On the design and implementation of the GSM auction in Nigeria - the world's first ascending clock spectrum auction

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Abstract

In late 1999 the Nigerian government decided to issue no more than four digital mobile licences. An attempt was made to award the licences using a comparative selection process, but this failed in February 2000 due to allegations of corruption. In March 2000 it was decided that the licences would be awarded by auction, which was regarded as the only method that would satisfy transparency and objectivity requirements. In January 2001 Nigeria awarded three GSM spectrum licences using a hybrid auction featuring an ascending clock phase and a sealed-bid phase. This paper describes the design of the auction, its implementation, the strategies of the bidders and the auctioneer, and the outcome. The auction provides an excellent case study of economic theory confronting the realities of political economy in a new democratic environment within an emerging economy. Economic theory played a key role in steering the design of the auction, while political economy constraints impacted significantly on the design selected and on the logistical processes chosen. The auction raised USD855 million and when adjusted for national income exceeds that raised in the UK 3G auction per MHz. The auction was acclaimed a great success by many around the world, and proved to be a watershed in Nigeria's recent democratic history.

Key Words: ascending clock auction, auction, comparative selection, design, GSM, Nigeria, strategy, transparency

JEL Classifications: D44 (auctions), L96 (telecommunications), N47 (Africa)

1. Introduction

In December 1984 the Independent Commission for Worldwide Telecommunications Development completed a report, *The Missing Link*[1], in which the Commission established the objective that "by the early part of the next century virtually the whole of mankind should be brought within easy reach of a telephone". While the Commission did not set an explicit target, it was widely interpreted that this phrase meant a teledensity[2] of at least one by the year 2000. More recently, in July 2000, the G8 established an initiative to bridge the 'digital divide', aimed at improving access to communications technologies in the world's poorer countries.[3] Despite international initiatives and worthy objectives, Nigeria, with a population of over 120 million, had in 2000 one of the lowest teledensity rates in the world at 0.38.[4]

The chronic shortage of mainlines in Nigeria, and in Africa more generally, is a major impediment to economic development.[5] In the late 1990s some African countries, such as Ghana, Uganda and Zimbabwe, responded to the woeful state of their telecommunications infrastructure by issuing new cellular telephony licences. This led to dramatic increases in teledensities. For example, the number of cellular subscribers in Zimbabwe increased from 20,000 to 150,000 in the twelve months before August 1999, whereas the number of fixed main lines hovered around 250,000 over the same period.[6] In Uganda the number of mobile subscribers overtook the number of fixed lines in July 1999, less than ten months after MTN Uganda (the largest cellular operator in the country) started competing against MSI-Celtel (another

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1 Sir Donald Maitland headed the Commission, and the report has since become known as the 'Maitland Report'.

2 The number of main lines per one hundred of the population.

3 The G8 established the 'Okinawa Charter on the Global Information Society' at the Okinawa Summit, Japan, July 2000.

4 In the year 2000 the median and average teledensities in the world were 14.3% and 22.7% respectively. The average teledensity in Africa at the end of 2000 was 1.98%. In 2000 Nigeria had only 500,000 main lines operational out of a capacity of 700,000, and only 30,000 analogue mobile telephony lines operational. Source: ITU statistics, May 2001 at http://www.itu.int/itudoc/itu-t/com3/focus/72404-fr.html (last visited August 7, 2001). See also Onwumechili (2001) on universal access to basic telecommunications in Nigeria, and Edelmuller and Feyt (2000).

5 Some studies conducted by the ITU (International Telecommunication Union) claim that each new telephone line in the developing world contributes approximately USD4,500 to gross national product, see the Executive Summary of the 'Telecom Development Summit', held in Geneva, October 1999, downloadable at http://www.itu.int/itudoc/telecom/tlc99/ex_sum.pdf. The relationship between telecommunications and development in Africa has been widely discussed, most recently at the Third African Telecoms Summit 'Universal Access and ICT in Africa - Strategies for Effective Development', Accra, Ghana, March 27-29, 2001, see http://www.afritelsummit.com.gh. Sadly Africa has fewer telephone lines than are installed in Manhattan or Tokyo, see http://www.sabcnews.com/SABCnews/south_africa/general/0,1009,17096,00.html (last visited August 15, 2001).

6 See ITU reference in footnote 5.

cellular operator).[7] While other countries were making great strides to increase teledensities, largely due to corruption this did not occur in Nigeria before 2000.[8]

In late 1999 a new democratic Nigerian Government prioritised the development of the telecoms sector.[9] After the many years of state investment in fixed line telecommunications had met with little success, the Nigerian authorities identified private investment in mobile cellular telephony as the best way forward, in the short term, to boosting teledensity.[10] Unlike nations with high teledensities, wireless telephony is a substitute rather than a complement to fixed line technologies in countries with low teledensities. Furthermore, wireless technologies are less prone to the problems suffered by wireline technologies in many parts of Africa, such as theft, vandalism, and damage due to inclement weather conditions.[11]

Experience in Uganda highlights that mobile telephony can speedily enhance productive capacity.[12] Recognising the need for an improved telecommunications infrastructure, the democratic Government published a new 'National Policy on Telecommunications' ('National Policy') in October 1999.[13] The National Policy, which was led by the President, emphasised the need for reform and private sector investment. In the short term it was stated that an objective would be the attainment of 1.2 million mobile lines within two years. The National Policy declared "there shall not be more than 4 digital National Cellular Operators for an initial period of 5 years" and that

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[7] See appendix and Brown *et al.* (2001) for an account of developments in Uganda.

[8] The scale of corruption in Nigeria continues to be a major problem. In a recent survey conducted by Transparency International, Nigeria was the second worst country out of 91 countries, see http://www.transparency.org/documents/cpi/2001/cpi2001.html, last visited August 13, 2001. In an empirical investigation Mo (2001) has estimated that a 1% increase in corruption reduces the growth rate of an economy by about 0.72%.

[9] A new democratic government, under the leadership of President Olusegun Obasanjo, came into office in May 1999, following fifteen years of military rule in Nigeria. See http://www.paulusoro.com/htmlfiles/january2000newsletter.html for a discussion on the political background behind the reforms in telecommunications in late 1999.

[10] According to some experts in Nigeria, if the country relied upon the incumbent operator NITEL to develop the basic infrastructure it would take 50 years and cost USD65 billion to achieve a teledensity of 10%. See Financial Times 'NIGERIA: Issues must be resolved before sector can take off', October 8, 2000 (source:http://specials.ft.com/ln/ftsurveys/sp6686.htm, last visited August 15, 2001). See also Henisz and Zelner (2001).

[11] Theft of cable is a major problem throughout many parts of Africa. According to the Financial Times, "removal of copper telephone cables has become an expensive and intractable problem", from 'TELKOM: High Tech Needs and Political Sensitivities', October 8, 2000 (source: http://specials.ft.com/ln/ftsurveys/sp65ee.htm, last visited August 15, 2001).

[12] See Lee and Anas (1992) for an analysis on the cost faced by Nigerian manufacturing due to deficient infrastructure.

[13] A revised version of the National Policy, dated May 2000, is available at http://www.ncc.gov.ng/telecommunications_policy.htm, last visited August 15, 2001.

"the modalities for appointing the carriers shall be competitive and transparent".[14]

Although the former military government had issued twelve mobile telephony licences (apparently nine of which were GSM licences) and granted approvals for twenty-one others (covering, local, regional and national operators), none of the licensees had apparently begun operating a commercial service before the end of 1999.[15] It has been alleged that the licensing process overseen by the military government was corrupt and the incentives to rollout infrastructure were limited. Most licensees were seeking either to sell on licences opportunistically or were waiting for regulatory clarity before undertaking large-scale infrastructure investments and irreversible marketing expenditures.

At the end of 1999 the NCC (Nigerian Communications Commission, the industry independent regulator[16]) placed adverts in some Nigerian newspapers inviting expressions of interest in not more than four national GSM licences, where each licence would cost USD100 million. This attempt to award GSM licences, which involved the Communications Minister as head of a specially set up Inter-Ministerial Committee, failed and was cancelled on February 28, 2000. The unsuccessful attempt to issue licences featured a two-stage process; a pre-qualification stage, where interested parties had to satisfy technical, financial, probity and compliance checks; and a bidding stage. The process was cancelled after doubts were raised about the integrity of the pre-qualification process.[17] The Government announced that a new award process would be set up. After some initial problems, the NCC was instructed by the President to oversee an auction process supported by international consultants.[18] In June 2000 the NCC appointed Radio Spectrum International (based in London) as principal consultant.[19]

Although a comparative selection process ('beauty contest') could have been chosen (as has been the case in many other countries, and would have been the case in the process cancelled in February), it was felt that this method is

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[14] As quoted at http://www.paulusoro.com/htmlfiles/january2000newsletter.html.

[15] General Sani Abacha, the former military dictator, began moves to liberalise telecoms in the early to mid-1990s and by the beginning of 2000 over 100 licences had been issued covering VSAT, cellular, fixed wireless, paging and other services.

[16] Not all measures undertaken by the military government were ill conceived. The NCC was established by decree in 1992 under the former military regime.

[17] There were seventeen applicants in the pre-qualification stage, of which seven were chosen to participate in the bidding stage. These were: Motophone Ltd, MTS, MTN, NITEL, CIL, United Networks Limited and Reliance Telecoms.

[18] See http://www.kilima.com/mediamonitor/mm-05-09.html#five, last visited August 15, 2001, for useful background on the politics leading up to the auction.

