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Spectrum policy for competition and development: a comparative study of approaches and outcomes in Africa

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As demand for mobile broadband grows, so too does the demand for radio frequency spectrum. In many countries, this has led to demand for spectrum from mobile operators outstripping its supply. "Market based" mechanisms for spectrum management such as spectrum auctioning, pooling, leasing and trading have been hailed as the solution to this problem, as they put a market-related value and opportunity cost on spectrum, such that it is likely to find its way to the user which will use it most efficiently. Over the course of 20 years, spectrum auctions have evolved from a relatively simple means of price discovery into complex, multi-objective processes which have had both great successes and radical failures. A key issue in terms of the effectiveness of market-based measures has turned out to be the extent to which they stimulate or stifle competition.

In Africa, countries are mostly just starting to consider the implementation of market-based measures for assigning spectrum; spectrum auctions have been held or proposed in Nigeria, Ghana, Mozambique, Senegal and South Africa with varying results. This means that there is great opportunity to learn from the experience of other countries, but also serious pitfalls to be avoided. Context is key to using market-based approaches successfully, and broader objectives need to be carefully considered.

This paper presents a comparative review of spectrum policy in African countries, and their potential impact on levels of competition. It briefly reviews international experience and best-practice in spectrum assignment and reflects on how this can be best adapted to the particular challenges of African countries.

1. Introduction

As demand for mobile broadband grows, so too does the demand for radio frequency spectrum. In many countries, this has led to demand for spectrum from mobile operators outstripping its supply. "Market based" mechanisms for spectrum management such as spectrum auctioning, pooling, leasing and trading have been hailed as the solution to this problem, as they put a market-related value and opportunity cost on spectrum, such that it is likely to find its way to the user which will use it most efficiently. Auctions are also more transparent and less vulnerable to lobbying than the more traditional beauty contest approach.

Over the course of 20 years, spectrum auctions have evolved from a relatively simple means of price discovery into complex processes, attempting to meet a wide range of objectives, some of which can be conflicting. Revenue generation and efficiency are generally of concern and in theory should be well-aligned, as the operator prepared to pay the most for the spectrum should have the highest valuation for it. However, authorities in search of high auction

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revenues may be tempted to set high reserve prices which could deter, or in extreme cases prevent, participation.

Another important concern which has been increasingly taken into account when designing spectrum auctions is the need to ensure that they promote rather than stifle competition. This can be in conflict with revenue generation goals since the firms able to bid the most for spectrum are usually the largest operators, and so auctions which generate high spectrum prices may exclude smaller bidders. Measures to ensure competition is not harmed include auctioning spectrum in small lots, spectrum set-asides for new entrants and spectrum caps to ensure that no operator is able to monopolise access to spectrum in a particular band or across bands. These have been used with varying success internationally.

In Africa, relatively few countries have implemented market-based mechanisms for spectrum assignment (spectrum auctions have been held or proposed in Senegal, Nigeria, Ghana, Mozambique and South Africa) and only a handful of countries have licensed "4G" spectrum in the 700MHz/800MHz and 2600MHz bands. Most therefore have still to determine how best to go about assigning this new and valuable spectrum for mobile use. Competition concerns are highly relevant, as many countries have relatively uncompetitive mobile markets, dominated by one or two large incumbents. In this context, lessons from past experience can be useful to help in designing spectrum assignment processes in order to balance competing objectives and avoid the possible pitfalls.

In this paper, we reflect on theory and experience with different mechanisms for spectrum assignment in order to provide insights into how the available approaches can best be adapted to the relevant context. Section 2 provides a brief discussion of the economics of market based mechanisms for spectrum assignment before section 3 presents a review of international experience focussed on the success of the various approaches in meeting different objectives, particularly the promotion of competition. In section 4 we reflect on past spectrum assignments in Africa and particularly on how and where 4G spectrum has been assigned. Section 5 then considers African experience of spectrum auctions and contrasts competition outcomes across the five countries which have attempted an auction. Section 6 draws conclusions and recommendations for best practice in the future assignment of spectrum.

