannesmann's behaviour have been suggested by Grimm *et al.* (2002), and by Ewerhart and Moldovanu (2001). These models capture only some aspects of the German auction, and as Klemperer (2002c)[17] has argued, it is not clear that what is left out is not important. Overall, it appears that a satisfactory explanation of bidding in the German auction is missing. It remains, however, that Mannesman's final decision to reduce demand to two blocks indicates that at prices which outsiders were willing to pay to acquire a small German licence, it was not worthwhile for Mannesmann to acquire more spectrum, and to push an outsider from the market.

The Austrian auction was much shorter than the German auction. In Austria only six bidders participated. By round 3 all bidders had reduced their demand to only two blocks of 2×5 MHz paired spectrum except for one of the two large incumbents in the Austrian market, Mobilcom. The auction continued for 11 more rounds. Then also Mobilcom dropped their demand to two blocks. Thus, Mobilcom appears to have indicated that its value of additional spectrum was not sufficient to continue bidding above the values which outsiders were willing to pay. However, it has been suggested by Klemperer (2002a) that the outcome of the Austrian auction reflected some form of implicit collusion where bidders feared that continued bidding would lead to prices as high as in the German auction. If this fear played a role, then not much about the value of additional spectrum can be concluded from the Austrian auction.

In principle, Mobilcom's behaviour in the Austrian auction raises a similar question to that about the behaviour of T-Mobil and Mannesmann in the German auction. However, because the Austrian auction was so short, the problem is quantitatively less important.

4.3. Greece

The Greek government chose a two-stage auction. In the first stage four licences each with 2×10 MHz paired spectrum and 5 MHz unpaired spectrum were offered in a pay-your-bid, sealed bid auction (Hellenic Republic National Telecommunications and Post Commission, 2001). If it turned out that there were less than four valid bids in the first stage, then a new auction was conducted in which it was now known that the number of licences for sale was only three. If that auction didn't attract enough bidders, then an auction with only two licences was conducted. In the second

[17] See also Klemperer (2002e).

stage, additional blocks of 2 × 5 MHz paired spectrum were sold in a multi-unit, pay-your-bid auction.[18] The number of these blocks equalled the number of first stage winners. In the second stage each bidder could bid for at most two blocks of spectrum. The rules also contained various further provisions aimed at creating privileged conditions for new entrants.

How bidders should bid in the first stage of the Greek auction is a complicated strategic problem, and depends on their beliefs about other bidders' characteristics as well as their anticipation of how first stage outcomes will influence second stage events. In the event, only the three second-generation mobile telephone incumbents submitted bids in the first stage, and their bids were only minimally above the reserve price. Another bidder had pre-qualified for the auction, but apparently it was clear to all bidders that this fourth bidder was only interested in a subsequent auction of second generation spectrum.

In the second stage three blocks of 2 × 5 MHz paired spectrum were available. As in the German and Austrian auctions economic theory would suggest that bidders bid for additional spectrum not only because it allows them to offer better services, but also because by buying spectrum others are prevented from buying it, and thus monopoly power, for example in the market for high rate data transmission, is created. In practice, however, all bids in Stage 2 were at most marginally above the reserve price. One of the incumbents won two further blocks of 2 × 10 MHz paired spectrum, another incumbent obtained one such block, and another incumbent won no such block. From the published information we cannot say whether the latter two incumbents placed some losing bids. The size of the winning bids suggests, however, that the value of extra spectrum, either to offer better services, or to push competitors out of the high-end market, was low.

5. CHOOSING LICENCE HOLDERS THROUGH A BEAUTY CONTEST

5.1. Overview

In this section we consider the experience of countries that have conducted beauty contests to assign licences to companies. In Table 5 we show the outcomes that obtained in these countries. Interesting features of Table 5 include:

- The payments per head of the population for which governments asked varied widely across Europe.
- Typically, all second-generation incumbents won a licence. The exceptions are Sweden, where two incumbents didn't win a licence, and Portugal, where one incumbent didn't win a licence.

[18] If four licences were awarded in the first stage, then the size of some of the additional spectrum blocks sold in Stage 2 was only 2 × 4.8 MHz.

Table 5. Licences awarded by beauty contests

Method	Country	Number of participants[a]	Licence winners[b]	Price (in € per head of the population)[c]
Method I (beauty contest)	Finland[d]	7[e] (*4*)	– Oy Radiolinja Ab – Sonera Oy – Telia Mobile Ab – *Suomen Kolmegee Oy*	0
	Spain	6 (*3*)	– Telefónica – Airtel – Amena – *Xfera*	15
	Sweden	10 (*6*)	– Europolitan – Tele2 – *HI3G* (*Hutchison*) – *Orange* (*France Telecom*)	0
	Portugal	7 (*3*)	– Telecel – TMN – OPTIMUS – *Oniway*	40
	France[f]	2	– France Telecom – SFR	168
	Ireland	3 (*1*) (for A) 2 (*0*) (for B)[g]	– *Hutchison Whampoa* (A) – O2 Communications (B) – Vodafone (B)	7 (A) 20 (B)
	Luxembourg	3 (*1*)	– Tango (Tele2) – EPT – *Orange (France Telecom)*	2

Notes:
[a] The number of outsiders among the participants is indicated in brackets.
[b] Outsiders are indicated in italics.
[c] The amount indicated is the total asked for, from all licence holders together. Fees were sometimes revised later, or additional taxes were levied (see our discussion in Section 5.4), and therefore what we are indicating doesn't necessarily represent actual payment.
[d] In Finland, companies could apply for nationwide or regional licences. All four licences awarded were nationwide. An additional fifth licence was awarded to Ålands Mobiltelefon AB. It covers the region of the island group Åland.
[e] We only count applications for nationwide licences.
[f] France has renewed its offer of 3G licences at a lower price, and on 27 September 2002 a third licence was awarded to Bouygues Telecom which is an incumbent in the French second generation market.
[g] The licence labels A and B were introduced in Table 3. The two companies which submitted a bid for a B licence also bid for licence A. In our table, they are counted among the three bidders for the A licence.

Sources: As Table 2.

Economists have emphasized a number of potential disadvantages of beauty contests. Economists have no well-developed theory of beauty contests, but their critique of this method contains implicit predictions about bidders' and governments' behaviour in beauty contests. Below, we try to make these predictions explicit, and we compare them to the evidence.

Before we proceed with the analysis, we briefly deal with one issue which is more important in the auction context, but which might be of interest for beauty contests,

too: participation. The third column of Table 5 shows the number of participants for each beauty contest. European countries have been concerned about participation rates in their UMTS licensing process. The reason is, presumably, that efficiency is more likely if participation rates are high because the larger the subset of participating potential UMTS network operators is, the larger is also the likelihood that this set will contain the best operators from the underlying total population.[19] One possible advantage of beauty contests is that many will participate because fees are typically, though not always, low. Participation in beauty contests has indeed in general been high. The only two exceptions from this rule are France and Ireland. The Irish beauty contest was one of the last UMTS licensing procedures in Europe, and thus the low participation rate in Ireland most likely reflects the general change in beliefs about the telecommunications industry which took place in the relevant years. The French beauty contest was much earlier. France's very high proposed fee of €168 per head of the population is likely to have caused the low participation there.