[19] The other consultants were: Chief Afe Babalola, SAN; Charles River Associates; Paul Usoro & Co.; and Skadden, Arps, Slate, Meagher & Flom. This consortium was a mix of technical consultants, lawyers, and economists.

susceptible to corruptive influences and, significantly, lacks transparency and hence credibility. Even if a beauty contest were to escape such influences, the views of international commentators about government administration in the country, based on Nigeria's recent history, would be too negative and consequently participation in the licensing process by overseas investors would be compromised. The Government of Nigeria was determined to choose a process that would have credibility in the eyes of international investors, so as to promote greater competition for the licences and signal to outside observers that the country was able to implement a public tender with integrity. If there were a successful conclusion to the auction, this would also begin to restore confidence in government processes within the country.

The auction for the GSM licences was held in January 2001 and is an excellent case study of economic theory confronting the realities of political economy in a new democratic environment within an emerging economy. Economic theory played a key role in steering the design of the auction, while political economy constraints impacted significantly on the design selected and on the implementation and logistical processes chosen. The auction, which raised USD855 million, was acclaimed as a great success by many commentators in Nigeria and around the world.

In this paper we look at the conceptual and practical issues surrounding the licence award process leading up the conclusion of the auction. Throughout we make comparisons with other recent, mainly 3G, spectrum auctions. In Section 2 we provide some background on Nigeria and its telecommunications infrastructure. Section 3 examines in detail the four stages of the award process, from the initial invitation stage through to the grant stage where licences were awarded to the successful bidders. Section 5 describes the outcome to the auction, and assesses the strategies chosen by the bidders and describes the reasoning behind the announced bids presented by the auctioneer. In this section we also speculate on what might have happened had the bidders played different, arguably more rational, strategies. In Section 6 we compare the outcome to the Nigerian GSM auction with recent 3G auctions. Here we show that the amount raised in Nigeria, when adjusted for national income, was higher than that in the United Kingdom per MHz. We conclude in Section 7 by arguing that the overall process was transparent and superior to alternative comparative selection methods. Finally, there is an Appendix.

2. Background: Nigeria and its telecommunications sector

The Federal Republic of Nigeria is situated on the Gulf of Guinea in West Africa. It shares borders with Benin, Niger, Cameroon, and Chad. The Federal Capital of Nigeria is Abuja, but most commercial activity takes place in Lagos. Key facts about the Nigerian economy and the demography of the country are shown in Table 1, and the country map is shown in Figure 1.

Table 1: Nigeria – key facts 2000

Population	124 million
Population of Lagos	13.4 million
Population density	136 per sq. km
Population annual growth, percentage	2.6
Number of households	22 million
Adult population	60 million
Percentage of population 15-24 years old	19.2
Median age, years	17.4
GDP per capita	USD 473
GDP per capita PPP	USD 853
Percentage of national income held by richest 10% of the population	40.8
Teledensity: main lines per 100 population	0.38

Sources: World Bank, World Development Indicators Database, April 2001; World Bank country database (www.worldbank.org); NIPC Investors' Guide to Nigeria; CIA World Factbook, 2000; ITU Yearbook of Statistics, February 2000; United Nations (www.un.org/Depts/unsd/social/inc-eco.htm); and the UNDP (http://www.undp.org/hdr2001/indicator/cty_f_NGA.html; http://www.undp.org/popin/wdtrends/pop1999-00.pdf; http://www.undp.org/popin/wdtrends/urbanization.pdf).

Figure 1: Map of Nigeria

Nigeria's large population of 124 million makes it the most populous country in Africa, representing approximately one sixth of the population of Africa. The population is also growing very fast and is young (the median age is 17.4 years). People are therefore more likely to respond positively to new technologies. Furthermore, the existing telecommunications infrastructure serves only a tiny fraction of the population and is of poor quality. On the other hand, Nigeria's GDP per capita at USD473 (adjusted for relative prices is USD853) is low and below sub-Saharan Africa as a whole (USD490 per capita).[20] However, Nigeria is characterised by a very unequal distribution of income; the richest 10% of the population account for 40.8% of the national income compared to around 25% in European countries such as France, Germany and the UK. This means that there are a significant number of people and businesses that can potentially afford the technology, although ultimately teledensity is unlikely to be as high as those in more developed countries for some considerable period.

An insight into the likely demand for mobile telephony services in Nigeria can be gained by looking at Uganda in east Africa. Uganda with a population one-sixth the size of Nigeria, has in most other respects a very similar demographic profile, literacy structure and GDP per capita to Nigeria. Although Uganda had a monopoly supplier of GSM services between December 1994 and October 1999, once the market was opened to competition with the entry of MTN, subscribers grew dramatically from around 30,000 to 150,000 by the end of 2000.[21] As the Nigerian GSM market

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[20] It was estimated that for 1998 some 34.1% of the population fell below the national poverty line, measured by the UNDP as USD1 per day (source of data, http://www.undp.org/hdr2001/indicator/cty_f_NGA.html).

[21] See the Appendix.

will feature competition from day one, if the operators offer similar tariffs and coverage to those that were offered in Uganda in late 1999, then there could be over one million subscribers in a little over two years.

2.1 The structure of Nigeria's telecommunications sector

The main players in the Nigerian telecommunications sector are: the Federal Government of Nigeria, the Ministry of Communications, the NCC, and the telecommunications service providers.

The Federal Government of Nigeria is responsible for: giving overall direction for telecommunications development; ensuring telecommunications policy is consistent with other national policies; and enacting necessary laws and taking other measures in support of the National Telecommunications Policy. The Ministry of Communications is responsible for broad telecommunications policy, which includes proposing policy options and recommending legislation to Government and monitoring the implementation of government policy.

The NCC is the independent regulator of the telecommunications industry. It issues licences, assigns frequencies and regulates all licensees and service providers. The NCC performs regulatory functions necessary to promote the development of Nigerian communications. The effectiveness of the NCC has been reduced by the fact that it has been, to date, unable to regulate NITEL. This is because the decree under which it operates specifies that the NCC is to be the economic and technical regulator of the *privatised* sector of the telecommunications industry. Therefore, the operator with a monopoly over the local loop and domestic and international fixed lines has not, to date, been brought under regulatory control. This should change following the impending privatisation of NITEL, which is scheduled to take place in September 2001. The NCC has recently given notice that NITEL will be issued with a National Carrier licence prior to its privatisation.

Nigerian Telecommunications Limited (NITEL), the state-owned incumbent fixed-line operator, was established in January 1985 following a merger between Nigerian External Telecommunications Limited (previously responsible for external communications) and the Telecommunications Division of the Department of Post and Telecommunications (previously responsible for domestic telecommunications). NITEL was commercialised in 1992, following the implementation of a program of privatisation and commercialisation by the then Federal Military Government. In September 2001 the Government aims to privatise NITEL and sell 51% to a strategic investor. At present, NITEL is the only national carrier and basic service provider for domestic and international telecommunications fixed-line services.[22] Its Public Switched Telephony Network (PSTN) has a capacity of around 700,000 lines, of which about 500,000 are connected. It operates

[22] The NCC is in the process of awarding a second national carrier licence.

approximately 1,600 public payphones – or one payphone for every 77,500 in the population.

With regard to cellular telecommunications, the state-owned company Nigerian Mobile Telecommunications Limited (M-Tel, which has recently been merged with NITEL) was the only national operator of cellular services in the country until the beginning of August 2001. However, M-Tel's coverage was barely national as it covered three cities (Lagos, Enugu and Abuja). M-Tel runs an analogue system with a capacity of 210,000 lines, with around 40,000 of these connected to subscribers as at July 2001. In the second half of 2001 NITEL will launch its GSM service.

In addition to the two national operators, there are several small private operators (e.g. Multi-Links Telecommunications Ltd., and Intercellular Nigeria Ltd.) serving Lagos. These primarily deploy fixed wireless technologies and are used by businesses and high net worth individuals. Some large companies (Shell is an example) have constructed their own private radio-communications networks.

Although in the run up to the auction there existed nine mobile (GSM) telephony licensees, their failure to build out infrastructure and launch a commercial service meant, according to the NCC, that they had violated the terms of their licences and therefore were not permitted to operate a service. Furthermore, the new process meant that their licences were not valid and *de facto* revoked. The issuing of new licences effectively rendered worthless the licences issued under the military government, and the NCC returned to the licence holders their application fees. One of the companies, Motophone, returned the funds to the NCC and mounted a legal challenge to stop the auction process.[23]

3. A four-stage licence award process

The licence award process featured four stages: an invitation stage; a pre-qualification stage; an auction stage; and a grant stage. The auction stage embodied both an ascending bid auction and a sealed-bid auction. Hence it was an 'Anglo-Dutch Hybrid', as it featured an English ascending auction and a sealed-bid auction.[24] The sealed bid auction was conditional on the numbers participating or would be used to resolve ties at the end of the ascending auction.

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[23] Motophone, who had been issued a licence by the General Sani Abacha regime, challenged in the High Court unsuccessfully the NCC's right to hold the auction and award new licences.

[24] A first price sealed bid auction for a single item is strategically equivalent to a descending Dutch auction, see McAfee and McMillan (1987). Klemperer (2001) asserts Anglo-Dutch spectrum auctions are superior to many other auction forms.

3.1 The invitation stage

The invitation stage comprised the publication of the Information Memorandum (on December 8, 2000), containing details about all the stages of the auction, application forms, and pre-qualification requirements.[25] The chronology of key events leading up to the auction is presented in Table 2.

3.2 Pre-qualification stage

Prospective bidders were asked to submit their applications along with a USD20 million deposit. A deposit of USD 20 million was selected for two main reasons. First, the deposit was set at a level that would not challenge those organisations serious about bidding for a licence, but would likely deter frivolous and speculative bidders. Second, the placing of a deposit meant that bidders could be penalised for violating the auction rules, either by a fine for minor misdemeanours or by forfeiting the deposit for serious violations.

If a bidder failed to meet the pre-qualification criteria (which were largely corporate probity checks, matters relating to experience with telephony services, and the submission of signed compliance certificates), the deposit would be returned to the applicant with interest. Applications were required to be submitted no later than 3pm December 21, 2000. Five consortia submitted applications to the NCC; these are described in Table 3.