2. Options for spectrum assignment: the economics of market based mechanisms

The FCC first licensed spectrum for mobile use through an auction process in 1994, with the UK's Ofcom following suit with its 3G auction in 2000. Since then, auctions have become the most common means of assigning spectrum, due to their attractive characteristics. A well-designed auction is likely to be efficient, which is why they are generally favoured by economists (Cramton, 2002). An auction should ensure that there is price discovery even where the regulator has imperfect information on how operators value the spectrum. This ensures that spectrum goes to market participants which will use it most efficiently. In theory, auctions also provide an equal opportunity for all potential market participants to acquire spectrum.

In short, "*the most beneficial advantages of auctions have been their transparency, for all stakeholders, in arriving at explainable outcomes and using the market's knowledge to arrive at a better appreciation of the value of spectrum*." (OECD, 2014).

On the other hand, beauty contests (the usual alternative to market-based mechanisms where the government or regulator makes the decision of which operators to assign spectrum to,

based on a set of criteria) tend to be slow and wasteful and vulnerable to lobbying by market participants (Cramton, 2002). They also lack transparency around why a particular applicant has been chosen over another and the regulator with imperfect information may not be able to identify the 'best' potential licensee. For these reasons, auctions have become a popular mechanism for allowing the market, instead of policymakers, to determine the best assignment of spectrum and ensuring that operators pay a market-related price for the valuable resource.

While under the right circumstances, auctions can be extremely efficient, there are also ways in which they can give rise to competition concerns. Where there is one or more large incumbent, there may be a concern that the "deep pockets" of these operators will advantage them at the expense of entrants, or even allow them to manipulate the auction process in order to exclude entrants and smaller rivals, for example by buying up all the spectrum and leaving none for competitors. Operators may also have an incentive to collude to divide the spectrum among themselves while paying a lower price than if they were to participate in a competitive manner. A well-designed auction should account for these possibilities and aim to encourage all operators to compete to invest in improving the quality of their service in order to gain more market share (Cramton et al, 2011). However, this can be difficult to achieve in practice.

As alluded to above, a regulator has a number of objectives when conducting a spectrum auction. It wishes to facilitate price discovery and ensure the spectrum is ultimately assigned to operators who will use it efficiently. At the same time, it must give attention to preventing collusion and attracting entrants to the process. There may also be public service obligations around coverage and access which the regulator must consider. From a pure competition perspective, the success of an auction is determined by its ability to achieve competitive outcomes and to attract a number of players, ideally including new entrants, to the auction. There have been attempts to design different auction mechanisms which can more effectively meet multiple objectives (effective price discovery, enhanced competition, investment incentives, public interest objectives) simultaneously. This has resulted in auction design becoming more complex over time.

There are two main categories of auction. The first is the ascending auction in which the price of the product rises as competitors bid. The final price is determined when there are no more bids offered. This can be either a simple or simultaneous round auction in which either one or several spectrum packages are auctioned at the same time. The main advantage of ascending auctions is that the process is transparent and that the spectrum is likely to be awarded the bidder who values it most. However, this approach can tend to favour large operators with deep pockets. Ascending auctions can deter entrants from participating as they believe they will not be able to out-bid large incumbents. This will have the effect of lessening the competitiveness of the auction. For this reason, regulators may decide to auction several similar packages of spectrum at the same time and apply spectrum caps in order to prevent excessive spectrum concentration.

The transparency of ascending auctions can also create another problem, as it makes it relatively easy for operators to collude. Bidders can signal to others during early rounds the packages that they prefer and then punish firms which do not comply by bidding up the price on packages which they know that the deviating firm prefers (Klemperer, 2002).

The second category is the sealed-bid auction, in which bidders can anonymously make final price offers for spectrum. The benefit of this method is that it is difficult for the bidders to collude as there is little opportunity to signal to each other their preferences. It also provides little opportunity for the incumbents to punish non-compliant firms. New entrants are also more

likely to participate as they have a higher chance of being successful. This means that the final price may be lower than it would under an ascending auction, which must be traded off against the possible competitive benefits of the approach.

Hybrid auctions can also be developed in which elements of more than one auction type are used, such as a hybrid of the ascending and sealed-bid auctions (called an Anglo-Dutch auction). In this case, an ascending auction is used until a small number of bidders remain and thereafter the sealed-bid auction is used. The sealed-bid auction creates uncertainty about the identity of the eventual winner which makes the auction more attractive to entrants and yet greater allowance is made for efficiency due to the ascending stage of the auction. The sealed-bid stage also makes it difficult for collusion to take place.

