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The Option Value of the UK 3G Telecom Licences: Was Too Much Paid?

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THE OPTION VALUE OF THE UK 3G TELECOM LICENCES: WAS TOO MUCH PAID?

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Abstract

In the article the aggregate option value of the UK 3G telecom licences is evaluated. Revenues, capital and opertaing costs of UMTS business are calculated for the period of licences' duration and are emplyed to show that the aggregate revenue extracted by the UK's Government is (slightly) lower than the aggregate price of licences payed by winning telecom companies.

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1 Introduction.

It is generally believed that the 3G Telecom (or UMTS) auctions have been among the most successful applications of an economic paradigm to a real-world problem. Some of the auctions through which licences were allocated raised a per capita revenue that far exceeded the government previsions.[1] Among them, the UK auction is believed to be one of the most efficient (Binmore and Klemperer, 2002). Yet, almost two years after the auctions, shadows on European telecommunication firms cast some doubts on the effective efficiency of the auctions, at least in the sense of total surplus maximization. Indeed, auctions succeeded in extracting significant payoffs from telecommunication firms but at the cost of a huge debt load that depressed stock prices and in some cases undermines the whole business of the firms.[2] In other words, the mainstream opinion of market analysts and operators is that markets are discounting the high prices paid for licences, since they did not correspond to the real participation value of the new business.[3]

Instead of focusing on the technical details of each auction through which licences were sold, the paper considers the first (and most famous) one, the British 3G auction, and shows that the option value[4] of the licences, i.e., the implicit value of licensing and marketing applications of theUMTS technology, indeed exceeds the revenues extracted from participants (i.e. licences' fees).

To prove this claim, the paper takes into account revenues that stem from UMTS services and installation, upgrade and maintenance costs of the UMTS networks (costs of capital) plus operating costs. The option value of the licences auctioned in the UK is evaluated and it is shown that the value (roughly) corresponds to the sum of licences fees paid by auction winners.

The article is organized as follows: in Section 2 the UK's UMTS aggregate revenues and costs are reported, estimated for the entire period of licences'

[1] Per capita revenues of 3G auctions across Europe were been: Austria 104, Belgium 46.8, Denmark 98.8, Germany 639.6, Greece 46.8, Italy 249.6, Netherlands 176.8, Switzerland 20.8, UK 676 (figures are in USD, exch.rate 12/02).

[2] This is the case of the IPSE2000 consortium that obtained an Italian 3G licence.

[3] See The Economist, 2000, 2001.

[4] We focus on aggregate data because of the difficulties in specifying disaggregate values (for instance, about market shares) and to avoid problems connected with the size of the frequency spectrum associated to each licence ("large" types "A" and "B" and "small" types "C", "D" and "E")

duration. In Section 3 the theoretical background of the application is set and the option value of the licences is evaluated. In Section 4 are the concluding remarks.

2 The UMTS's revenues and costs.

The UK 3G auction was the first European auction allocating radio spectrum frequencies delivering UMTS services. There is by now a consistent body of literature on both the story of the UK auction and the technical aspects involved. Interested readers should refer to Binmore and Klemperer (2002), Borgers and Dustman (2002) and references therein or should consult directly the Spectrum Auction website of the United Kingdom's Radiocommunication Agency that ran the auction in Spring 2000. The auction lasted for 150 rounds; five licences were sold, which expire at the end of year 2021. The final aggregate price paid for the licences amounted to $35,610$ billions of dollars, over 27 times bigger than the entry auction's base (792.12 millions).[5]

Several data can be collected in order to forecast revenues, capital cost and operating costs associated with the delivery of UMTS services.[6] Total revenues are compounded by taking into account revenues that come from delivering UMTS services to customers (such as videophone services, SMS, data exchange and internet "surfing" services, and multimedia and advertising services, etc.). Capital costs include costs of upgrading the existing networks and developing the UMTS systems and other specific costs of information services applications (hardware and software development to deliver specific services). Operating costs refers to network maintenance costs, marketing costs, interconnection and roaming costs, specific UMTS services operating costs, and similar voices.

In order to calculate revenues and costs it is necessary to separate the duration of licences into two equal periods. In the first ten years, data cover the patterns of revenues and costs that arise from services that are generally agreed to be the future UMTS services and therefore whose structure and composition can be easily deduced.[7] In fact, such a duration corresponds to the 3G tech-

[5] All figures of the article are in US dollars (exchange rate with UK Pound of 12/02).

[6] We highlight here that even though our data reflects information that was easily available at the time of the choice, we do not intend to claim that any of the auction participants effectively used this data.