5.2. Favouritism

A first reason why beauty contests are often criticized by economists is that they are in danger of becoming corrupted. When comparing beauty contests and auctions, John McMillan, for example, cites the example of a Canadian beauty contest to argue: 'Not only are some of the criteria vague, but the weights assigned to the different criteria are unstated. . . . It is hard for applicants to determine the basis for the government's decision. The winner, it often seems, is the firm that has hired the most efficient lobbyists. The government does not explain to losing applicants why they did not receive licences. The lack of transparency can be self-defeating.' (McMillan, 1995).[20] Although McMillan refers here to a specific beauty contest it is clear from the context that he means this as a general prediction about beauty contests. Along similar lines, Klemperer has argued: 'Allocation by bureaucrats leads to the perception – if not the reality – of favoritism and corruption. In fact, some governments have probably chosen beauty contests precisely because they create conditions for favoring "national champions" over foreign competitors. This is unlikely to benefit consumers or taxpayers' (Klemperer, 2000b). Note that Klemperer points out the obvious reason why favouritism is a concern: favouritism reduces the probability that the best bidders obtain licences.

We will not observe favoritism directly. But we can look for indirect signs of favouritism that were listed in the quotations above: (1) lack of transparency of the selection criteria; (2) lack of transparency of the reasons for the decisions made; (3) bias towards incumbents. To investigate whether these signs of favouritism are present, we

[19] In auctions, in addition, governments might have expected higher revenues if there were more participants.

[20] Although McMillan refers here to a specific beauty contest, it is clear from the context that the purpose is to construct a *general* argument against beauty contests as allocation mechanisms.

shall first present two case studies, Finland and Sweden, and then discuss the experience of other countries.[21]

5.2.1. Finland. The Finish government used criteria such as: Does the applicant meet 'the users' reasonable needs for telecommunications'? Will the companies offer a 'high quality service'? (Finish Ministry of Transport and Communications, 1999, p. 22). It seems that these criteria do indeed lack transparency. As regards the transparency of the actual licensing decisions, the reasons for the licensing decision have been stated in public (Finish Ministry of Transport and Communications, 1999), but the applicants' financial statements, as well as their plans for networking, investment and financing have been kept confidential, although they constituted important input into the licensing decision. As a result, it is difficult to verify the reasons for the decisions made. According to the official government statement the four companies that were awarded licences were best according to each of the six choice criteria used. This implies that the government explanation has the appearance of an *ex post* justification rather than a complete explanation of the decision making. Finally, it is noteworthy that incumbent operations are often cited as proof that a criterion is satisfied: An example is the way in which 'high quality' has been judged: 'As far as the applicants are concerned, the telecommunications network companies have with their previous operations shown that they are capable of offering a high quality service' (Finish Ministry of Transport and Communications, 1999, p. 13). All three incumbents who applied for nationwide licences obtained such licences.

5.2.2. Sweden. The Swedish beauty contest differs in significant ways from the beauty contest in Finland. As regards the transparency of the decision criteria, the government announced that after an initial 'feasibility' test, selection would be based on commitments regarding coverage and development rate of the proposed network. It was described in detail how applicants' scores would be calculated (Swedish National Post and Telecom Agency, 2000a, p. 10). The 'feasibility' test that formed the first stage of the evaluation of applicants was less transparent. Applicants had to demonstrate financial capacity, technical feasibility, commercial feasibility of their bids, and they had to demonstrate that they had appropriate expertise and experience.

In the event, it turned out that among the ten applicants, five were ruled out because they didn't pass the 'feasibility' test. Only one was then ruled out on the grounds that it obtained the lowest score in stage 2. The Swedish government has published detailed reasons for its decision (Swedish National Post and Telecom Agency, 2000b). Rejection reasons in stage 1 are in some cases of a technical nature, in other cases of a financial nature. Among the applicants rejected in the first stage was Telia, the leading incumbent operator in the Swedish market. The rejection

[21] We selected Finland and Sweden for our case study because the beauty contests in both countries are well documented, but are very different from each other.

reason provided was that the plans which Telia submitted for fulfilling its coverage promises were technically inconsistent. For the five applicants that remained after stage 1, the detailed scores for each applicant have been published. In this second stage, another of the incumbent operators, Telenordia, was rejected. Overall there does not seem evidence of favouritism in the Swedish beauty contest, and the beauty contest does not seem to have suffered from the problems described in the citations at the beginning of this section.

5.2.3. Other countries. Among the other beauty contests the one in Spain has been widely regarded as particularly opaque. However, the Spanish government did publish a comparatively detailed statement of the criteria which it would use to evaluate submissions and of how submissions would be scored (Ministerio de Fomento, 1999). The Spanish government used more criteria, and more qualitative criteria, than Sweden, and therefore its explanation of how submissions would be scored is less precise than the Swedish statement. The Spanish government issued only a terse description of the outcome of the beauty contest without detailed justification (Ministerio de Fomento, 2000). All three incumbents obtained licences.[22] The case of Portugal is similar to that of Spain, except that the criteria by which applications were judged were stated in more detail than in Spain. Portugal rejected an incumbent.

Ireland has been somewhat less clear than Spain regarding criteria (Irish Office of the Director of Telecommunications Regulation, 2001). Like in Spain, no detailed explanation of the ultimate decisions was provided. However, the Irish government used independent consultants to evaluate submissions. The largest licence in Ireland was awarded to an outsider, Hutchison Whampoa.

The French government, like the Swedish government, published in advance of the licensing process the criteria by which it selected applicants. Like in Sweden, this was a scoring rule, but the number of criteria was much larger than in Sweden (Autorité de Régulation des Télécommunications, 2000, p. 24). Moreover, unlike in Sweden, many criteria were relatively vague. For example, the government indicated that one criterion would be 'the contribution which the project makes to the multimedia mobile telephony market and, more generally, to the development of the information society in France' (Autorité de Régulation des Télécommunications, 2000, p. 25). The French government received only two applications for four licences in its beauty contest, and these applications came from incumbents. It did publish nonetheless the reasons for accepting these applications.

We conclude that a general statement that all beauty contests suffer from favouritism and corruption would be too blunt. Some countries have succeeded in implementing relatively transparent procedures, and incumbents have not always been

[22] Xfera, the outsider which owns the fourth licence in Spain, and which is partly owned by the Spanish construction company ACS, is widely rumoured to be well connected to the Spanish government, and ACS is supposed to have received favourable treatment in other contexts. We have no evidence, though, that we could offer to confirm these rumours.

successful in beauty contests. However, in other countries beauty contests have clearly been problematic. Finally, we note that there could be a selection bias in our observations. It might be that only countries which control their bureaucracies well, and suffer from little corruption, have opted for beauty contests. Alternatively, it might also be that only countries where regulators and industry are particularly close have chosen beauty contests. If the former hypothesis were true, our conclusions in this section would be overly optimistic.

5.3. Lack of credibility

Another argument with which beauty contests are often criticized is that the commitments in beauty contests are not enforceable: 'How could government monitor and enforce any commitments made by those companies?' (Klemperer, 2000b). Lack of commitment endangers efficiency because, if commitments are not enforced, promises are not informative, and therefore a beauty contest does not generate the information needed to allocate licences efficiently.

It is too early to investigate in detail whether the commitments made in the European beauty contests were indeed kept. We have, however, one piece of direct relevant evidence (from Sweden) which we shall discuss later. First, we shall organize our discussion around a more indirect approach. If bidders' commitments are not credible, but if governments follow well-defined criteria in bidder selection, then nothing stops bidders from claiming that they will satisfy all government selection criteria perfectly. Thus, if a scoring rule is used, all bidders should bid the maximum amount according to this scoring rule. We now ask whether this has indeed been the case in the countries listed in Table 5.