What is clear from the above is that the type of auction which is most appropriate will differ depending on the context and the objectives to be achieved, and that careful design is necessary in order to meet these requirements. In the following section, we consider international experience with spectrum auctions and competition.

3. International experience with market based mechanisms and competition

A number of 3G auctions[2] took place Europe in the early 2000s, beginning with the UK in 2000. The different approaches taken in these auctions and the results achieved provide a number of useful insights in terms of auction design. The UK market at the time consisted of four incumbent mobile operators, and five licenses were made available by auction, with no bidder allowed to purchase more than one licence. Sharing of licenses between two or more bidders was also prohibited. The fact that one more license was offered than existing incumbents meant that entrants were encouraged to participate as they had a realistic opportunity to win the last license. A total of thirteen operators participated (the highest number of bidders in any of the European auctions that took place during this time), nine of which were entrants. In this context, an ascending auction was less problematic from an entry-deterrence perspective and the auction appears to have been successful in generating competition and encouraging entrants and smaller firms to participate. However, as this was the first auction in Europe, the auction benefited from considerable uncertainty around operators' spectrum valuations, which may have enhanced the competitiveness of the process.

The Netherlands auction took place two months after the UK auction, but was not so successful. The Netherlands followed the ascending auction design used in the UK and also offered five licenses, although in a context where there were five strongly established incumbent operators. Only one entrant competed in the process and it dropped out a week prior to the auction following threats of legal action from one of the incumbents. The remaining entrants partnered with the incumbents rather than bidding independently. Klemperer (2002) argues that an Anglo-Dutch auction would have worked better in this case as the uncertainty of the sealed bid stage would have drawn more entrants. The bidders would have also bid higher prices knowing that they faced greater competition from these entrants.

The Italian auction which took place in October 2000 attempted to modify the UK design by stating that if there was a greater number of licenses than serious bidders, the regulator would reduce the number of available licenses. Six bidders entered the auction but one dropped out two days before the auction. Arguably, it was too clear in advance which operators would win

[2] This section is based on Klemperer (2002) which summarizes the details of a number of 3G auctions between 2000 and 2002.

the licenses, and so entrants were deterred and encouraged to partner with incumbents rather than compete with them. Competition, in this case, was not robust and revenue received from the process was less than the amount anticipated by the government; only slightly above the reserve price.

In Switzerland, an ascending auction was used to sell four licenses. There was significant interest initially but the number of bidders reduced, possibly deterred by the larger resources of the stronger players. To encourage entrants, the government allowed for joint-bidding which had the effect of reducing the bidders to only four. Having set the reserve price low, the auction brought a fraction of the revenue anticipated and was uncompetitive.

What is apparent from the above experiences, is the importance of getting the right design for each auction bearing in mind the structure and economic circumstances in each country at the time of the auction. Achieving the goals of encouraging entrants, reducing the likelihood of collusion and ensuring that a market-related price is ultimately determined requires careful balancing.

There are a number of ways that auctions can be designed to promote pro-competitive outcomes. In order to reduce the ability of firms to collude, regulators can restrict bidders to bidding only round numbers to reduce the chance of them signalling their preferences to one another. Past auctions have shown that some operators use the last digits of the bid amount to signal lot preferences (Klemperer, 2002). Anonymous bidding keeps the number of bidders confidential to increase uncertainty amongst the bidders and thus reduce the ability to collude. The lots sold at auctions can also be disaggregated to reduce the possibility of collusion. Where lots are particularly large, operators may collude to acquire the lot and thereafter split it between themselves (if this is permitted from a regulatory perspective).