[7] For a survey of the structure and evolution of the UMTS business, see the UMTS forum

nology development period that has already been planned (and this was known when the auction occurred). It is generally agreed that the development of the UMTS capabilities (that is connected to the growth of the connection speed) depends on a technology that will continuously improve throughout the whole decade. Therefore, the data for the first period derives from the elaboration of information about UMTS services development, as well as other market data (such as actual and forecasted mobile phones' diffusion, infrastructure growth and needs, actual and forecasted population, and other financial and wealth indicators) that are (and were at the time the auction took place) easily available[8] (as well as from personal communications with business operators).

The evolution of technology for the subsequent ten years is less predictable at this stage; this implies the need to make hypotheses about the evolution of UMTS technology and the development of other alternative services that will affect UMTS costs and revenues for the second decade of licence validity. This paper adoptes a prudential assumption, that is, it is supposed that yearly cost and revenues will remain constant throughout the second decade. Even though it is a naive conjecture, it reflects the level of knowledge available now about future IT services. Moreover, it provides more plausible figures than other possible hypotheses, like a constant rate of growth.[9]

Summing up, the following table reports the twenty years estimate of UK aggregate revenues, operating and capital costs associated to the licences.

[table I here]

First years' figures include revenues that are derived from cellular phone services that will be provided by incumbent operators through a combination of existing and upgraded networks (GSM and GPRS) and by the newcomer

(2001) and the downloadable reports therein (see also the International Telecommunication Union website).

[8] See, for instance, the Oftel report (2001).

[9] However the optimistic assumption of a constant growth of revenues is considered also and compared with the prudential one. Under the former hypothesis, revenues would reach a total amount of $524,310$ millions of dollars in 20 years, which correspond to a (yearly) 1.19% share of total UK's GDP, given the rate of 3% domestic growth (it would be 1.34% if growth was 2% per year). On the contrary, the latter hypothesis of constant revenues in the second decade shows that the revenues correspond to a 1.02% share of UK's GDP under the 3% growth assumption (1.15% for a 2% growth rate). Interestingly enough, at the end of the last decade, mobile phone telecommunication revenues amounted to just 0.48% of total UK's GDP (Source: Oftel).

through roaming on existing systems. This reflects both the choice of taking into account aggregate data only and the licence holders services' development itself.[10]

3 The real option value as the implicit value of the licenses.

Each investment decision that involves irreversibility and heightened uncertainty has the prerogative to create (strategic and real) options and the latter value should be considered in analyzing corporate investment projects. Irreversibility breaks the temporal symmetry between the past and the future, meaning that restoration to an original natural state can be technically impossible or extremely expensive. Uncertainty occurs when the consequences of development decisions cannot be fully determined ex-ante and all the uncontrolled variables of the decision process are random variables, which depend on the possible state of nature that will occur in the future. As a result, many financial analyses of different investment projects based on the traditional approach of picking the opportunity with the highest NPV (DCF analysis) are likely to ignore other option values that are embedded, such as the opportunity to delay an investment without losing it forever, to abandon a project, to adjust an operative strategy and to exploit new profitable opportunities.

In seminal articles, Arrow and Fisher (1974) and Henry (1974a, 1974b) independently point out that under uncertainty, when a given decision could (at least partially) have irreversible effects and learning is possible before future decisions have to be made, it is generally valuable to keep open an option, even if the decision-maker is risk neutral and her marginal utility is constant. They call "quasi-option value" the extra value attached to the preservation of an option in order to stress the crucial role played by irreversibility and learning and show its independence from risk attitude. Arrow and Fisher (1974) introduce the notion of quasi-option value and argue that whenever uncertainty is assumed, "even where it is not appropriate to postulate risk aversion in evaluating an

[10] See the Information Memorandum that was distributed to the auction participants: "*During the early years of operations it is expected that a combination of 3G and GSM systems will be used, at least until a sufficient 3G coverage is available*". (Radiocommunications Agency & N. M. Rothschild and Sons Ltd., p.6).

activity, something of the feel of risk aversion is produced by a restriction on reversibility of decision" (Arrow and Fisher, 1974, p.318). Henry (1974b) shows that by replacing the initial random problem by an associated riskless problem, i.e., an equivalent certainty case, the decision-maker could obtain a non-optimal solution, even if she is risk-neutral and the payoff function is quadratic.[11]

Some different methods of measuring quasi-option value have been suggested in the context of empirical decision problems. The most notable of them is real option analysis. Real option-pricing theory considers an irreversible investment as a financial call option, which gives up the possibility of waiting for new information to arrive that might affect the desirability or timing of the expenditure. Applications involving financial instruments and project-investment valuations have a common element for using option-pricing: "the future is uncertain (if it were not, there would be no need to create options because we know now what we will do later) and in an uncertainty environment, having the flexibility to decide what to do [...] has value. Option-pricing theory provides the means for assessing that value" (Merton, 1998, p 339).