In many spectrum auctions bank guarantees (usually set at a level equal to at least the reserve price) have been required as part of pre-qualification, to ensure credible bidding so that successful bidders can and do pay for the objects won. For example, in the Italian 3G auction bidders were required to submit a bank guarantee for 2,065,827,596.36 euros. However, in the context of Nigeria, few (if any) international banks would entertain extending guarantees for USD100 million (the reserve price). It was felt by the NCC that the demands of the banks would be such it would unduly delay the auction timing. Furthermore, there was a distinct possibility that a bank guarantee requirement would compromise the participation of Nigerian led businesses, which was deemed politically sensitive. Although the economists on the auction design team were enthusiastic about prospective bidders presenting a bank guarantee, it was decided not to impose this as a condition of qualification into the auction. The risk of doing this would be default post-auction, which in fact occurred, although this was apparently not due to an inability to pay, see Section 5.2 below.

[25] The 'Information Memorandum' is located at http://www.ncc.gov.ng/digital_mobile/infomem (last visited August 20, 2001).

Table 2: Chronology of events leading up to the GSM auction in Nigeria

Date	Event	Key points
February 18, 2000	New Executive Vice Chairman (EVC) of the NCC	Engr. Ernest Ndukwe appointed as EVC of the NCC
February 28, 2000	Cancellation of comparative selection process	President requests an auction – to promote transparency
June 26, 2000	NCC appoints Principal Consultant	Radio Spectrum International appointed as Principal Consultant
October 25, 2000	NCC publishes Initial Consultation Document (ICD)	ICD sets out auction timetable: • End Sept - Information Memorandum to be published • Mid Nov – Deadline for applications to pre-qualify • Nov / Dec – Auction and grant of licences
November 29, 2000	NCC confirms that one licence will be reserved for NITEL	NITEL to pay the price determined by the auction
December 4, 2000	Deadline for applications and deposits extended	• Dec 21, 2000 – deadline for submission of applications and deposits • Jan 8, 2001 – qualified bidders to be announced • Jan 17, 2001 – start of auction
December 8, 2000	Information Memorandum (IM) published	IM contains application form, detailed auction rules and auction logistics
December 21, 2000	Five consortia apply for the auction and submit deposits	Applicants: 1. Econet Wireless Nigeria Ltd, 2. United Networks Mobile Ltd, 3. MTN Nigeria Communications Ltd, 4. Communication Investments Ltd, 5. MSI-Celtel Nigeria Ltd.
January 8, 2001	NCC announces qualified bidders	All five applicants qualify for the auction
January 16, 2001	Mock auction with bidders and Bidder Briefing	Modifications to auction rules, publication of the Bidder Information Pack (see http://www.ncc.gov.ng/digital_mobile/misc_docs/ bidder information pack 1.doc)
January 17, 2001	Auction begins	Supplemental Bidder Information Pack issued to bidders (see http://www.ncc.gov.ng/digital_mobile/misc_docs/supplemental bidder information pack.doc)

It may seem strange to have a pre-qualification stage, particularly as the outcome of auction ought to ensure that the best-qualified applicants succeed in winning licences.[26] The main reasons a pre-qualification stage was chosen was to ensure that the applicants were not engaged in money laundering or other illegal activities, that they satisfied the ownership rules designed to deter collusion, and to enable the NCC to punish bidders credibly.[27] While the NCC was keen to attract high-profile international telecommunications service providers, it recognised that the pre-qualification stage would have little bearing on the demand for licences.

On January 8, 2001 all five applicants successfully satisfied the pre-qualification criteria and were announced as 'Qualified Bidders'. The qualified bidders were mainly African investors, see Table 3.

[26] In most spectrum auctions there is usually a pre-qualification stage, requiring applicants to submit deposits and information. In Nigeria the pre-qualification criteria were undemanding, whereas in some other countries they have been particularly onerous. For example, in the forthcoming 2G and 3G spectrum auction in Israel in the questionnaire that the applicants need to complete they need to provide "an inclusive marketing and business plan **for the ten years** following the date of grant of the License", from Chapter D, Appendix A, *Tender No. 1/01 For the Award of a Combined License for Mobile Radio Telephone Services Using the Cellular Method (MRT) in Israel*, Ministry of Communications, August 2001, emphasis added.

[27] See Masciandaro (1999) on regulation and money laundering, and Swamy (2000) for a discussion on money laundering in Nigeria.

Table 3: Qualified Bidders

Qualified Bidder	Brief description
Communication Investments Limited	Nigerian led consortium with Dr Mike Adenuga Jnr as main shareholder and German consulting firm Detecon GmbH as technical adviser.
Econet Wireless Nigeria Limited	Consortium led jointly by Econet Wireless International Limited (listed on the Zimbabwe stock exchange) and First Independent Networks Limited (a consortium of Nigerian investors). Econet operates cellular services in several sub-saharan African countries.
MSI-Celtel Nigeria Limited	Consortium led by MSI Cellular Inv (Nigeria) BV, wholly owned by the Dutch group MSI Cellular Investments Holdings BV. MSI operates mobile services in several African countries.
MTN Nigeria Communications Limited	Consortium led by MTN International Limited, ultimately owned by M-Cell listed on the Johannesburg stock exchange. A major player in South African mobile telecoms.
United Networks Mobile Limited	Consortium led by Orascom Telecom, a major telecommunications operator in Egypt and North Africa.

3.3 The auction stage

Design

A well-designed spectrum auction should achieve efficiency (in an expected sense) and be fair (in the sense that the interests of the auctioneer and the bidders are sensibly balanced).[28] An efficient auction ensures that the licences would be awarded to those who value the spectrum the most, and those who have the highest valuations should provide society the greatest net benefit. A well-designed auction should therefore elicit the highest bids from those who hold the highest values for the objects being auctioned. Auctions, unlike comparative selection processes, are more likely to achieve efficient outcomes because the process forces bidders to estimate the value, to them, of a licence for the spectrum. Depending on the form of the auction, some or all of this information is revealed to the market during the bidding process. This price discovery reduces bidder uncertainty and improves the efficiency of the auction. In the context of Nigeria the use of an auction also meant that the process would be seen as objective – the outcome of the auction would be easy to understand and difficult to challenge.

In designing a spectrum auction, factors that need to be taken into account are resource constraints, transactions costs (complexity), and factors that might lead to collusion among bidders.[29] The absence of reliable communications and power infrastructures in Nigeria militated against the use of sophisticated auction support systems. While electronic bidding systems over secure extranets are increasingly a feature of spectrum (and other) auctions in Europe, North America, and Australia, such technologies could not be supported in Nigeria.[30] To ensure credibility the Nigerian auction design had to be simple and easily understood by prospective bidders and commentators. Finally, the auction design had to be robust against collusive tendencies, which had arguably undermined the success of some 3G auctions in Europe.[31]

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[28] Dasgupta and Maskin (2000) define an efficient auction as maximising surplus conditional on all available information. In a private value auction, a second price Vickrey auction (for one good) or its Groves-Clarke extension (for multiple goods) is efficient. The Nigerian auction of course included common values, but Dasgupta and Maskin prove for a class of common value auctions these can be constrained efficient.

[29] See Cramton (2001), Klemperer (2001) and McMillan (2001).

[30] In the Swiss 3G auction the server was located in Boston, USA, see http://www.fedcomcom.ch/docs/rohstoff_290800_e.pdf.

[31] The apparent failure of competition in some European 3G auctions towards the end of 2000 coincided with the period when the Nigerian auction was designed. Two 3G auctions in Europe suffered in the final quarter of 2000: Austria in November, and Switzerland in December. The problem besetting these auctions was a low number of bidders relative to the number of spectrum packages available. Participation problems arose because of an increasingly negative outlook for demand, rising technological uncertainty, and more sophisticated bidder actions in response to the auctions designed. Melody (2001) has argued that Europe mismanaged 3G mobile spectrum auctions, claiming that they

As well as the above factors, the number of objects and their characteristics are critical inputs to the design of an auction. The Nigerian GSM auction comprised three 'identical' licences: each containing rights and obligations, with a fourth reserved licence to be issued to NITEL.[32] The rights were fifteen years exclusive access to a 40 MHz spectrum package, comprising 2x5 MHz in the 900MHz band and 2x15MHz in the 1800MHz band, to be used for the purposes of delivering digital mobile telephony services. The obligations were, amongst other things, rollout obligations, annual licence fees related to audited net revenues, prohibitions on anti-competitive behaviour, etc. While the quantity of spectrum in each package was known to be identical before the auction, differences *ex post* could arise depending upon the spectral location of each package.[33] However, the spectral location of each spectrum package was not specified before the auction (other than the overall frequency range within which all the packages resided). In order to maintain identical packages *ex ante*, the precise frequency locations of the packages were to be determined by a publicly observable random draw after the conclusion of the auction, see Section 3.4.

Ideally the auction should have been designed to encourage the bidders to focus on assessing valuations. This is straightforward where the value of a licence is entirely private. However, spectrum licences are influenced by both private and common values.[34] In auctions where an element of the value is common (essentially influenced by factors common to all bidders), this tends to give rise to the winner's curse. The effect of the winner's curse can be particularly pronounced for the case of a sealed bid auction. However, because an ascending auction is a discovery process it tends to promote more accurate price discovery, which ought to mitigate the winner's curse, and so prices should more closely reflect true market values.

In deciding how to auction three identical packages, the design team considered many competing auction formats. These fell broadly into two classes of auction: sealed bid auctions and ascending bid auctions. The success in raising substantial sums in some ascending bid spectrum auctions, notably the PCS auctions organised by the FCC in the mid-1990s (see Cramton (1995) and Milgrom (2000)), and the 3G auctions in the UK in 2000

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failed to improve efficiency and enhance competition. Klemperer (2001) also criticises many of the 3G auctions in Europe held in 2000.