Spectrum caps protect competition by limiting the amount of spectrum that one operator can hold, thus ensuring that operators cannot monopolise or hoard scarce spectrum resources. They have been used in a number of countries (OECD, 2014) and may be either band specific and/or cap the overall amount held. For instance, an Austrian multi-band auction that took place in October 2013, limited the amount of spectrum a participant could win to no more than 2x35 MHz of spectrum in bands below 1 GHz, 2x20 MHz in the 800 MHz band and 2x30 MHz in the 900 MHz band. Additionally, the total spectrum any one operator could win was 2x70 MHz (GSMA, 2015). Arguably, this cap was too weak, potentially allowing a single operator to obtain over half of the available sub 1-GHz spectrum and two operators to acquire all the spectrum on offer (Frontier Economics, 2014). As of 2015, in India, no operator can hold above 50% of spectrum in any frequency band or more than 25% of the total spectrum available.[3]

In considering how to assign portions of 800MHz and 2600MHz spectrum, Ofcom (the UK regulator) had regard to the impact of the assignments on competition (Ofcom, 2012). It was aware that that spectrum is a critical asset for wholesalers and therefore the planned assignment of spectrum, which was likely to be the last for the foreseeable future, could have serious implications for competition in the sector. After applying merger control criteria to the national wholesale market, Ofcom concluded that in order to preserve competition and mitigate any possible negative impacts on consumers, it was important to reach an outcome to the auction which ensured at least four credible national wholesalers: two infrastructure based wholesalers (Everything Everywhere and Vodafone/O2), and four services based

[3] Economic Times, 24 November 2015. 'Spectrum cap: Telecom Commission approves Trai's recommendations' Available here.

wholesale players (Everything Everywhere, Vodafone, O2, 3). Again, two wholesale infrastructure players arguably may even by too few to ensure robust competition.

In order to ensure that the auction did not reduce competition, Ofcom implemented a basket of measures including a sub-1GHz safeguard cap of 2x27.5MHz as well as an overall spectrum cap of 2x105MHz per operator. Ofcom considered that in this case, spectrum caps would help to ensure that a sufficient number of independent spectrum licence holders could compete in the UK mobile market. Reserve prices would be set by reference to estimated market value with a discount. Finally, one spectrum portfolio would be reserved for a fourth national wholesaler.

The use of spectrum caps has become less popular and some have even been removed as additional spectrum is allocated for mobile and assigned. In the US, the Federal Communications Commission (FCC) decided to eliminate the use of spectrum caps in 2003, with the option to reinstate them if required in particular cases. The decision was made in order to promote greater spectral efficiency as a smaller numbers of operators with larger proportions of spectrum are able to take advantage of economies of scale and may therefore invest more (Moore, 2010).

As also highlighted by Ofcom, in light of the emerging demands for wider channel bandwidths for LTE services, it may result in higher efficiency to assign larger portions of spectrum to a smaller number of operators, as long as this does not result in a lessening of competition. If competition is reduced, however, this may be counter-productive since operators face less incentive to invest and lower prices to customers.

An alternative to spectrum caps can be to set aside spectrum for new entrants. This may attract more bidders to the auction and hence generate higher revenues (Cramton, 2002). In the UK 3G auction described above, the license that held the largest amount of spectrum was set aside for an entrant. Canada has also taken this approach, with some success. In March 2015, the authorities announced a plan to auction spectrum for Advanced Wireless Services (AWS) in the Bands 1755-1780 MHz and 2155-2180 MHz, setting aside 60%, of the total 50 MHz available for companies that were already providing wireless services but with less than 10% of national market share and less than 20% of market share by province. A sealed-bid auction was used and the spectrum packaged into blocks. New entrant Wind Mobile paid the reserve price for the spectrum and was able to extend its holdings by 180% (Industry Canada, 2015).

Set-asides are not without their challenges. In Ghana, in 2012, the National Communications Authority (NCA), awarded Broadband Wireless Access (BWA) Licenses in the 2600MHz spectrum band exclusively to three wholly Ghanaian-owned companies, Surfline Communications, Blu Telecoms and Goldkey Telecoms in alignment with the government's local content policy at a cheaper price of USD 6 million compared to the USD 25 million at which the 2G and 3G licenses had previously been sold. Of the three operators, only two are still operational and the remaining operators have been slow to deploy 4G services. By contrast, MTN Ghana, the dominant player in the market was able to provide 2G and 3G services to the whole country within the prescribed period (Ametorgoh, 2015). The UK has also had a problematic experience with set-asides for entrants including bankruptcy and delays in using spectrum, a risk when dealing with smaller players (Cramton, 2002). These examples highlight the risk of using a set aside policy.