Real option value ($r.o.v.$) is equal to the maximum difference between R^*, the expected revenue of the random problem, and R, the expected revenue of the riskless problem, that is, $r.o.v. = max[R^* - R, 0]$. The real option value represents the conditional value of information, conditional to the reversible action. It is worth noting that an irreversible investment opportunity is equivalent to a financial perpetual call option on common stock[12], where the investment expenditure is the exercise price and the project value (that is, the expected payoff from investing) is a share of the underlying asset. Dixit and Pindyck derive "the value of the extra freedom, namely the option to postpone the decision" (Dixit and Pindyck, 1994, p. 97), as the difference between the expected net present

[11] If the criterion function is quadratic, the planning problem for the case of uncertainty can be reduced to the problem for the case of certainty simply replacing, in the computation of the optimal first period action, the certainty future values of variables by their unconditional expectations. In this sense, the unconditional expected values of these variables may be regarded as a set of sufficient statistics for the entire joint probability distribution, or alternatively as a set of certainty equivalence (Simon (1956)). Malinvaud (1969) generalizes the applicability of certainty equivalent method to risky situations in which payoff function is not quadratic but functions involved are twice differentiable. However, this approach is inapplicable with irreversibility, which introduces discontinuity in the derivatives of either functions or payoff.

[12] A disinvestment opportunity (partial reversibility) is equivalent to a put option and the act to disinvest is equivalent to exercising such an option.

values of a random problem and an associated riskless one. Pindyck (1991) observes that dynamic programming and contingent claims analysis yield the identical solution (the rule that maximizes the market value of the investment opportunity), if the decision-maker is risk-neutral and the risk-free interest rate replaces the discount rate.[13] Whenever markets are complete or at least sufficiently complete (spanning assumption), the value of a project and the value of the option to invest is determined by constructing a replicating portfolio or determining some perfectly correlated assets and using option-pricing theory.[14] That is, the value of the option to invest is based on the construction of a risk-free portfolio in which the asset is traded (long or short position) or by finding out another asset or a combination of assets, whose prices are perfectly correlated with the price of the output of the investment project, if that asset is not traded.[15]

The implementation of the UMTS technology can be considered a modular evolutionary process. Every application of a new technology can be considered a foray into an unknown space and the choice to modularize its implementation can be conceived as a portfolio of options provided by new markets and products. The opportunity to enter a new market (the new 3G mobile telecommunication services introduced by the implementation of the UMTS technology) is a shared and compound option. Expansion of the scale of the project, temporary suspension of the investment outlay while preserving the technological feasibility of the project, abandonment of the project and switching among alternative operating modes in the face of newly-uncertain market conditions are other real options that follow the entry in the new market. The acquisition of a UMTS license is a shared strategic real option, since it involves non-exclusive rights shared by a fixed number of competitors in the industry. This gives the operator the opportunity to invest in the new market of mobile phone services provided by the UMTS standard. It is an expiring real option, since competitive and contract conditions overtake the value of any wait-and-see option.

[13]Risk-neutrality means that the discount rate equals the risk-free rate (e.g., Cox & Ross, 1976).

[14]If the spanning assumption does not hold, it is possible to value the investment project and the decision to invest by dynamic programming with an exogenous discount rate (Pindyck, 1991, p. 1116).

[15]Real option approaches are particularly applied to real-estate investments and development decisions - pharmaceutical, aerospace and consumer electronics industries - (Merton, 1998; Triantis 2000).

Using data reported in table 1, the aggregate option value of the UMTS licences are calculated by applying the Black-Sholes model (Damodaran, 2000)

$$r.o.v. = S \cdot e^{-yt} N(d_1) - K \cdot e^{-rt} N(d_2) \tag{1}$$

where $N(\cdot)$ denotes the normal distribution of

$$d_1 = \frac{\ln(\frac{S}{K}) + (r - y + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} \tag{2}$$

and

$$d_2 = d_1 - \sigma\sqrt{t} \tag{3}$$

In the formulas above, S is the actual value of profits, which are the actual value of revenues less the operating costs; K corresponds to the actual value of capital costs; licence duration t is 20 years (the expiration of the option), so that the yearly dividend y amounts to $\frac{1}{20}$ of the whole licences' value; the variance parameter σ^2 refers to the variance of net revenues; the riskless interest rate was set to 5.5%. (Bank of England base rate; average April 99 - April 2001).