[32] NITEL, the state owned incumbent operator, was being prepared for privatisation. As the monopoly provider of public switched telephony services in Nigeria, it was regarded as crucial for economic development that it acquired GSM licence. However, NITEL was excluded from the auction, in return for the guarantee of receiving a licence at the same price as yielded in the auction. There was a fear that other bidders might suspect the government would use NITEL to influence bids. Furthermore, NITEL, as the sole provider of interconnect services, was in constant discussions with all the bidders and its participation might have increased greatly the chances of collusive and strategic bidding.

[33] For example, the quality of spectrum used by x can be affected by neighbouring users, those with frequency boundaries (almost) contiguous with the frequency boundaries of x.

[34] See McAfee and McMillan (1987), Milgrom (1985,1987) and Wilson (1982) for a discussion on auctions, information and bidding.

(see Klemperer (2001)), excited some in Nigeria. But those closely involved in the process were less mesmerised by the revenue raising potential and more concerned with: ensuring that the process was transparent (*i.e.* free of corruption), achieving an efficient allocation, and that the successful bidders would commence commercial operations.

Although the NCC was confident that there would likely be substantial interest in the licences, with market sentiment around the world turning adversely against telecommunications investments in late 2000 there was a concern that a small number of prospective bidders might collude in an attempt to avoid paying high prices in a competitive auction. The NCC was determined to avoid the situation that arose in the Swiss 3G auction, where the number of bidders who were to participate in the auction fell from ten (in August 2000) to four just before the auction was due to start on November 13, 2000 (equal to the number of licences to be auctioned).[35]

Collusion prior to and during the auction needed to be deterred[36] and so in the Information Memorandum[37] it was stated "A Bidder is not allowed to communicate with any other Bidder from the Application Date [December 21, 2000] through to the end of the Auction Stage on matters that could have a material effect on either the price paid for DMLs [Digital Mobile Licences] or the identity of Successful Bidders…The Commission [NCC] prohibits any and all communications between and among Bidders related to the Auction, including but not limited to: bid strategy, budgets, willingness to pay, valuations, identities of bidders, etc.". If a bidder violated these rules, he would have forfeited his deposit of USD20 million and been excluded from the auction. In the event, this did not arise.

Although anti-competitive collusion was unwelcome, it was even more important to ensure that there would be at least four applicants. For given demand expectations, the key variables affecting participation in a spectrum auction are the reserve price and the number of licences (a proxy for post-auction competition). In the Nigerian auction the designers effectively had no discretion over these key variables. The previous aborted process in early 2000 had set a licence fee of USD100 million and this resulted in seventeen applications, and so public expectations effectively forced the hand of the

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[35] See Total Telecom, 'Swiss UMTS auction is postponed as five become four", November 13, 2001, http://www.totaltele.com/view.asp?articleID=33712&Pub=TT&categoryid=625&kw=switzerland.

[36] In some recent spectrum auctions designers have striven to counter collusion by: making bidders names anonymous when announcing results in the auction (e.g. the Hong Kong 3G auction, see http://www.3gnewsroom.com/country/hong_kong.shtml); making bidders commit to participation by not allowing withdrawal once an application has been submitted (e.g. Denmark, where prospective bidders must include their first bid with their application to participate in the auction, see http://www.tst.dk/index_uk.htm (a similar rule applied in the Nigerian GSM auction, as bidders would have forfeited their deposits had they withdrawn in the first round); and by cancelling the auction if the number of bidders is less than or equal to the number of licences at the start of the auction (e.g. Taiwan, see http://www.dgt.gov.tw/).

[37] Section 4.7.1.

auction designers to choose a USD100 million reserve price.[38] The number of licences to be awarded had been set by the government in the National Policy.

A hybrid auction

Because of the possibility that the number of bidders applying to take part in the auction would be small, it was decided to design a hybrid auction. Depending on the number of qualified bidders, the auction would commence as an ascending clock auction or a sealed bid auction. If the number of qualified bidders were equal to four, a (fourth price) sealed bid auction would take place.[39] An ascending clock auction would arise in the event of five or more qualified bidders.

In an ascending clock auction the auctioneer announces prices to bidders that increase over time (ascend with the clock) and bidders choose whether to accept or reject the announced prices. A bidder choosing to reject an 'announced price' reveals that he or she is not willing to pay that sum for the object being auctioned. While competitive ascending bid spectrum auctions where bidders submit prices have featured in many countries, the Nigerian auction is believed to be the first ascending clock (spectrum) auction to have taken place.

Where the objects in an auction are identical, the auctioneer needs to announce only a single price in an ascending clock auction. Where objects differ, the auctioneer would need to announce a price for each item. In the Nigerian GSM auction the licences were identical and hence the auctioneer could announce a single price. When the auctioneer announces a price, which is the required bid amount, bidders must accept this amount in order to remain in the auction. The auction is over when the price rises to the point where the number of bidders willing to bid on the licences, at the required bid amount, is equal to the number of licences being auctioned. The winning bidders pay the required bid amount and each winning bidder is assigned one of the identical licences.

The main complication that can arise in an ascending clock auction stems from discrete changes made to announced prices. For example, the number of bidders can fall from above to below the number of licences available

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[38] Had a different reserve price been selected it was felt that intense scrutiny by the media would have undermined confidence in the auction. A lower price would have resulted in accusations of giving away the family silver, and a higher reserve price would have resulted in accusations that the price was so high it would deter Nigerian investors.

[39] The Information Memorandum did not specify what would happen in the event of three or fewer qualifying bidders. This was due in part to the NCC being confident there would be more than four applicants, based on expressions of interest and on the process cancelled earlier in the year, and due in part of not wanting to signal to prospective bidders that the NCC believed there was low market demand. The Information Memorandum did, however, state that the "Commission reserves the right not to proceed with the Auction or to change the timing or any other aspect at any time without prior notice" (page 29).

because the announced price overshoots some or all of the valuations. In the Nigerian GSM auction a case that needed to be considered was where the number of active bidders fell from, say 4 to 2. That is, in a round following a new price announced by the auctioneer more than two bidders say they are not willing to pay the amount. The solution implemented to deal with this kind of possibility was a secondary sealed bid auction. The purpose of holding a sealed bid auction, rather than instigating another ascending clock auction, was partly motivated by a desire to promote competition in bidding, but mainly due to a desire to end the auction quickly.

An important constraint on the auction design was 'symmetry': the requirement that each successful bidder should pay the same price. This constraint reflected a fairness consideration held by the public and many politicians; that identical licences should be sold for identical prices. If the ascending auction ended with the number of successful bidders equal to the number of licences, symmetry would not present a problem. However, if the ascending clock auction were to enter a sealed bid secondary auction, this required some imaginative thinking. To reconcile the objective of symmetry with sealed bids having different values, we differentiated between what we termed the 'Final Price', which all successful bidders would pay, and a 'Premium' that successful bidders in a secondary sealed bid auction might pay.

The rules of the secondary sealed bid auction were straightforward. Each bidder in the sealed bid auction was required to submit a bid in units of USD10, which could not lie below the highest Announced Price at which the bidder responded "Yes" in the ascending bid phase.[40] At least that part of the design was simple. The Final Price could not exceed the price agreed by a successful bidder in the ascending clock auction. As the winner(s) of the secondary sealed bid auction would be determined by the highest bids submitted, it was necessary to deter bidders from submitting unrealistic or infeasible bids.[41] But the winning bidder(s) in the sealed bid phase would have to pay the same Final Price as the successful bidder in the ascending phase. To deter unrealistic bids and accommodate symmetry we designed the total amount to be paid to comprise the Final Price, which was identical across all successful bidders and hence symmetric, and a Premium that might be paid by those succeeding in the sealed bid phase. In this case the Premium would constitute a penalty on any successful bidder who submitted a sealed bid lying above the highest announced price agreed by a bidder in the ascending clock auction.

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[40] In the unlikely event that all bidders exercised waivers for all announced prices, the reserve price of USD100 million would constitute the floor in the secondary sealed bid auction – and this would be the Final Price. Bidders would pay a premium on top of this determined according to their submitted bids.

[41] This issue was raised by one of the actual bidders during the real mock auction held on January 16, 2001.

Examples of possible auction outcomes using hypothetical figures were presented to the bidders at the Bidder Briefing on January 16, 2001. Example 1 in Figure 2 is a case where the ascending clock auction enters a secondary sealed bid auction. The example has four bidders competing for three licences. The ascending clock auction ends with one bidder agreeing to pay USD47, and three others saying "No". Hence, one bidder is granted a licence at USD47 and the other three enter the secondary sealed bid auction.

Figure 2: Example of secondary sealed bid auction presented to the bidders on January 16, 2001

Example 1

Suppose a Successful Bidder has said Yes at $47 and does Not enter the Sealed Bid Phase
Assume there are 3 Eligible Bidders in the Sealed Bid Phase Competing for two (2) Licences
Assume the 3 Eligible Bidders in the Sealed Bid Phase submit Sealed Bids: Bidder 1 submits Sealed Bid $45, Bidder 2 submits Sealed Bid $48 and Bidder 3 Sealed Bid $52
There are two Successful Bidders paying a Final Price: $47 Plus a PREMIUM = $1 for Bidder 2 and PREMIUM = $5 for Bidder 3

The Successful Bidder in the Ascending Bid Phase pays a Final Price: $47

Auction rules

Auction rules are often very detailed and cover activities by bidders before, during and immediately after the auction. Rules are required to prevent collusive behaviour that could undermine efficiency, and to provide detailed guidance about what is and what is not permitted during an auction. Detailed and precise rules are required so as to give bidders as much certainty as possible, encouraging them to concentrate on valuing the licence rather than engaging in excessive strategizing against each other. Spectrum auction rules are typically drafted by economists and lawyers, who together work with the auctioneer. In the Nigerian GSM auction the NCC, advised by its consultants, wrote the rules.