The most detailed observations of the beauty contest selection process are available for Sweden and France. In Sweden, we do indeed find that the five bidders who survived the first stage of the Swedish selection process obtained almost perfect scores in the second stage. The Swedish government awarded the maximum number of points to all applicants except Telenordia. Telenordia received a lower score because it promised somewhat less coverage than the other companies. As a consequence, Telenordia was not awarded a licence. A somewhat similar case is Finland, where government documents indicate that the four companies that were awarded licences were best according to all criteria used by the government. The two applicants in the French beauty contest did not achieve perfect scores. Out of a total possible score of 500 points, France Telecom was awarded 379 points, and SFR was awarded 410 points. However, one reason for this may be that the criteria which entered the French scoring rule were more vague and subjective than the entirely quantitative coverage criteria that were used in Sweden. Spain is similar, as newspaper reports indicate that the winning companies' scores were asymmetric, but the criteria used were often qualitative. For Portugal we don't have enough information to investigate the question.

Overall, the evidence therefore does not really allow us to conclude that promises in beauty contests are never serious. When interpreting the evidence, it should be borne in mind that the potential selection biases which we pointed out in Section 5.2 apply here as well. Finally, as direct evidence that beauty contest promises may be binding, we offer the fact that both Orange and Vodafone (Europolitan) have recently applied to the Swedish National Post and Telecom Agency to have their roll-out commitments reduced. Both applications were rejected.

5.4. Revenue

Finally, it has been predicted that beauty contests lead to lower government revenues than auctions: 'A beauty contest, by contrast [to auctions], can give away valuable assets at a fraction of what they are worth' (Klemperer, 2000b). One reason might be that in beauty contests the prices charged for licences are the result of lobbying activities, and, like in Section 3.4, one might observe decisions biased in favour of the lobbyists, which in this case would mean low prices. If one abstracts from lobbying, then a government that awards licences in a beauty contest for a fixed fee acts like a seller who fixes a price instead of conducting an auction. As a consequence, bidders' willingness to pay is easily over- or underestimated. In the former case the object is not sold at all. In the latter case it is sold at a price that is lower than its true market value. Both cases are at the taxpayer's expense.

To evaluate this claim we can compare Table 5 to Tables 6 and 7 in which we display the revenue per head of the population in countries that conducted auctions. It is evident that revenues were typically much lower in beauty contests than in auctions. This might be taken as evidence that the fees were the result of effective lobbying. Exceptions from low fees were Portugal and France. Whereas Portugal awarded all licences offered, France set its initial fee too high. Only two applications for four licences were received. France thus illustrates the risk that a price fixer overestimates buyers' willingness to pay. France later revised its fees downwards. A country that illustrates particularly starkly the risk of setting a price too low is Spain. Spain later tried to recoup value through a special annual tax on UMTS licence holders.[23]

6. CHOOSING LICENCE HOLDERS THROUGH AUCTIONS

6.1. Overview

We now turn to a discussion of the experience of the countries that used auctions to allocate licences to firms. In Tables 6 and 7 we show the outcomes that obtained in these countries. Interesting features of Tables 6 and 7 include:

[23] The potential selection biases listed in Section 5.2 might affect our observations in this section as well.

Table 6. Licences awarded in auctions with pre-determined licence size

Method	Country	Participants[a]	Licence winners[b,c]	Price paid[d] (in € per head of the population)
Method II (Auction of licences of government-determined size)	United Kingdom	13 (*9*)	– *TIW* (A) – Vodafone (B) – BT3G (BT) (C) – One2One (D) – Orange (E)	642
	Netherlands	6 (*1*)	– Libertel (A) – KPN (B) – Dutchtone (France Telecom) (C) – Telfort (BT) (D) – 3G Blue (Deutsche Telekom) (E)	173
	Italy	6 (*2*)	– *Andala* (*Hutchison and Tiscali*) (A) – *IPSE 2000* (*Telefonica and Sonera)* (B) – Omnitel (Vodafone) (C) – Wind (Enel and France Telecom) (D) – Telecom Italia Mobile (E)	213
	Belgium	3 (*0*)	– Belgacom Mobile – KPN Mobile 3G – Mobistar	44
	Denmark	5 (*1*)	– TDC – Telia – Orange – *Hi3G Denmark* (*Hutchison)*	96

Notes:
[a] The number of outsiders among the participants is indicated in brackets.
[b] Outsiders are indicated in italics.
[c] Symbols in brackets refer to the labeling of licences provided in Table 3.
[d] The amount indicated is the total spend by all licence holders together.

Sources: As Table 2.

- The payments per head of the population varied widely across Europe.
- Later auctions raised significantly less revenue than earlier auctions. Two exceptions from this trend were the auctions in Germany and Denmark.
- Typically, all second-generation incumbents won a licence. The exceptions are Italy and Denmark, where in each case one incumbent did not win a licence.

We shall organize our discussion of the auctions in Tables 6 and 7 in three steps. First, we shall consider which features of auctions led to a high number of participants. Secondly, we shall consider whether bidding strategies in intermediate rounds of the auctions were as predicted by theory, and, if there were deviations, how these deviations might be explained. Finally, we shall consider the auction revenues, and how they can be explained. We shall focus in this section mostly on those auctions

Table 7. Licences awarded in auctions with endogenous licence size

Method	Country	Participants[a]	Licence winners[b,c]	Price paid[d] (in € per head of the population)
Method III (Auction of licences of variable size)	Germany	7 (*3*)	– Mannesmann (Vodafone) (A) – E-Plus 3G (KPN, Hutchison) (A) – T-Mobile (A) – Viag (02) (B) – *Group 3G (Telefonica, Sonera)* (A) – *MobilCom (France Telecom)* (A)	619
	Austria	6 (*2*)	– Max.Mobil (T-Mobile) (A) – Mobilkom (A) – Connect (TDC, Telenor, Viag, Orange) (C) – Tele.ring (Vodafone) (C) – *3G Mobile (Telefonica)* (C) – *Hutchison 3G* (B)	103
	Greece	3 (*0*)	– Panafon (A) – Cosmote (B) – Stet Hellas (C)	46

Notes:
[a] The number of outsiders among the participants is indicated in brackets.
[b] Outsiders are indicated in italics.
[c] Symbols in brackets refer to the labeling of licences provided in Table 4.
[d] The amount indicated is the total spend by all licence holders together.

Sources: As Table 2.

in which the number and size of licences was exogenously fixed. Auctions with endogenous number and size of licences were already discussed in Section 4.

6.2. Participation

We discussed in the previous section why efficiency considerations imply that wide participation in the licensing process is desirable. To encourage participation in auctions, European governments had two instruments available.

- The basic structure of the auction.
- Offering special treatment of outsiders in the auction.

As regards the basic structure of the auction, Klemperer (2002a) has argued that a first prize sealed-bid design, or at least a design involving a first price sealed-bid element, would encourage entry. Klemperer's main reason for advocating first-price sealed bid auctions is that 'the outcome is much less certain than in an ascending auction' (Klemperer, 2002a, p. 179). In an ascending auction the outcome is 'certain' because bidders who have higher values will always win, at least if values are private. By contrast, for given number of bidders, if bidders are asymmetric, first price sealed-bid auctions may lead to an *ex post* inefficient outcome because stronger bidders may

shade their bids in equilibrium more than weak bidders (Maskin and Riley, 2000). A bidder who is known to have a lower value therefore has a stronger incentive to enter a first price sealed-bid auction than an ascending auction. In our context it seems plausible that firms that do not operate a second-generation network in a country will have lower valuations of licences than firms that already operate such a network. Thus, Klemperer's view suggests that a first price sealed-bid auction will attract more outsiders.