Calculating d_1 and d_2 by means of equations 2 and 3 using data reported in table 1 the following estimates of the Normal distributions are obtained:[16]

$$N(d_1) = 0.958; N(d_2) = 0.6 \tag{4}$$

which yields the following (rounded) figure for the real option value of 3G UK licences:

$$r.o.v. = 36,330.302 \tag{5}$$

Taking into account the length of the auction and the "strange bids"[17] by some participants (at least in early stages of the auction) the difference between the real option value and the price effectively paid by licences winners appears to be extremely small, amounting to just 2% of the price.[18] In other words, it seems that firms estimated carefully the value of participating in the new mobile telecommunication business.

[16] figures are rounded off at the third digit.

[17] In the sense of Borgers and Dustman (2002). For a different opinion, see Klemperer (2002)

[18] Under the optmistic assumption about the UMTS revenues, the real option value would be $r.o.v. = 37,285.175$, which is 4.7% bigger than the paied fees.

4 Conclusions.

It is believed that the high price raised by the auctions that allocated 3G licences was a major factor in explaining the loss in market value for telecommunication firms, but this paper shows that the real option value embedded in the UMTS licenses in the UK is very close to the fees paid by purchasers, even in a very prudential scenario. Real option theory shows that the UK Government's revenues from the auction are not high enough to explain the difficulties of the winning TLC operators, since they are slightly lower that the value of participating in the new business. Other specific facts (difficulties of implementing the "killer application", tecnological failures, etc.) could be quoted to explain the decline of TLC shares in the stock markets. An example from the Japanese TLC market might help to clarify this point. The giant DoCoMo telecom, the first provider of UMTS service (FOMA), failed in obtaining the forcasted number of customers ($1,400,000$ UMTS users) and has only $149,000$ users. On the contrary, Kddi, the second Japanese operator, has signed up $3,320,000$ UMTS users since last April, even if its standard has a speed of transmission of 144 kilobyte per second (384 kilobyte per second for DoCoMo); moreover the Kddi standard does not allow users to send photo-mail. Differences in performances are due to delays in DoCoMo's providing nation-wide coverage and in specific technical problems (low battery duration, etc.).

Even if the article considers the UK figures only, the same argument should be applied to other national markets. Actual technical diffculties and the world-wide economic downturn are depressing TLC business perspectives. Nevertheless, it is very likely that on a twenty-years basis both the economy will recover and the specific temporary difficulties will be overtaken by technological progress (for instance, in the Japanese market, during year 2003 it will be possible to download from an internet site a song within time-frame of a second only, which coud represent the "killer application" of the market) and UMTS services will start to become a very profitable business.

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year	1-3	4-5	6-8	Tot. Rev.	9	10-12	13-15	Tot. cap. costs	16-19	20-21	22-27	Tot. op. costs
2001	13634	11	0	*13645*	9812	15	1	*9828*	8071	3775	17	*11863*
2002	15158	31	10	*15199*	9792	30	11	*9834*	5947	4093	66	*10106*
2003	16523	284	543	*17350*	9792	62	23	*9877*	6488	4346	251	*11085*
2004	16464	1098	1123	*18685*	0	117	39	*156*	6261	4367	658	*11286*
2005	15121	2617	1746	*19484*	0	176	78	*254*	6052	4231	1212	*11496*
2006	14078	3938	2427	*20443*	0	230	119	*349*	5887	3996	1785	*11669*
2007	14065	5030	3216	*23311*	0	275	160	*435*	5763	3701	2360	*11825*
2008	13885	5881	3623	*23389*	0	318	200	*518*	5670	3371	2776	*11817*
2009	13618	6617	4016	*24251*	0	358	241	*599*	5591	3021	3106	*11718*
2010	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2011	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2012	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2013	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2014	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2015	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2016	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2017	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2018	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2019	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*
2020	13289	7330	4530	*25149*	0	399	281	*679*	5532	2659	3414	*11604*

[figures are in M$]

Legend:

1-9. Revenues accruing from the following services: video-voice (1); SMS (2), e-mail (3), information and surfing (4), advertising (5), business data (6), machine to machine (7), and multimedia services (8).

9-15. Capital costs, including: cost of upgrades of GSM networks to GPRS and installing UMTS networks (9), specific hardware and software expenditures associated with e-mail (10), advertising (11), business data (12), information (13), machine to machine (14), and multimedia applications services (15).

16-27. Operating costs, composed of: selling and marketing costs (16), handset subsidiation costs (17), customer support costs (18), UMTS network maintenance costs (19), interconnection costs (20), roaming costs (21) and product development costs of services such as e-mail (22), information (23), business data and transactions (24), information (25), machine to machine (26), and multimedia applications (27).

Table I: UMTS's Revenues and Costs