Another approach to lowering barriers to auction participation for new or smaller players is to offer the spectrum for sale in smaller packages in a so-called package clock or combinatorial clock auction. This makes it more affordable for smaller firms to acquire spectrum, and allows larger firms to bid for a number of packages to create a larger overall assignment. Firms may bid on generic small lots (say 2x5MHz), and then the assignment of particular channels to specific operators would happen at a later stage, such that the spectrum purchased can be assigned as efficiently as possible (Cramton, 2013). Spectrum caps are a useful complement to this type of auction, to ensure that larger firms do not buy up a large proportion of the available spectrum. This approach has advantages in that it does not rely on the regulator deciding what packages will be attractive to operators, but allows the auction to facilitate the makeup of packages. It also avoids the potentially inefficient setting-aside of spectrum to be assigned to firms which will not make good use of it, while still providing smaller firms with the opportunity to acquire small portions of spectrum. However, it can be complicated to implement.

International experience has, therefore, advanced a number of ways in which spectrum auctions can be designed in order to promote competition, although in some cases this has to be balanced against what is likely to result in the most efficient use of spectrum. Critically, what will work best depends on the particular market structure and market dynamics as well as the economic circumstances. Past experience, however, provides a great deal of guidance in terms of the advantages and disadvantages of different approaches, and their potential pitfalls.

4. Spectrum assignment in Africa

In Africa, most countries have licensed at least the 900Mhz, 1800MHz and 2100MHz bands to mobile operators. Table 1 shows that in addition to this, seven countries (Ghana, Nigeria, Senegal, Kenya, Rwanda, Tanzania and Uganda) have licensed “digital dividend” spectrum in the 800MHz band, two of which (Ghana and Senegal) awarded the spectrum through an auction or partial auction process. Senegal and South Africa also attempted to license spectrum in the 700MHz band through an auction process, but did not ultimately do so. In the higher frequency bands, Nigeria and South Africa have both awarded TDD spectrum in the 2300MHz band to a single operator, Nigeria via auction and South Africa to the fixed line incumbent. Ghana, Nigeria and Uganda have awarded spectrum in the 2600MHz band, Ghana and Uganda through a non-competitive licensing process, and Nigeria through another spectrum auction.

The highest price on a USD per MHz per capita basis was achieved by Ghana, which awarded 800MHz using an auction with a high reserve price, and sold only one lot, to the largest operator. Senegal also achieved a relatively high price for the 800MHz and 1800MHz spectrum which it licensed to only the incumbent operator following an unsuccessful auction. Kenya achieved the lowest (known) price for 800MHz spectrum. After initially assigning 800MHz only to the largest operator, Safaricom, the regulator split the available spectrum equally between the three operators.[4] The price paid by the Ghanaian operator was four times higher than that paid by the Kenyan operators, but the Kenyan authority was able to award three times as much spectrum as the Ghanaian authority. Prices paid for the higher frequency

[4] See GSMA (2016); Telegeography 17 December 2015, ‘Safaricom asked to return 5MHz of 800MHz spectrum’, available here.

(2300MHz and 2600MHz) spectrum were generally much lower, possibly reflecting its lower value. Information on the price paid was not available for Rwanda, Tanzania and Uganda.