To what extent does the experience of the European auctions confirm the prediction? Only one country adopted a straightforward first price sealed-bid format: Denmark.[24] Greece adopted a multi-round system, as indicated in Table 2, where each stage had the form of a first price sealed-bid auction. The Danish auction was conducted at a time at which the general 'market mood' regarding the telecom sector, as expressed for example in share prices, was very negative. The Danish auction did indeed attract one new entrant. The Greek auction a little earlier did not attract any new entrants.

We now turn to the second instrument for encouraging participation – an asymmetric design that offers special favours for outsiders. Three countries used this policy instrument: Italy, Greece and the UK. Italy reserved two blocks of 2×5 MHz paired spectrum for outsiders. If more than two outsiders participated in the Italian auction, then these two blocks were to be auctioned among the outsiders in a second stage of the Italian auction. Otherwise, the outsiders would be awarded these blocks automatically. In the event, only two outsiders participated, and therefore there was no second stage auction.

A different approach to favouring outsiders was implemented by the Greek government where outsiders enjoyed a privileged status in the auction. For example, if there were not enough bids in the first round to allocate all four licences, then the number of licences was reduced, and a new auction began, but only insider bidders had to bid again. Outside bidders won a licence at the price bid in the first round. A similar rule applied to the second round of the Greek auction. As only incumbents participated in the Greek auction, there is no evidence that this design improved outsiders' willingness to participate.

The most interesting case is that of the UK. The UK government set aside the largest UK licence, consisting of 2×15 MHz paired spectrum + 5 MHz unpaired spectrum, and only new entrants were allowed to bid for this licence. The idea was that there would be less competition for this licence. Therefore, most likely, it would be sold at a lower price than other licences. If entry is costly, a lower expected price makes entry more attractive. The expectation of the British government came true. The price of the licence set aside for a new entrant was 26% lower than the price of the next largest licence, which was a 2×15 MHz paired spectrum licence without any unpaired spectrum. Moreover, bidders seem to have anticipated this correctly.

[24] More precisely, as Denmark sold four licences, the design was a uniform price auction where the uniform price was the fourth highest bid.

Thirteen bidders, among them nine outsiders, participated in the UK auction. This is more than in any other auction.[25]

A closer inspection of events in the UK auction suggests, however, a slightly more cautious evaluation of the UK experience, owing to the following three points. First, it was hard to write 'tight' rules defining the concept of an 'outsider'. Secondly, rules that favour one particular group of bidders create incentives for bidders to artificially become a member of the favoured group. Thirdly, rules which favour one particular group of bidders create an incentive for members of that group to act as arbitrageurs – to bid in the auction in their own name, and to sell licences later to bidders which do not belong to the favoured group. We illustrate these three points in turn.

As regards the definition of outsiders, the UK's auction rules nominated explicitly the four operators of second-generation networks in the UK as incumbents. However, there is an additional second-generation service provider: Virgin Mobile. This is a joint venture of the Virgin Group and Deutsche Telekom. The Virgin Group was allowed to be part of an outsider consortium. Thus, the outsider status was defined according to ownership of a network rather than access to an existing customer base. This seems somewhat arbitrary.

Turning to the second point, we note that Hutchison Whampoa, which ultimately acquired the licence that was reserved for outsiders in the UK, created and initially solely owned the company Orange in the UK. Orange was one of the four second-generation incumbents in the UK. However, in 1999, Hutchison sold its stake in Orange to Mannesmann. According to company information, Hutchison sold its *entire* stake in Orange in November of 1999.[26] The UK government's information memorandum regarding the auction, in which it was indicated that outsiders would receive preferred treatment, was released on 1 November 1999 (Rothschild, 1999). The auction rules had been discussed in detail with the industry even before that date. Hutchison's decision to sell its stake in Orange may thus have been a strategic move. It might have decided to become an outsider because of the advantages that this would offer.

However, it appears that Hutchison Whampoa did not dispose of its stake in Orange fast enough. According to comments by the then chief executive of the UK Radiocommunications Agency, David Hendon, Hutchison would not have been allowed to bid directly in the auction as an outsider, because at the time of the pre-qualification procedure it had not yet sold a sufficiently large proportion of its share in Orange. Therefore, it would not have been regarded as an independent bidder.[27]

Hutchison Whampoa seems to have been aware that it was not allowed to bid. Indeed, it did not participate in the auction. The winner of the licence that was

[25] Another factor that may have contributed to the large participation in the UK auction was that it was the first 3G spectrum auction in Europe. Bidders may have seen the UK auction as an opportunity to begin the acquisition of a Europe wide network of 3G licences.

[26] Source: http://www.hutchison-whampoa.com.

[27] Note that Hendon's view contradicts the information provided by Hutchison Whampoa cited in the previous paragraph.

reserved for outsiders was a Canadian telecom company called TIW. However, shortly after the auction TIW sold the subsidiary that owned the licence to Hutchison Whampoa. This appears to have been a transaction that was arranged in advance of the auction. Indeed, confidential documents, available to the authors, indicate that Hutchison Whampoa had already circulated to investors their evaluations of the 3G-business case in the UK before the auction.

If our interpretation of events is correct, then TIW acted as an arbitrageur for Hutchison. It was suited to that role because it was evidently not an incumbent in the UK market. It bought an outsider licence, but with the intention of selling it to Hutchison. It seems hard to protect asymmetric rules against this type of arbitrage. This is the third lesson about favouring outsiders that emerges from the UK experience.

6.3. Bidding strategies

In this section we focus on those auctions that used a simultaneous, ascending bid format with an exogenous number and size of licences. The reason is that no empirical analysis of a one-shot, sealed-bid auction (Denmark) is possible, and that the key features of the bidding strategies in the European auctions with endogenous number and size of licences have already been considered in Section 4.

In a simultaneous ascending auction several licences are offered at the same time. Bidding proceeds in rounds. In each round, each bidder who is not currently the leading bidder for one of the licences, must pick one licence and place a bid for that licence by overbidding the currently leading bidder by some minimum increment. Leading bidders are committed to their bids until they are overbid. A bidder who is not currently leading bidder, and who does not want to overbid the leading bidder for any licence, must exit the auction. The auction ends once all bidders except the leading bidders have quit.[28]

We begin by considering the theory of bidding in such auctions. The most prominent theory is that of straightforward bidding. We have already explained this theory in Section 3.3. Its essence is that bidders bid myopically for that licence which currently offers the largest surplus, that is, difference between value and minimum admissible bid. Straightforward bidding implies efficient outcomes if licences are substitutes (Milgrom, 2000). This result is one of the major reasons for using simultaneous ascending auctions to sell licences. In the result 'efficiency' is taken to mean that the sum of bidders' valuations of licences is maximized.

We have already mentioned that some bidders' behaviour in the auctions in the UK and the Netherlands was well explained by straightforward bidding. Others deviated quite strongly from straightforward bidding. Deviations can take a number of forms. We focus here on three deviations. The first is that bidders can seek to

[28] Most European auctions have offered bidders a limited number of 'waivers', that is, rounds in which they could remain inactive.

collude. The second is that bidders can try to push up other bidders' prices with the goal of weakening competitors' financial position. The third is that bidders can threaten each other.

All three strategies are easier to pursue in open ascending auctions than in sealed bid auctions. Moreover, all three strategies potentially endanger the efficiency of the auction. That collusion can threaten efficiency is obvious. Bids that are placed to raise the price which other bidders have to pay endanger efficiency because in the absence of complete information about other bidders' willingness to pay, such bids are in danger of winning by mistake. Finally, threats might deter bidders from strategies which reveal their true valuation, and might endanger efficiency in this way.