Auction designers often specify rules for almost all eventualities, even for circumstances that may seem highly unlikely. In the context of designing the Nigerian auction, considerable attention was paid to events that did not materialise, and were only expected to occur with a very low probability.

Had the designers not accounted for outcomes that were viewed as highly unlikely, this would have resulted in the bidders (and other commentators, which importantly in Nigeria included the media and politicians who were closely scrutinising every move) losing faith in the auction process.

Waivers and increments

In many ascending spectrum auctions, bidders are given an opportunity to pause and reflect on their strategy. This is usually permitted in two ways: via 'waivers'[42] and through the calling of a 'recess'[43]. The action of a waiver is where a bidder is allowed to abstain from making a bid in a round. In an ascending clock auction this would amount to a situation where the bidder is neutral, neither responding "Yes" or "No". A waiver is intended to give a bid team pause for thought and possibly time to communicate with financiers and other interested parties. In the Nigerian GSM auction, communication between the bid team and external advisors was not allowed during the auction day. Hence, granting waivers to bidders would serve the purpose of allowing a bid team extended time to discuss its bid response.

Whether or not to allow waivers in an auction poses a challenge for the auction designer. Bidders expect and should be granted a reasonable amount of time to discuss their valuation, particularly as bidders in high-stakes spectrum auctions are typically consortia whose members may have different views and means of access to capital. However, allowing bidders time to compose bids by granting waivers means there is a chance they could use waivers to mislead other bidders, or to take advantage of information revealed in an auction by other bidders.[44] It was decided that bidders would be permitted a maximum of three waivers. However, we chose not to grant the option of a recess, where a bidder can call a halt to the auction for a finite period.[45] The fear was a recess would heighten the prospect for collusion, especially as the bidders were located at one location.

The increments to the announced price were bounded, but were set so that they would not increase by more than ten per cent between rounds (rounded up to the nearest USD1 million). Not fixing the increments provided

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[42] Waivers are intended to provide a bidder breathing space at a stage in an auction when bid values may be close to the bidders' valuation, or where in a multi-unit auction a bidder needs more time to recompute his or her preferred combination of objects.

[43] A recess is where a bidder requests the auction is suspended for a finite duration, usually a day.

[44] Playing waivers at the beginning of a multi-unit ascending bid spectrum auction could provide a strategic advantage if other bidders do not play waivers at the same time. Playing early waivers can benefit the bidder playing a waiver and the other bidders not playing a waiver. This is because strategic use of waivers in such auctions can lead to demand reduction, see Ausubel and Cramton (1996). See Section 4.2 for further discussion on this point.

[45] In many recent spectrum auctions recesses have been allowed. For example, in the forthcoming Israeli 2G and 3G auctions, bidders are allowed to call a twenty hours time-out. In the UMTS auction held in the UK in March and April 2001, Telefonica called a recess day on April 6 so that it could hold a meeting of the Board.

discretion over the pace of the auction. Furthermore, on each auction day the announced price was not allowed to increase by more than fifty per cent (rounded up to the nearest USD1 million). By not providing the option of a recess, it was necessary to give bidders a clear indication of the maximum possible price each day in the auction, given their inability to communicate externally.

3.4 The grant stage

The successful bidders in the auction stage progressed into the grant stage. Within fourteen days of the auction ending, each successful bidder had to pay the outstanding sums owed to the NCC. Upon payment, the 'provisional' successful bidders would acquire a fifteen-year licence.

4. The auction logistics

4.1 Preparing the staff of the NCC

An important requirement of the process was to keep the Commissioners and staff of the NCC fully informed of the preparations for the auction and how the auction itself would run. This was needed for two reasons: first, it was essential that the auction advisers were kept accountable to the Commission and, second, NCC staff had important tasks to fulfil during the running of the auction.

Training and informing the NCC staff about the auction took the form of briefings, workshops and mock auctions. The first such briefing was held in October 2000 in Abuja, Nigeria, and took the form of a presentation to the Board of Commissioners of the NCC. This was to present the preliminary thoughts of the auction design team to the Commissioners and to propose a way forward based on the conclusions of the market analysis, industry consultation and other work undertaken by the auction design team.

Following the publication of the Information Memorandum, there was a further presentation to the staff and Commissioners of the NCC in Abuja. This was to present the final version of the auction rules to the NCC and to ensure that all personnel involved in the auction knew how the auction would operate. This was followed by a workshop in early January 2001, which took the auction team and the NCC through the auction procedure in great detail, ensuring that all the personnel involved in the auction knew exactly what their role entailed.

The next stage in the process was to hold a series of internal mock auctions. These aimed to replicate the actual auction as closely as possible. Hence they were held in the same location (using the same rooms) as the real auction.

NCC staff played the role of bidders. In order to test as many potential scenarios as possible, "bidders" were given different valuations in order to construct different outcomes. Thus the auction designers were able to engineer an outcome in which the secondary sealed bid auction was used in addition to the ascending clock auction. In order to avoid speculation as to actual bidders' valuations (which may have been leaked to the media), the bid teams made up of NCC staff were given names of Nigerian cities (Abuja, Kaduna, Lagos, Port Harcourt and Warri – see Figure 1) rather than names of actual bidders, and the valuations used did not correspond with expectations of the real bidders' valuations.

4.2 The auction process

During the initial consultation phase, the possibility of holding the auction remotely using secure fax or Internet links was discussed. However, it was concluded that this would not be appropriate in the Nigerian context due to the inadequacies of the communications and power infrastructures. There was a real possibility that communication links between bidders and the auction control team could fail during the auction. Therefore, it was decided that the auction would take place at a single location (the Nicon Hilton Hotel, Abuja) with all the bidders present.

With all the bid teams present at the same location, there was a possibility this would increase the likelihood that they may communicate, despite this being forbidden in the auction rules.[46] To minimise the prospects for collusion, bidders were called to the auction location on January 16, which was as close to the start of the auction as possible. On this date a bidder briefing session was held in which the auction rules were reiterated in detail, particularly those forbidding communication among qualified bidders, and the auction logistics were explained.

The bidder briefing was followed by a mock auction in which the bidders participated. This took the same format as the internal mock auctions; that is bidders were given artificial valuations and took the names of Nigerian cities in order to retain anonymity. The mock auction was a chance for the auction control team to test its procedures and also for the bidders to test the

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[46] On the other hand, an argument in favour of having bidders present at one location is that it makes it easier to monitor interaction between bidders. Where an auction makes use of the Internet or fax, it is much more difficult for an auctioneer to monitor communications between bidders. A good illustration of the challenges posed in an Internet based auction arose recently where CRA advised a bidder. The bidder chose a strategy in the first round of calling for a recess day. This unusual strategy led the auctioneer to suspect that the bidder was buying time to enable talks with other bidders over a weekend. As it was a multi-unit auction, there were arguably additional incentives to collude (e.g. choosing demand reduction strategies). The bidder needed to correspond with the auctioneer to provide an assurance that the strategy had been chosen for reasons connected with a matter not related to the other bidders. Had the auction been held in one location, this may have been unnecessary. However, where auctions may extend over long periods and feature recess days (as happened in the New Zealand and UK 3G auctions), it would be unreasonable to demand that bidders be present at a single auction location. Also, where the number of bidders is expected to be large, as is often the case in US spectrum auctions, it would be a logistical nightmare to accommodate all the bidders and their advisors in a single location.

robustness of the auction processes.[47] In fact, modifications to the auction rules were made in response to suggestions received during the mock auction, as explained in Section 3.

The auction proper began at 10am on the day after the mock auction (January 17, 2001). The bid teams were escorted to their bid rooms by independent observers. The independent observers were members of the NCC staff who carried out two roles. They were the point of contact between the bid teams and the auction control team and they sat with the bidders in their bid rooms to ensure they observed the auction rules. Bidders were not allowed to communicate with people outside their bid rooms during the day. If a member of a bid team had to leave a bid room for any reason during a day of bidding, he or she was not allowed to return and could not be replaced during that day.

Rooms were randomly allocated to bid teams at the beginning of each day and were not located adjacent to each other. The fact the bid teams knew that the announced price could not increase by more than fifty percent on an auction day, removed the need for communication with outside interested parties (key shareholders, investors, etc.) during the day. The nature of the auction, and the fact that communication with bid teams was not possible during the bidding, meant that bid teams largely consisted of senior directors (Chairman, CEOs, CFOs, etc.) of the companies involved, so that key decisions could be taken during the day.

To lend credibility to the process and prevent contravention of the auction rules, all communications between the bid teams and the auction control team were verified using approved signatures and passwords. Bid teams were notified in writing by the auction control team at least thirty minutes before the start of each round of bidding. Each round lasted twenty minutes. At the beginning of a round, bid teams received a bid form stating the announced price, to which they had to respond "Yes", "No", or "Waive". Bidders were given two copies of the bid form, which they had to return in separate envelopes; one of which was only opened in the case of a dispute.

After the auction control team received the bid forms, a bid confirmation form was issued. If bidders disputed the recorded bid, they could respond in writing within five minutes. Provided there were no disputes (which was the case throughout the auction), a form was then issued to all bidders showing the results of the previous round (*i.e.* the responses of all the bidders) and the timings of the next round. This marked the end of a round. The process was then repeated, provided there were sufficient active bidders remaining in the auction.

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[47] In all spectrum auctions where the authors have advised bidders, the rules have been fine-tuned close to the start of the real auction. Not surprisingly, improvements in the rules and logistics are usually made during mock auctions with the actual bidders.

At the end of an auction day, bidders were to vacate the bid rooms. This allowed bidders time to communicate with their advisors, and to prepare their strategy for the following day.

4.3 Dissemination of information

It was decided that, as with 3G auctions in Europe and elsewhere, information on the progress of the auction would be made available to as wide an audience as possible after the conclusion of each round. This level of disclosure and transparency was without precedent in Nigeria.