Table 1: spectrum assignments in Africa

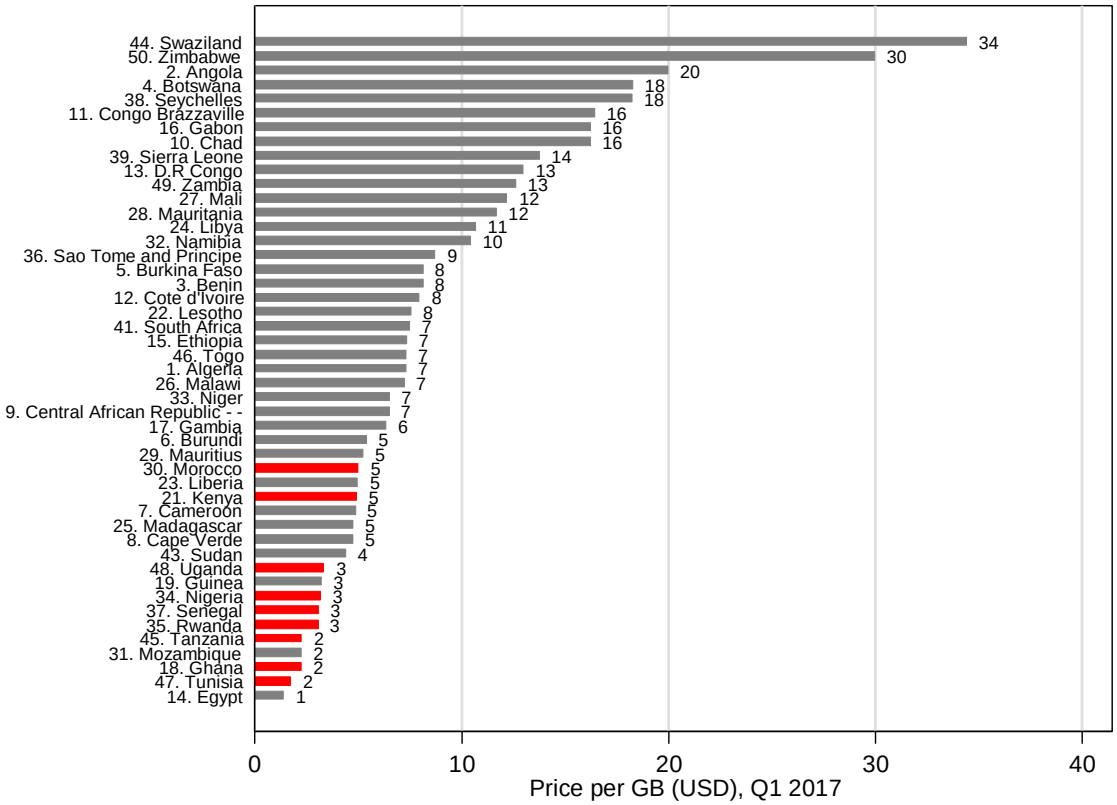
Band	Country	Details of award	Cost (USD per MHz per capita)
700MHz	Senegal	Attempted to auction 700MHz but did not ultimately license it (see below)	N/A
	South Africa	Attempted to auction 700MHz as part of four packages including 800MHz and 2.6Gz, but did not ultimately license it (see below)	0.08 (based on total spectrum for sale and reserve prices for each lot)
800MHz	Ghana	Auction – one lot of 2x10MHz sold	0.12
	Nigeria	Used for CDMA historically, now being used for LTE as CDMA operator bought by MTN	N/A
	Senegal	Auction failed, incumbent awarded 2x10MHz (plus 2x10Mhz of 1800Mhz)	0.08
	Kenya	2x10MHz awarded to each of 3 operators for USD 25 million	0.03
	Rwanda	Unclear, but at least 1 wholesale operator appears to have been assigned spectrum	Unknown
	Tanzania	Unclear, but at least 1 operator (Smile) is operating an LTE network on 800MHz	Unknown
	Uganda	Unclear but according to the regulator, 2x30MHz has been assigned	Unknown
2300MHz	Nigeria	Auction – 1x30MHz awarded to 1 operator	0.004
	South Africa	TDD awarded to fixed line incumbent	N/A
2600MHz	Ghana,	Ghana – awarded to small operators with limited success	0.02
	Nigeria	Auction - 6 2x5Mhz lots awarded to 1 operator	0.01
	Uganda	Unclear but according to the regulator, 2x60MHz has been assigned	Unknown

Source: various press reports and author's own analysis

Notes: spectrum costs in USD/MHz per capita may not be comparable due to differences in assignment, license term and purchasing power parity, among other factors

Figure 1 illustrates the price of the cheapest 1GB mobile data bundle in a range of African countries. The bars highlighted in red represent countries which have licensed 800MHz spectrum. Strikingly, these countries are clustered at the lower end of the chart suggesting that there is a correlation between countries which have licensed spectrum and countries with cheap mobile data. However, in the longer term, spectrum assignments can have an important impact on competition between operators and hence on price, quality and investment levels. We deal with the potential competition implications of African spectrum auctions in the next section.