Each of the three possible strategies described above has been allegedly observed in the European auctions. We begin with collusion. Collusion in open, ascending-bid auctions can be self-enforcing, or it can be enforced by side-payments among bidders. Self-enforcing collusion typically relies on bidders placing low bids initially, and then bidding aggressively if some bidder deviates from the original plan. Such a strategy makes it profitable for all to stick to the initial low bids. We are not aware of any sign of self-enforcing collusion in the European spectrum auctions. Collusion can, however, also be enforced by side-payments. It has been alleged that collusion of this second type affected the Italian auction. In Italy five identical licences were for sale. Six bidders participated, but in round 10 one of these, BLU, withdrew. The auction then closed, and the five remaining bidders were awarded one licence each. BLU was a consortium in which Autostrade had a share of 32% and British Telecom had a share of 20%. Some reports have attributed BLU's withdrawal to disagreements among the shareholders of BLU. But immediately after the auction there were also allegations of collusion between BLU and other bidders. Because BLU did not derive any obvious benefit from the withdrawal, collusion would have been in its interest only if it had extracted a side-payment from one of the other bidders.

A peculiarity of the Italian auction design created a second incentive to collude. As mentioned in Section 2, the Italian government had reserved the right to reduce the number of licences for sale if fewer serious bidders participated than there were licences. By participating in the auction, BLU thus ensured that the number of licences was not reduced. The other bidders might have recognized BLU's contribution through this manoeuvre.

We now turn to the second form of strategic, not-straightforward bidding in ascending auctions, namely bidding to raise other bidders' prices. There are two alleged incidents of this in the European auctions, in the UK auction and in the Dutch auction. We begin with the UK auction, where it has been alleged that the 3G bidder owned by British Telecom, BT3G, bid in order to raise the price to be paid by its main rival in the UK mobile telephone market, Vodafone. Such a strategy became possible in the UK auction because throughout the UK auction Vodafone only bid for one licence, namely the single large licence (2×15 MHz of paired spectrum) for which incumbents were allowed to bid. Whenever any competitor

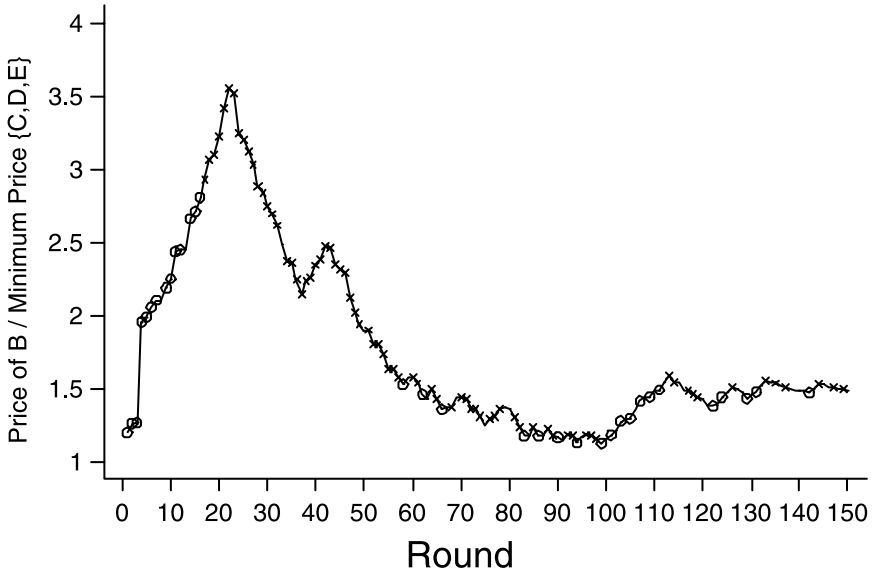

Figure 7. BT3G's bids in the UK auction (the 'ratio rule')

Notes: Bids for the large licence B are marked with a circle (○) and bids for the small licences C, D and E are marked with a cross (×).

Source: Börgers and Dustmann (2002a).

overbid Vodafone, Vodafone returned immediately with a higher bid for the licence. Once it became plausible that Vodafone was pursuing this strategy, it became possible for its competitors to push up its prices. The main piece of evidence that shows that BT3G might indeed have pursued this strategy is displayed in Figure 7.

Figure 7 shows on the horizontal axis the 150 rounds of the UK auction. On the vertical axis we display the ratio of the price of the only 2×15 MHz licence in the UK for which incumbents were allowed to bid (licence B) and the lowest of the prices of the three 2×10 MHz licences. We mark in the graph with a circle the occasions when BT3G bid for licence B, and with a cross the occasions when BT3G bid for a small licence. We see in Figure 7 that approximately from round 100 onwards BT3G bid for licence B if and only if the price of licence B was not more than 50% larger than the price of licences C, D or E. Thus, BT3G bid for licence B whenever the per MHz price was lower on licence B than on the other licence.

Klemperer (2002d) has suggested the following explanation for BT3G's behaviour. BT3G did not want to win licence B. It only wanted to raise the price that Vodafone had to pay for licence B. However BT3G was convinced that Vodafone was willing to raise any bid for licence B only as long as the price of licence B was not more than 50% higher than the price of licence A. Klemperer has given several arguments why BT3G might have held this belief. Klemperer's explanation is a speculation, but, if true, this would be an extremely important and prominent instance of a strategic manipulation of an open ascending auction.

A second instance of bidding behaviour of this type occurred in the Dutch auction.[29] Versatel, the only outsider participating in the Dutch auction, indicated ahead of the auction skepticism about its own chances: 'We doubt businesses or consumers will be allowed an alternative to the incumbent providers'. It went on to say: 'We would however not like to see that we end up with nothing whilst other players get their licences for free. Versatel invites the incumbent mobile operators to immediately start negotiations for access to their existing 2G networks as well as entry to the 3G market either as a part owner of a licence or as a Mobile Virtual Network Operator.'[30] This suggests that Versatel might have viewed its participation in the auction as a bargaining chip so as to obtain better conditions for network access from incumbents. Participation could serve as a bargaining chip because Versatel's participation raised prices.

The Dutch case also brings us immediately to the final form of strategic manipulation, threats. The Dutch auction was brought to an end when one of the incumbents, Telfort, threatened legal action against Versatel on the grounds that Versatel was bidding strategically to raise prices, but not with the intention of actually winning the auction. When Telfort made this threat, Versatel immediately withdrew from the auction.

We conclude from the discussion in this section that several of those European auctions that were organized as open, ascending bid auctions were affected by strategic play by bidders. The European governments do not seem to have found effective countermeasures yet.

6.4. Revenues

Regarding the revenue raised by auctions we might hope to find evidence in the European data that bears on two theoretical predictions. First, if bidders are symmetric and have private values, expected revenue from an auction is increasing in the difference between the number of bidders and the number of licences. Secondly, in several scenarios, if entry is endogenous, then sealed bid auctions will yield higher expected revenue than open ascending auctions, as they will induce more entry.

The set of auctions constituting our set of observations is very small. Deviations from the above predictions may easily be due to the fact that the *realizations* of revenue that we observe do not reflect the *expected value* of revenues. Keeping this obvious problem in mind, we now describe relevant features of the observations available to us.

As regards the first prediction, we note that the difference between the number of licences and the number of bidders was in most European auctions either one or zero. If it was zero, then the auction outcome was driven by the reserve prices. By

[29] For a discussion of the Dutch auction see van Damme (2002).