At the end of each round, there was a press briefing. This took place in the same location as the auction immediately after the bidders had been informed of the results of the round. In addition, an even wider audience had access to information on the auction through the Internet. The auction results were uploaded onto the NCC's website[48] around twenty minutes after the conclusion of each round.

5. The auction outcome

The auction lasted three days and the Final Price was USD285 million. The process was heralded as a great success in Nigeria. Table 4 provides the full auction outcome and results. While market expectations[49] indicated that the licences would probably double in price, the final outcome was a surprise to many (see Section 6 below).

5.1 Auctioneer's strategy

The auctioneer's discretion was limited in the auction to the setting of the increments to the announced price. Even here discretion could have been sacrificed in favour of an approach where the announced price increased by ten per cent in each round. Increments of ten percent would have meant that the number of rounds in a day could be kept to a minimum. However, for a higher announced price, fixed increments of ten percent would lead to larger absolute increments. As the auctioneer wanted to minimise the prospect of a situation where all bidders responded "No" following a previous round where they all responded "Yes", a discretionary approach to the setting of the announced price was preferred over a formulaic approach.

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[48] http://www.ncc.gov.ng/digital_mobile/auct_info/auction_info.htm provides full round-by-round details of the auction.

[49] In an article in the Financial Times, January 11, 2001, it was reported, "Bidding starts at USD100m each, but analysts expect the price to double". Source: http://globalarchive.ft.com/globalarchive/articles.html?id=010111001636&query=Nigeria (last visited August 11, 2001).

It can be seen in Table 4 that on day one of the auction the announced price increased between USD9-11 million in each round, and concluded after six rounds at USD150 million. In every round the responses received from each bidder was "Yes". If the auctioneer had increased the announced price by the maximum permitted each round, there would still have been six rounds on day one.[50] The Bid Teams vacated their approved rooms at around 6pm on day one.

The auction commenced on day two at 10am and again concluded after six rounds at around 6pm, with all five bidders present. In the first round on day two the announced price increased by the maximum permitted, leading to an absolute increment of USD15 million. All bidders responded "Yes" to the announced price of USD165 million. However, in the second round on day two, United submitted "Waive" in response to the announced price of USD178 million. This resulted in discussions among the auction control team, who slightly reduced the increment for the next announced price. For the remainder of day two all the bidders responded "Yes" and the announced price reached the maximum permitted for the day, USD225 million. By the end of day two the outcome surprised many, and speculation in the press intensified.

At the beginning of day three the auctioneer believed this would be the final day. Nobody on the auction control team expected the price of a licence to exceed USD338 million, the maximum permitted for day three. The auctioneer believed a big increment would be needed at the beginning of day three, to see whether this would lead to the withdrawal of one bidder and thus bring in sight the end game. The motivation for choosing a large increment at the beginning of the day was based on the responses received on the previous day. The first increment on day three was a maximum ten percent, or USD23 million, which was the largest absolute increment to the announced price made in the auction. This resulted in an announced price of USD248 million, and to the surprise of the auction control team all bidders responded "Yes".

In formulating the announced price for round two on day three, another large increment of USD17 million, though proportionately less (6.9%) than that made in round one, was made. This elicited four "Yes" responses and a "Waive" from the bidder MSI. This was the second waiver played in the auction, but given the high level of the announced price, MSI's waiver was interpreted as a sign of their impending exit.[51] Because no other bidder had waived on day three, a high increment to the announced price was made in round 3 (USD20 million, 7.5%) to force the pace of exit. This resulted in three "Yes" responses and two "Waive" responses from MSI and United.

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[50] In this case the announced price would have progressed as follows: 100, 110, 121, 134, 148, 150 (all USD million).

[51] Assuming MSI were playing rationally, their valuation was probably around USD250 million.

The auctioneer was confident that the end game was in sight, and in an effort to avoid overshooting and precipitating entry into a secondary sealed bid auction, the increment to the announced price for round 4 was set much lower at USD10 million (or 3.5%). This resulted in only two "Yes" responses, from CIL and Econet, two "Waive" responses, from MSI and MTN, and a "No" response from United. Hence, United had withdrawn from the auction, and MSI had played the maximum number of waivers allowed under the rules.

The auctioneer expected the auction to conclude in the next round. The belief was that MSI would respond "No", and the other bidders would respond "Yes" or "Waive". The smallest increment to the announced price for the entire auction was made, USD5 million (or 1.7%), resulting in an announced price of USD300 million. Only CIL responded "Yes", with Econet and MTN responding "Waive" and MSI responding "No".

Thus the ascending clock auction finished at the end of round five, day three. The Final Price was USD285 million, which was determined in round three on day three — the round in which all three successful bidders last responded "Yes". The total amount raised was USD1,140 million, pending full payments to be made by February 9.

5.2 Bidders' decisions and strategies

Each bidder prepared for the auction by assessing the market for mobile telephony services in Nigeria. Using this 'common' information and other 'private' data, each bidder compiled a detailed business plan. The business plans were then used to inform the bidding consortia about the valuation of a licence. As with all business plans, they are highly sensitive to the assumptions invoked and methodologies deployed. Where differences would manifest themselves is in the modelling of the post-auction market. Having informed numerous bidders in other spectrum auctions, it is our expectation that each (well-organised) bidder would have built a model of the post-auction market to predict the evolution of supply and demand, and consequently the evolution of equilibrium prices.

Table 4: The round by round results of the Nigerian GSM auction

Day	Round	Announced Price	Increment		Communications Investment Ltd.	Econet Wireless Nigeria Ltd.	MSI-Celtel Nigeria Ltd.	MTN Nigeria Communications	United Networks Mobile Ltd.
			Percent	Absolute					
1	1	100.000.000			Yes	Yes	Yes	Yes	Yes
1	2	110.000.000	10.0%	10.000.000	Yes	Yes	Yes	Yes	Yes
1	3	121.000.000	10.0%	11.000.000	Yes	Yes	Yes	Yes	Yes
1	4	130.000.000	7.4%	9.000.000	Yes	Yes	Yes	Yes	Yes
1	5	140.000.000	7.7%	10.000.000	Yes	Yes	Yes	Yes	Yes
1	6	150.000.000	7.1%	10.000.000	Yes	Yes	Yes	Yes	Yes
2	1	165.000.000	10.0%	15.000.000	Yes	Yes	Yes	Yes	Yes
2	2	178.000.000	7.9%	13.000.000	Yes	Yes	Yes	Yes	**Waive**
2	3	190.000.000	6.7%	12.000.000	Yes	Yes	Yes	Yes	Yes
2	4	200.000.000	5.3%	10.000.000	Yes	Yes	Yes	Yes	Yes
2	5	212.000.000	6.0%	12.000.000	Yes	Yes	Yes	Yes	Yes
2	6	225.000.000	6.1%	13.000.000	Yes	Yes	Yes	Yes	Yes
3	1	248.000.000	10.2%	23.000.000	Yes	Yes	Yes	Yes	Yes
3	2	265.000.000	6.9%	17.000.000	Yes	Yes	**Waive**	Yes	Yes
3	**3**	**285.000.000**	**7.5%**	**20.000.000**	**Yes**	**Yes**	**Waive**	**Yes**	**Waive**
3	4	295.000.000	3.5%	10.000.000	Yes	Yes	**Waive**	**Waive**	**No**
3	5	300.000.000	1.7%	5.000.000	Yes	**Waive**	**No**	**Waive**	**Inactive Bidder**

An issue that needs to be addressed when modelling prices in the post-auction market, is whether the licence fees paid materially affect consumer prices. In the light of outcomes in some recent 3G auctions, and earlier PCS auctions in the United States, it is often asserted in the popular press that high licence prices entail high retail prices. However, economic reasoning is often applied to debunk this claim.[52] But capacity constraints play a key role in new cellular markets and these could act to link retail prices with the amount paid for a licence, particularly where a licence fee may impact on a firm's cost of capital. The installation of a network takes time, and during the early stages of build-out demand will likely outstrip available supply. The effect of capacity constraints is to push prices above variable costs, even where firms compete in prices (*e.g.* see Kreps and Scheinkman, (1983)). Where demand exceeds supply, a firm can choose to increase prices or expand supply, or do a mixture of the two. The ability to expand supply through increasing capacity is critically affected by the cost of capital, and as debt can play a significant role in affecting credit ratings and hence the costs of capital, high licence fees could indirectly influence retail prices.

Hence, in the business plans developed by bidders in spectrum auctions involving mobile telephony licences, complex modelling is often required to incorporate the effect of capacity constraints, the cost of capital and behavioural assumptions. In many instances the models will have multiple solutions, and the business judgement of senior executives is severely tested. The inevitable result of this will be heterogeneity in valuations across bidders.