[30] Press release of 5 July 2000, available on: www.versatel.com.

contrast, if there was one more bidder than licences, then bidding typically proceeded over a number of rounds. Thus, the prediction of economic theory is trivially verified if one eliminates difference in observed revenue due to reserve prices. We also note that the auction in which the number of bidders exceeded the number of licences by more than one – that is, the UK auction – achieved the largest revenue per head of the population among all European auctions. However, it should be kept in mind that the large UK revenue may also be due to the fact that this auction was the first European UMTS auction. Market mood was very positive, and bidders might also have bid to obtain a toehold in a Europe-wide network.

As regards the second prediction, we note that the Danish sealed bid auction achieved a lower revenue than the other two auctions in which the number of bidders exceeded the number of licences by one, that is, the auctions in the Netherlands and Italy. However, it may have been precisely the sealed bid element which attracted the outsider to the Danish auction, as explained earlier. Moreover, the revenue of the Danish auction appears high once one takes into account the decline in market expectations concerning the mobile telephone business that occurred in 2000 and 2001.

7. CONCLUSION

We have reviewed the experiences of the 15 member states of the European Union in allocating UMTS licences. Our main findings can be summarized as follows:

- Most countries of the European Community used consultations with telecom companies as the main source of information to choose the number and size of licences. Some of those consulted seem to have strategically withheld information in this consultation process. In particular, the information regarding the required amount of unpaired spectrum was probably less precise than it could have been.
- In those countries which used auctions to determine the number and size of licences it appears that the desire for monopoly power has been a less important driver of bidding strategies than economists had expected. The observed bidding behaviour in these auctions is still poorly understood.
- 'Beauty contests' have sometimes but not always been conducted in a transparent manner. Whether the promises that have been made will be kept is still to be seen, but indications are that some companies have taken their promises seriously, and have thus thought it possible that they will be held to these promises.
- In several major licence auctions unexpected strategic bidding behaviour was observed. Speculative explanations have been put forward, but no general pattern has emerged that would allow us to predict behaviour in future auctions with any degree of confidence.

The foundations of economists' advice regarding licensing methods needs to be improved by further theoretical and empirical research.

Discussion

Juan Carillo

Columbia Business School and CEPR

This paper describes the rules employed by the 15 countries in the European Union to decide, first, the number and type of third-generation mobile telephone licences to be sold and, second, the allocation mechanism among the potential buyers. The rules employed for each of these decisions can be roughly divided into two categories: 'bureaucratic' (i.e. determined by a public official) or 'auction' (i.e. determined in a competitive bidding process). Contrary to the standard classification, the authors argue that the process can be bureaucratic in the first stage and competitive in the second stage. Their main conclusions are: (1) governments have not been able to extract from the consultants all the information they possessed about the optimal partition of the spectrum; (2) bureaucratic procedures have not been less fair and transparent than auction procedures although (3) they have raised a substantially lower revenue and can be criticized by their inability to enforce the commitment of the applicants to their submissions; (4) some of the observed behaviours of bidders are hard to reconcile with the predictions of auction theory.

Overall, this is an enjoyable, easy to read, and informative study. The paper is very systematic, the arguments are well presented and the authors try to avoid an '*ex post* rationalization' of the observed behaviours. However, I was disappointed by the highly descriptive nature of the paper. I was hoping to see a model and/or an empirical analysis. Instead, there is only a description of different procedures grouped into categories and a careful interpretation of some of the observed facts. Furthermore, given the scarcity of data and the generality of the question (two problems for which we obviously cannot blame the authors) many conclusions are tenuous. I will now proceed to a brief discussion of some of the points made in the paper.

First of all, it is very frustrating to read a paper in which the objective function of one of the main players (namely the government) is not specified. It is certainly not the fault of the authors if each government can have a different objective and they all remain deliberately vague about the goals of the licensing award process (as it is clear from the quotes provided in the paper). Naturally, the overall function can only be a combination of the following criteria: surplus of consumers, profit of firms and revenue of government. However, every decision is going to affect each of these objectives differently. Therefore, it is very difficult, even impossible, to compare the expected and realized outcomes if the weights are not well specified.[31] It would have been methodologically more satisfactory if the authors had stated what they believe

[31] As an extreme (and obviously caricaturized) case, suppose that the government only cares about the profits of firms. In that situation, lobbying cannot be considered as an unexpected or undesirable outcome.

is the objective function of the different governments and then used it as a benchmark for comparison. In that case, we could debate on whether it is a sensible and realistic choice of objective function. More importantly, we would have had a benchmark (however imperfect) for comparison.

I find the distinction between the first stage (determination of size and number of licences) and the second stage (allocation of licences) extremely interesting. It is very striking that all the governments that decided to have a bureaucratic procedure in both stages chose an almost identical partition of the spectrum, whereas the governments that decided to have a bureaucratic procedure only for the first stage chose very different partitions. I miss in the paper an interpretation of this fact. In my view, it could indicate that the incentives for lobbying the government in the first stage depended on the type of contest in the second stage. Incumbents might have found it desirable to persuade their government to increase the size and limit the number of licences when they anticipated that they had a good chance of being selected and the price was going to be fixed (beauty contest). By contrast, when they knew that they would have to bid for the licence in the second stage (auction), they probably anticipated that the government would capture in the bidding process most of the rents due to any restriction of competition.

One of the conclusions of the lobbying analysis is that consultants did not provide all the information they possessed about the optimal partition of the spectrum. It is hardly surprising to learn that interested parties strategically withheld information. However, a different issue is to know whether governments were able to deduce all the relevant information from the one received. A related issue (which goes back to my previous remark) is to understand why countries chose radically different partitions. One would think that the optimal partition (in efficiency terms) should be very similar in all countries. After all, it is mainly a matter of how much spectrum firms need to operate satisfactorily. It is then quite surprising to observe not only a wide range of choices but also a lack of coordination and communication between governments on this matter.

The analysis of bidding behaviour is, from a methodological viewpoint, somewhat unsatisfactory. The authors assume 'straightforward bidding' of firms. Then when NTL Mobile does not bid according to the predictions of this strategy they conclude that the firm 'had significant uncertainty about the value of incremental spectrum, and that it changed its mind about this value during the auction'. In my opinion, there is a big gap between the observation that a firm did not bid straightforwardly and the conclusion that it changed its valuation during the auction. In Section 6.3 the authors agree that firms might very well be following other (rational) bidding strategies. Unfortunately, the paper does not provide a theoretical model comparing in a systematic way the different predictions of the different strategies.

Related to that point, it seems that the authors have strong feelings against 'strategic bidding' of firms as a way to raise the rival's price. At some point, the authors state: 'governments do not seem to have found effective countermeasures yet'.

Yet it is not at all clear to me why strategic bidding is problematic. The authors argue that, under incomplete information, this strategy increases the *ex post* likelihood of winning by mistake (that is, without having the highest valuation). Yet, it is probably optimal for firms to bid this way, otherwise they would not rationally do it. Since the *ex ante* approach is obviously the appropriate one, my guess is that whether 'strategic bidding' is desirable or harmful from the government's viewpoint will crucially depend on its primary maximization criterion (consumer surplus, profit of firms or revenue of government). Once again, in the absence of a better sense of the government's objective function and a theoretical model, I find it difficult to make conclusive assertions about the desirability of eliminating that or any other behaviour.

I found especially interesting the section on 'beauty contests'. One conclusion of the paper is that this bureaucratic method worked relatively well: it has been problematic only in achieving commitment of the applicants to their submissions. I agree when the authors say that this is highly surprising for economists. Yet, from my reading of the paper, I would tend to be less optimistic about the average performance of this procedure. First, because one of the main criteria in determining if the method works well is precisely based on how successful it is in inducing firms to keep their promises.[32] Second, because beauty contests have generated systematically lower revenues. I agree with the authors that it is difficult for governments to assess accurately the firms' willingness to pay (which is precisely the reason why some governments opted for the auction mechanism). I also agree that revenue maximization may not be the unique objective and that overestimation of the firms' valuation can be welfare damaging because it may end up generating an excessively concentrated industry, as in the case of France. However, differences in revenue like those shown here can only be explained either by lobbying or if the only argument in the governments' objective function is the maximization of the firms' profits. To my view, and at the risk of sounding somewhat radical, the two explanations are quite similar.[33]

Building on this last comment, let me conclude with a suggestion for the future design of procedures to award licences. From the analysis of this paper, it seems that a basic distinction between the bureaucratic and the auction procedures is that only the former can take into account the identity of the bidder (which is good because the public official can then determine important factors such as the expected quality of the service, the likelihood that the firm will comply with the roll-out obligations, etc.). This has to be traded-off against the fact that the auction is best at revealing the willingness to pay of bidders. If this claim is correct, it should be possible to design a multi-dimensional auction in which firms submit proposals that include both a bid and details of the service (coverage, etc.) and governments do not commit to award

[32] The case of Telenordia and Orange in Sweden is the perfect example of why allowing *ex post* renegotiation between firms and government is just a form of inefficient and unfair lobbying.

[33] Note that the revenue raised with the sale of licences is a form of non-distortionary taxation of firms. So, even if the government does not incorporate maximization of revenue as part of its objective function, as long as it is partly concerned with consumer's welfare, it necessarily has to value this revenue.

the licence to the highest bidder. It would then be very similar to the beauty contest, with the exception that the government would partly extract the bidders' willingness to pay for the licence. This means that the mechanism would then combine the strengths of both methods.

All in all, I think this is a very valuable and informative paper that anyone interested in the auction of telecom licences should read. I am also convinced that the lessons drawn from this analysis will be extremely helpful for the future design of licence award procedures.

Marcel Thum

Dresden University of Technology, ifo Dresden and CESifo

The allocation of spectrum rights for UMTS in Europe provides a wonderful research area for economists. By now more than 20 European countries have issued licences and they have done so in many different ways. There is not only the general distinction of whether licences were allocated via auctions or beauty contests. Even within both approaches, large differences with respect to size of licences, number of licences, duration of the contract, roll-out criteria etc. can be found. Tilman Börgers and Christian Dustmann have managed to make use of this variety in the licensing procedures and offer very interesting insights into European UMTS licensing. Whereas most papers so far have focused on design and outcome of auctions, the present paper widens the scope by including bureaucratic procedures.

This innovative approach yields particularly valuable insights into the political economy aspects of licensing. It allows the authors to deal with important questions such as: did incumbents benefit from favouritism in beauty contests? Did incumbents lobby for fewer licences to achieve a more concentrated market for mobile telecommunication services? Did potential licensees strategically withhold information from the government to influence the design of licensing procedures in their interest? As already said, the paper provides fascinating views on the outcome of the European licensing process. Nevertheless, there are several instances where the authors could have exploited the available information more efficiently to gain additional insights.

Auctions

When it comes to evaluating auction outcomes, the price paid per head of the population is often taken as an indicator of success – at least in terms of revenue. Börgers and Dustmann also use revenue data to evaluate whether auction outcomes are in line with predictions from auction theory (e.g., the effect of the number of bidders on revenue, revenues in open ascending auctions versus in sealed bid auctions). However, when undertaking cross-country comparisons of the outcome of European UMTS auctions, one should keep in mind that the differences in revenue are driven by two clearly distinct effects. One effect stems from variations in the auction design which influence revenues via entry of bidders and bidding strategies.

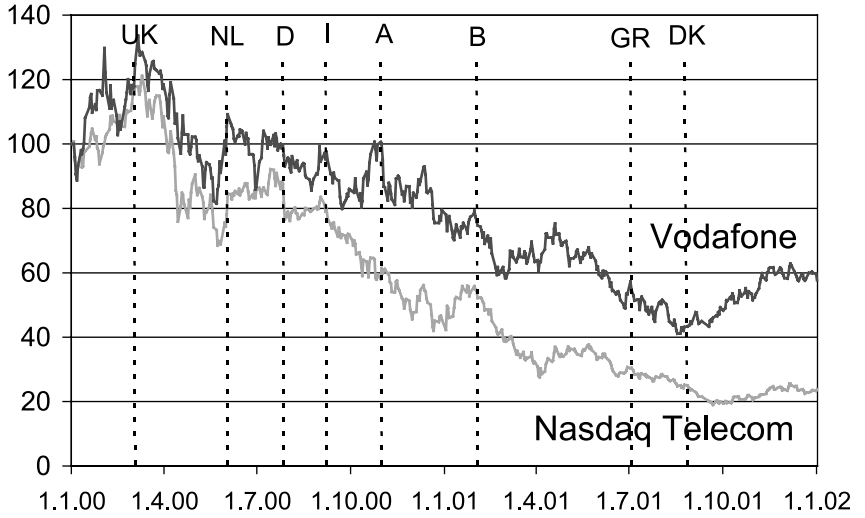

Figure 8. Telecom share prices

The other determinant of revenues is the timing of auctions. European UMTS auctions were held over a period of 18 months – starting with the auction in the UK (March 2000) and ending with the Danish auction (September 2001). Within this period, expectations about the future of UMTS changed quite dramatically. It became clear that UMTS applications and equipment would not be readily available; profitable UMTS business might be further in the future than initially expected.

Figure 8 shows the NASDAQ telecom index and the share prices of Vodafone – one of the big players in the battle for UMTS licences (1 January 2000 = 100). When the UK auction was held, both time series were at their maximum. The subsequent decline reflects to some extent the changing expectations in the telecom business (of course, not only regarding UMTS). The Danish auction was held when stock market values were at a low. Therefore, it is essential to adjust revenue figures by discounting with an appropriate (stock market) index to avoid misleading conclusions about the impact of variations in the auction design.

Defining licences

Let me now turn to bureaucratic processes. One of the central messages of the paper is that companies and industry groups strategically withheld information in the consultation process. The authors argue that the informational lobbying of interested parties left the government with significant uncertainty about the value of large versus small licences. Taking a closer look at what determined the number and size of licences in the first place, that is, before auctions or beauty contests were held, is an interesting approach but it also creates new questions which demand satisfactory answers.

The first question concerns the interests of the relevant players: in which direction did firms want to influence the political decisions? We have to know more about the incentives of the various groups (incumbent companies, outsider firms, industry groups and so on) and about their ability to undertake informational lobbying. Otherwise it is hard to understand what informational lobbying might have achieved. For instance, incumbents may have anticipated that they had higher chances of obtaining licences than outsiders. Therefore, they might have argued for more spectrum per licence as this would reduce the number of available licences and lead to a less competitive market environment. Outsiders, however, had an incentive to push towards a larger number of licences in the consultations process. Why were incumbent firms successful with their news management and why did entrants fail in transmitting the relevant information?