Having established a valuation for a licence each bidder chooses its bidding strategy, given the auction rules and expectations about the other bidders' valuations. A crucial issue for a bidder in an auction is to identify where his or her valuation lies in respect to the valuations of the other bidders. In an

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[52] A common argument about sunk costs is usually applied to justify why the price of a licence should not impact on post-auction equilibrium prices, *e.g.* see McMillan (1995). This argument rests critically on the licence fee being an up-front payment, and that the firms operate in the absence of binding capacity constraints. Even where licence fees are deferred and sequenced over a number of years, these will still be fixed costs. As firms compete and operate, at least in the short-run, by choosing strategies that cover variable costs, licence costs should not impact on strategic pricing decisions directly. However, where debt commitments lead to a potentially distressed position, as arguably is the case with some of the 3G licence holders in Europe, this may lead investors to exit or negotiate with other firms with a view to sharing costs or consolidation. In August 2001, Finland's Sonera returned its 3G licence to the Norwegian regulator, exiting the market because of its distressed debt position. Ironically the licence cost $11.2 million in a comparative selection process, but the company has saved on infrastructure rollout costs that would have been substantially in excess of this figure. Consequently, the number of 3G operators in Norway has fallen to three. The arguments presented in March 2001 to the German telecommunications regulator (RegTP) about sharing infrastructure rollout costs, were motivated very much by the significant debt and high gearing of the licence holders. The decision by RegTP (see www.regtp.de) to permit some sharing of infrastructure costs has changed the post-auction market, and therefore the high licence fees paid in this will have a demonstrable effect on market structure. The prices faced by consumers in Germany ought to be lower because of infrastructure sharing, as variable costs will be lower. On the other hand, sharing infrastructure costs carries the risk that the firms involved will be tempted to collude (tacitly), and hence result in a higher margin between price and cost. Offerman and Potters (2000) have argued auctions have a tendency to select firms that are more likely to collude and set higher prices. Events in Germany are consistent with this viewpoint. In addition, the same authors show in experimental evidence that where firms use mark-up pricing rules, high licence prices increase the probability of high consumer prices.

auction for several identical objects, the outcome (final price) is likely to be influenced by the 'pivotal bidder', that is the bidder with a valuation lying below the valuations held by *n* other bidders, where *n* is equal to the number of objects to be auctioned. We label this bidder *m*, the 'marginal unsuccessful bidder'. If a bidder is confident that his valuation lies above that of the pivotal bidder, he ought to take advantage of auction rules that accommodate strategies that steer the final price to a level no higher than *m*'s valuation.

In the Nigerian auction, the optimal strategy appeared to be one where a bidder should play a sequence of three waivers before saying no to an announced price above the bidder's valuation.[53] If each bidder accorded with the principles of rationality, then the deployment of this purported optimal bid strategy should have resulted in a final price that reflected the valuation of the marginal unsuccessful bidder.

Where bidder *m* was identified as having played its first waiver, the three bidders with valuations above *m* ought to have started playing waivers in response to each successively higher announced price. This should have resulted in an expected final price below the marginal unsuccessful bidder's valuation, by an amount dependent on the total number of waivers available. The more waivers available to a bidder, the lower the (expected) final price.

A priori theoretical reasoning therefore suggests that the end of the auction should feature each bidder submitting waivers, once bidder *m* had been identified as playing a waiver. Below we assess what actually happened in the auction.

CIL

CIL was the only bidder to respond "Yes" to every announced price. At the end of the auction therefore CIL was apparently prepared to pay USD300 million for a licence. However, CIL failed to make its payment to the NCC on time, amid controversy about the spectral location of the frequency it was assigned.[54] Motophone, a company that had attempted unsuccessfully in the

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[53] This strategy appeared to be a weakly dominant strategy for a bidder 'close to' his or her valuation. We do not prove this assertion, though examples can be constructed for the case of fixed increments and fixed 'private' valuations, where the optimal strategy forms part of a Perfect Bayesian Equilibrium. This outcome has a dual in ascending bid auctions where bidders submit bids subject to a minimum increment requirement. The discrete nature of bid increments in such auctions means that a bidder will play a so-called 'death jump' as bid values approach his or her valuation. A death jump is a bid above the minimum bid required and is played by a bidder to ensure that he or she does not exit an auction at a price below his or her valuation.

[54] Each successful bidder (and NITEL) had to pay in full the amount outstanding, approximately USD285 less the deposit USD20 million, by February 9, 2001. CIL failed to submit the required funds by the due date, and on March 15, 2001 the NCC declared that the revocation of CIL's licence was final (see http://www.ncc.gov.ng/Press%20Releases/dmlupdate_pressbriefing.htm). CIL claimed it submitted a payment on time, but CIL's banker BNP Paribas made payment conditional on assurances it wanted from the NCC regarding the occupancy of the frequency allocated to CIL. There has been some heated political controversy in Nigeria surrounding the revocation of CIL's licence, which cast a shadow over an otherwise successful licence award process. The NCC has stated throughout that CIL failed to adhere to the auction rules in the Information Memorandum, which all bidders had agreed to comply

courts to prevent the auction from taking place, had been awarded a licence to spectrum rights by the General Abacha regime, which made use of frequencies within the package offered to CIL. The NCC removed the rights of Motophone before the auction, but this was subject to litigation. At the time of writing, it is not clear whether CIL will pursue the matter in the courts.

CIL did not make use of a waiver in the auction. CIL clearly deviated from the optimal strategy we have described above.

Econet

Econet responded "Yes" in every round except the last round. This suggests that Econet were prepared to pay at least USD295 million for a licence. Their strategy would also appear to deviate from the optimum.

MSI

This was the only bidder to use three waivers consecutively and respond no, exactly in line with the optimal strategy described above. Assuming USD265 million exceeded the valuation MSI attached to a licence, they made use of the waivers strategically and rationally. MSI were the 'marginal unsuccessful bidder' *m*.

MTN

MTN's strategy of playing "Waive" in round four on day three saved the company USD10 million, assuming that MTN would have been prepared to pay USD295 million for a licence. However, MTN Finance Director Rob Nisbet stated after the auction that the licence price "was getting to the top end of our valuations"[55], and Irene Charnley, Chairperson of M-Cell, owners of MTN, stated in an interview on January 22, 2001 "the amount that we [MTN] paid for the license has been on the upper side of our limit"[56]. These quotations suggest MTN's waiver in round four on day three did not save the company USD10 million, as it would appear they were probably not prepared to pay much more than USD285 million for a licence.

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with. However, Mr. Nduka Irabor, Chairman of the House of Representatives Communications Committee, has accused the NCC of not clarifying the legal status of the spectrum packages made available in the auction: "one of these was subject of litigation. NCC could have made that known to companies before, during and even after the auction." See http://allafrica.com/stories/200103020195.html, last visited August 12, 2001, and also http://www.nigerdeltacongress.com/iarticles/more_the_merrier.htm.

[55] Source: "Nigeria licence to gobble MTN profits", available at http://www.mg.co.za/mg/za/archive/2001jan/23jan-business.html, (last visited August 10, 2001).

[56] Source: http://www.marketupdate.co.za/Archive/January/SAfm-22-01-2001-03.html, (last visited August 10, 2001).

If we assume MTN's valuation were USD290 million, then its strategy arguably deviated slightly from that which we have claimed to be optimal.

United

This was the only bidder to play a "Waive" response before day three. In round two on day two, United played a waiver after the auctioneer announced USD178 million. As United followed the waiver with "Yes" responses up to USD265 million, we can infer that the waiver was played to allow the consortium extra time to discuss revising their valuation in the light of other bidders' responses.

United's next use of a waiver occurred in round three on day three when the auctioneer announced USD285 million, the round immediately after MSI had played its first waiver. If MSI and United were behaving rationally, and importantly held similar expectations about increments to the announced price, then United appeared in round three to be the 'marginal unsuccessful bidder' *m*. However, in the next round United said "No" after USD295 million had been announced, whereas MSI played a waiver. Given United used two waivers before withdrawing, this suggests they wasted an opportunity to use a waiver. The rational strategy for United would have been to play a waiver in round two. United was the first bidder to exit the auction.

Hakeem Belo-Osagie, chairman of United Bank for Africa, UBA, and one of the key players in the United Networks consortium, said at the end of the auction that at USD285 million, "the final amount was a higher figure than we thought was economic" and Naguib Sawiris, Chairman of Orascom, added that USD285 "exceeded the company's threshold".[57] If USD285 million were United's valuation, then it certainly should have played a waiver at USD265 million. Perhaps the reason United did not pay a waiver was due to their expectations about the likely increment to the announced price. United probably expected the increment to be lower than it was in round three.

5.3 Would the outcome have differed if the bidders had used waivers optimally?

In Table 5 below we reconstruct the auction outcome based on what might have been had <u>all</u> the bidders played rationally (according to the arguments presented above) – given our assessment about the bidders' valuations based on actual bidding or on disclosures made to the press after the auction. We believe that round two would have been the critical moment, with waivers played by MSI <u>and</u> United. Given this outcome, the other bidders would have formed the beliefs that one of these bidders was the 'marginal

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[57] Sources: Tell Magazine.com http://www.tell.org/archive/business06022001.htm (last visited August 10, 2001), and Total Telecom (www.totaltele.com), January 22, 2001.

unsuccessful bidder'. Consequently, in round 3 we believe rational bidders would have submitted waivers. In this case the successful bidders would have been identical to those in the real auction, but the final price at USD265 million would have been USD20 million lower. Hence, the Nigerian government would have raised USD60 million less than it did had the bidders conformed to our interpretation of rationality.

Table 5: Predicted auction outcome had every bidder played 'rationally'

			CIL	Econet	MSI	MTN	United
		Estimated valuation millions USD	300+	c295	<265	c290	<295
Day	Round	Announced Price					
3	1	248,000,000	Yes	Yes	Yes	Yes	Yes
3	**2**	**265,000,000**	**Yes**	**Yes**	Waive	**Yes**	Waive
3	3	285,000,000	Waive	Waive	Waive	Waive	Waive
3	4	295,000,000	Waive	Waive	Waive	Waive	No
3	5	300,000,000	Waive	Waive	No	Waive	Inactive Bidder

6. Comparison with other recent spectrum auctions

The outcome of the auction exceeded many analysts' expectations, and the Nigerian government raised USD855 million.[58] This was reflected in a movement in the share price of M-Cell, MTN's parent company, which dropped by nearly four percent on January 22, 2001, following the announcement of acquiring a licence in Nigeria.[59] However, the stock price of Econet, listed on the Harare stock exchange in Zimbabwe, increased by 36% following the auction.[60] The increase in Econet's stock price largely reflected

[58] See "Cellular telecoms in Nigeria: Where angels fear to tread", at http://www.fm.co.za/01/0126/cover/coverstory.htm, last visited August 13, 2001. However, from the same source a Deutsche Bank analyst was reported as saying that he would have accepted a price as high as USD500 million!