This brings me to my second point. Even for those who actively participated in the consultation process it will be almost impossible to judge whether it was informational lobbying or an exchange of favours that had a more significant effect on the number of UMTS licences. (At least, I can think of no test to discriminate empirically between these two aspects of lobbying in the case of UMTS.) The more important question is whether the consultation process led to a bias in the amount of spectrum reserved for each licence. There is some evidence for such a bias. First, the authors show for the case of the UK that Orange's valuation of 2×5 MHz extra spectrum was fairly low. Even in the case of Vodafone which showed the highest willingness to pay for extra spectrum, there are no signs of 'increasing returns to scale' with respect to spectrum. Hence, contrary to the claim of the UMTS Forum, small licences of 2×10 MHz were probably the efficient choice. Second, the consultation process led to a larger number of licences when auctions (rather than beauty contests) were used in the subsequent allocation procedure. All the countries with beauty contests offered four licences whereas three of the five countries with auctions (Italy, the Netherlands and the UK) opted for five licences. This is perfectly in line with the lobbying argument. The additional rents emerging from a more concentrated market structure are partly dissipated to the government through auctions. In contrast, the rents remain largely with the licence winners when beauty contests are used. Hence, firms have less incentive to lobby for fewer licences in the consultation stage when auctions are used to allocate the licences.

Favouritism

Favouritism and the value of political connections for firms are now widely debated in the political economy literature. Hence, the question of whether favouritism affected spectrum allocation in beauty contests could be of interest beyond the UMTS market. Here, the paper merely delivers a description of what happened in the various countries. I wonder whether it would be possible to support the conclusions regarding favouritism with some evidence grounded in data. The obvious choice,

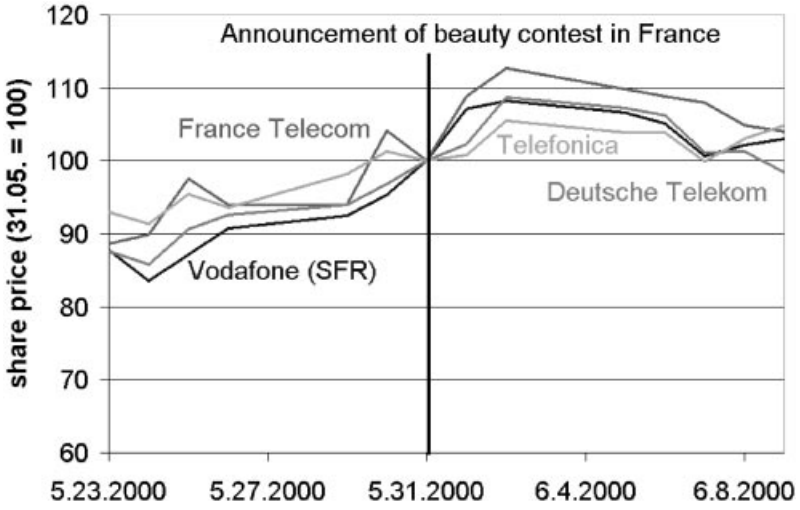

Figure 9. Announcement of beauty contest in France

namely the number of incumbents winning licences, would not be an appropriate indicator as incumbents were also predominantly successful in auctions. (As the cost considerations in the paper show, it was probably also efficient to award licences to incumbents.) We should observe incumbents dominating the field independent of whether there was favouritism or not and independent of whether auctions or beauty contests were held. And indeed, in only four countries, two of which allocated licences via auctions and two via beauty contests, did incumbents lose licences to entrants.

However, one might think of using a different procedure to identify favouritism. The authors argue that incumbents were better at lobbying than outsiders due to their already well-established political connections. If a country's choice between beauty contests and auctions remained at least to some extent uncertain until the final decision, we could exploit the reaction of stock prices at the date of announcement. If beauty contests give politically connected firms a headstart, incumbents should perform better than outsiders.

Figure 9 gives a very simple example of such a natural experiment. It shows the share prices of four important players in the French UMTS licensing around the date of announcement of beauty contests in France. France Telecom had significant political connections due to its previous status as a national monopoly. Vodafone's main pillar in France, SFR, also had well-established connections to the bureaucracy through SFR's second large shareholder Vivendi. The Spanish company Telefonica was already operating a 2G network in France but lacked deeply rooted political connections. Finally, Deutsche Telekom was clearly an outsider in the game. The share prices of the two politically connected firms, France Telecom and Vodafone, went up by 7% and 9% respectively the day of the announcement, while Deutsche Telekom and Telefonica experienced increases of only 2% and 1%. This is clearly a

very simple and naive experiment but it shows how stock market valuations could be used to gain further insights into potential favouritism during the UMTS licensing process.[34] A more comprehensive analysis of favouritism might reveal further insights into the value of political connections in Europe.

Panel discussion

Tilman Börgers replied to the comments of Juan Carrillo that it is difficult, if not impossible, to pin down government objectives. This was why the authors had focused on descriptive statistics and did not evaluate the results.

Michael Haliassos and Luigi Guiso thought it unlikely that the method of license allocation had not been randomly chosen by the government. The choice of the method depends on the goals of the government and its efficiency. Tilman Börgers agreed but pointed out that the data set contained only very few countries, so that tackling endogeneity was not feasible.

Tito Boeri wondered about the pessimistic judgment of economic theory in the paper. Paul Klemperer also found the judgment of economic theory too hard. He pointed out that slight modifications of the simple theoretical models discussed in the paper could improve their predictive power.

Tito Boeri thought that a crucial choice was the timing of when to allocate the licences. Jeroen Hinloopen and Paul Klemperer mentioned that the results of the auction in the UK had an influence on the lobbying of Dutch firms and the government's expectations for the revenue. Tilman Börgers replied that it was not clear how the sequence of auctions might affect the conclusions of the paper, though he agreed that this deserved further investigation.

Philip Lane thought it important which part of the government took the decision to allocate licences. The ministry of finance might be more interested in generating revenue, while the telecommunications ministry might be more interested in a beauty contest. He argued that more could be learned about the objectives of the government by looking at the procedures of privatization in various countries. Winfried Koeninger added that the different extent of public ownership of telecom companies, as well as the varying fiscal pressures in different countries, might be useful in explaining variations in government objectives.

Responding to the discussion of Juan Carrillo, Paul Klemperer mentioned that lobbying mattered in the UK as information was withheld by the consulted parties

[34] The entire UMTS licensing process provides even more opportunities for natural experiments. For instance, the British government increased the number of licences from four to five in November 1998. The German regulatory agency opted for auctions with endogenous number and size of licences rather than offering fixed blocks as initially planned. If these changes in the licensing conditions were not fully anticipated, they might have had an impact on stock prices thus revealing who benefited from the changes.

and affected the quality of the auction design. With respect to entry he pointed out the problem that some potential bidders might not enter because of suspicion that the rules are biased against them. He did not think that this played a role for Greece where the small size of the market was more important.

Paul Klemperer also pointed out that there was learning about how to set up the auction over time. He argued that the Danish government learned from the Dutch experience so that the Danish auction went relatively well.

Jacob Heinsen commented on the Danish experience. The process was not as transparent as stated in the paper, and based on empty promises since firms had since been unable to meet their stated objectives. He argued that auctions should not be used to determine the number of licences because consumer interests are not well represented in the process (as discussed in the paper of Jehiel and Moldovanu). Moreover, he stressed that the number of bidders does crucially depend on the auction design; the Danish auction had performed well with respect to the number of bidders. For the Danish experience he emphasized that practitioners had learned a lot from economic theory for the design of the auction.

Gilles Saint-Paul was interested to know more about the politico-economic determinants of the choice of auctions versus beauty contests. The choice might be related to differences in constitution, the industrial organization of the sector or ideology.

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