[59] "M-Cell drops as MTN gains Nigerian licence", see http://www.dispatch.co.za/2001/01/23/business/BUS.HTM, last visited August 13, 2001.

[60] In the same week the market index in Harare rose 28.4% due to declines in interest rates. Source: Stock Market Indicators weekly report, week ending January 26, 2001, from: http://www.kingsec.co.zw/archive/weekly/weekly_01262001.htm, last visited August 13, 2001.

a favourable response to diversifying risk away from an increasingly deteriorating economic outlook in Zimbabwe.

Table 6: Comparing 3G auctions with the Nigerian 2G auction

Country	Total raised (USD)	Raised per MHz = X (USD)	GDP =Y (USD)	Ratio = X/Y
Switzerland	120 million	0.86 million	258.6 billion	$0.03 * 10^{-4}$
New Zealand	51.4 million	0.37 million	54.7 billion	$0.068 * 10^{-4}$
Australia	352 million	3.2 million	404.0 billion	$0.079 * 10^{-4}$
Austria	610 million	4.2 million	208.2 billion	$0.2 * 10^{-4}$
Greece	376.8 million	5.0 million	125.1 billion	$0.4 * 10^{-4}$
The Netherlands	2,508 million	18.6 million	393.7 billion	$0.47 * 10^{-4}$
Italy	10,070 million	80.56 million	1,200 billion	$0.67 * 10^{-4}$
Germany	45,850 million	316.2 million	2,100 billion	$1.5 * 10^{-4}$
United Kingdom	35,390 million	252.8 million	1,400 billion	$1.8 * 10^{-4}$
Nigeria (2G)	**855 million**	**7.1 million**	35.0 billion	**$2.0 * 10^{-4}$**

Source: www.cellular-news.com; www.worldbank.org country databases 1999 GDP; www.3gnewsroom.com, (all last visited August 13, 2001); ITU, Status of IMT-2000 (UMTS) 3G mobile licensing in Western Europe (situation at May 2001).

In Table 6 we compare the amount raised in the Nigerian GSM auction with the amounts collected in various 3G auctions held since 2000. While the total amount collected in the UK 3G auction was over 35 times more than that raised in Nigeria's GSM auction, in relation to GDP the amount paid per MHz in Nigeria exceeded that in the UK. According to this statistic, the amount raised in Nigeria's GSM auction is arguably the most impressive seen in any spectrum auction to date.[61]

[61] The informal sector in Nigeria is considerable and the official statistics reporting GDP may significantly understate income, see Arimar (2001). However, even if reported GDP were doubled, Nigeria would still have a ratio of price per MHz over GDP above $1 * 10^{-4}$.

7. Concluding remarks

The Nigerian GSM auction had a profound impact on Nigeria. Public and political interest in the process was intense throughout the auction, and in the immediate aftermath.[62] Many in Nigeria viewed the GSM auction a resounding success, largely because the transparency of the process was unprecedented.[63]

Participating bidders, winners and losers, commented very favourably upon the auction. Ms. Irene Charnley, Chairperson of M-Cell, owners of MTN, remarked the "NCC had conducted the auction in a professional and commendable fashion, and that the auction was the first telecommunication licence auction successfully conducted in Africa"[64], adding that the "Nigerian auction was adjudged as better packaged and organised than the one in the U.K. recently" [65]. Bolaji Balogun of Econet Wireless "expressed gratitude to the NCC, its advisers for the success of the auction"[66]. Naguib Sawiris, Chairman of Orascom Telecom (leader of the United consortium), stated the auction was "very professional and transparent".[67]

Observers from around the world have acclaimed the auction a success. The Financial Times in London reported "Nigeria's GSM mobile telephone auction in January proved a watershed in more ways than the price".[68] The U.S. Ambassador to Nigeria, Mr. Howard F. Jeter, stated in Lagos in March, 2001, "2001 should be a banner year for the development of telecommunications in Nigeria. This year began with the successful auction

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[62] Immediately after the auction concluded the auction control team were invited to an audience with President Obasanjo on January 20, 2001, where he congratulated the team and the NCC for the success it had help achieve. The President remarked that the auction was a very important landmark in Nigeria's path towards establishing democracy, and that the process was unprecedented in terms of its transparency.

[63] A Nigerian news portal Amebo! Reported: "The recent successful GSM auction that was applauded all over the world as the most transparent auction exercise Nigerian government ever embarked upon is a welcome development." (See http://www.amebo.com/business/bus2564.htm, last visited August 15, 2001.) The success of the GSM auction process has led to continuing debates in Nigerian newspapers, and many have advocated the use of auctions in other public tenders. In an editorial in *The Vanguard*, a major Nigerian newspaper, on April 27, 2001, the GSM auction was used as an example to justify applying auctions to privatisation. See http://www.vanguardngr.com/23042001/pv270401.htm (last visited August 9, 2001).

[64] Source: *Post Express*, Nigerian newspaper, January 20, 2001.

[65] Quoted in the Nigerian *Guardian*, February 9, 2001.

[66] Source: *Post Express*, Nigerian newspaper, January 20, 2001.

[67] Total Telecom (www.totaltele.com), January 22, 2001.

[68] Financial Times, March 30, 2001, "Nigeria: Investment points to optimism".

of GSM licenses for wireless networks."[69] Leading ITU official Hamadoun Toure was reported as saying "Nigeria's credibility has been fully restored internationally".[70]

On August 7, 2001 Econet launched its commercial GSM service, and a day later MTN launched its service.[71] Within the near future NITEL should launch its GSM service. By August 2002 there are likely to be around 300,000 or more GSM subscribers in Nigeria. This will increase the number of telephone lines in the country by nearly 60%, greatly stimulating prospects for economic growth.

The use of an auction in Nigeria was motivated largely by the need for transparency and objectivity. Faced with these constraints, it was essential that participants had faith in the mechanism used to select successful bidders. A well-designed auction was deemed superior to alternative comparative selection methods, the latter having failed previously due to alleged wrongdoing. While opinion may differ as to the merits of auctions in awarding spectrum licences and other scarce public resources, the experience in Nigeria highlights how they can be applied successfully in the most challenging of circumstances.

The unprecedented transparency of the Nigerian GSM auction coupled with the substantial revenue raised by the government were a watershed in Nigeria's history.

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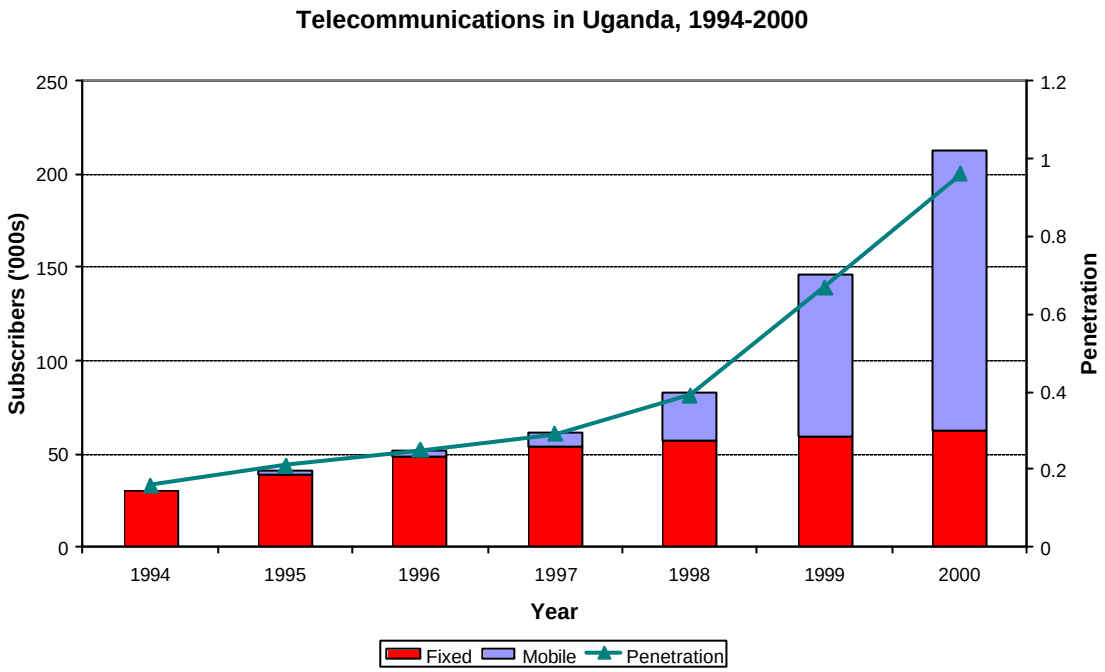
[69] Speech given by U.S. Ambassador to Nigeria Mr. Howard F. Jeter, March 15, 2001, to the conference Information Technology and Telecommunications Business Development Conference, held at the Muson Center, Lagos. Source: http://usembassy.state.gov/nigeria/wwwhp03b.html.

[70] Hamdoun Toure, Director of the Telecommunications Development Bureau at the ITU, was quoted in the Nigerian newspaper 'This Day' on March 2, 2001. See http://www.thisdayonline.com/archive/2001/03/02/20010302news20.html, last visited August 15, 2001.

[71] To comply with regulations each licensed operator had to launch a commercial service by August 9, 2001. However, NITEL/M-Tel failed to meet this deadline and is expected to launch its GSM service in September 2001. See http://news.bbc.co.uk/hi/english/business/newsid_1484000/1484319.stm, last visited August 13, 2001.

Appendix

Below we present a chart showing the successful growth in mobile subscribers in Uganda since the middle 1990s.



Source: www.msi-cellular.com, last visited August 16, 2001; www.mtn.co.ug, last visited August 16, 2001; ITU, The Internet in an African LDC, Uganda Case Study Report (http://www.itu.int/itu-d/ict/cs/uganda/material/uganda.pdf), January 2001; ITU Yearbook of Statistics, February 2000.

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