Figure 1: Cheapest price for 1GB basket by country, USD per GB



Source: author's own analysis of Research ICT Africa dataset, available here

5. Spectrum auctions and competition

As alluded to above, there have not been a large number of spectrum auctions in Africa. Those which have taken place have met with mixed results. In late 2015, Senegal's 4G spectrum auction was suspended after the Regulation Authority of Post and Telecoms (Autorite de Regulation des Telecoms et des Postes, ARTP) announced there had been no bids received from operators.[5] The operators boycotted the auction claiming that the reserve price had been set too high, at USD 49.86 million. The ARTP registered its concern with the "collective and coordinated non-participation of the operators". Subsequently, the incumbent Sonatel was licensed with 2x10MHz of 800MHz and 2x10MHz of 1800MHz for a price of USD 53.8 million. The other operators did not receive any spectrum.

As noted above, the Senegalese regulator was able to collect a relatively high price on a per MHz per capita basis, however, as illustrated in Table 1, only 29% of the spectrum on offer was ultimately licensed. In addition, the fact that only the largest operator was able to obtain spectrum could have implications for the ability of its smaller rivals to compete. Figure 2 illustrates that between 2013 and 2016, the market share of Sonatel in terms of total subscribers slowly fell as the share of its two rivals increased. This seems to indicate that so far at least, there has not been a negative impact on the ability of rivals to compete (although it is possible that their share could have grown faster had they had access to more spectrum).

[5] ITU, 19 January 2016. Senegal's incumbent cellcos 'boycott' 4G licence tender; ARTP invites bids from new entrants. Available here.

However, given that the auction was only held in late 2015, it is also likely that 2016 is too soon to see any competition effects of the asymmetric assignment.

From Figure 3 we can see that mobile data prices in Senegal fell dramatically between Q3 2014 and Q1 2017, with a fall of more than 50% between Q4 2016 and Q1 2017. As illustrated in Figure 1, Senegal now has amongst the lowest mobile data prices in Africa. We cannot account for all the factors which could have impacted on prices, however, it seems that so far the assignment of spectrum has coincided with a major decline in mobile data prices.

Table 2: spectrum auctions in Africa

Country	Spectrum for auction	Auction details	Established MNOs and market shares	Auction outcome
Senegal	700MHz 800MHz 1800MHz	3 2x10MHz blocks of 800MHz 4 2x5MHz blocks of 700MHz 2 2x10Mhz blocks of 1800MHz Reserve price of USD 49.86 million	Sonatel/Orange – 57% Tigo – 23% Sudatel/Expresso Telecom – 20%	Collective boycott by operators – possible collusion Eventually 2x10MHz of 800MHz and 2x10MHz of 1800MHz licensed to Sonatel for USD53.8 million
Nigeria	2300MHz	30MHz nationally Computerised ascending clock auction 2 pre-qualified bidders Reserve price USD 23 million	MTN – 39% Airtel – 23% Globacom – 23% Etisalat – 15%	Bitflux purchased the spectrum for USD23.25 million
	2600MHz	14 lots available		MTN acquired 6 lots or 30MHz Other operators cited high reserve price
Ghana	800MHz	Two lots available, reserve price of USD67.5 million each	MTN - 50% Vodafone – 17% Airtel – 16% Glo Mobile – 1.4% Expresso – 0.2%	MTN acquired one lot of 2x10MHz at the reserve price
Mozambique	800MHz	6 2x5MHz lots, one withheld to restrict supply, reserve price USD30 million each	mCel – 29% Vodacom – 23% Movitel – 38%	No spectrum was licensed
South Africa	700MHz, 800MHz, 2600MHz	Multi-round ascending with reserve price and spectrum cap Five packages on offer combining 700/800MHz with 2600MHz	Vodacom – 43% MTN – 36% Cell C – 17% Telkom Mobile – 4%	Regulator's ITA challenged by government in courts and process stopped pending hearing

Source: various media reports

Nigeria held a spectrum auction in 2016 which attracted only one bidder, MTN. MTN was able to purchase six of the 14 lots at the reserve price of $16 million per lot, and is to be licensed

with 30MHz in the 2.5GHz band.[6] MTN is the largest operator in Nigeria with a market share of 39% in terms of subscribers.[7] It appears that the reserve price may have been set too high for the other operators who cited this, combined with economic conditions in Nigeria and the cost of rolling out networks as the main reasons that they did not participate.[8] Again, a substantial portion of the offered spectrum was not acquired and only the largest operator received spectrum in the auction. Compared to Senegal, Nigeria has seen a more extensive reduction in the market share of the largest operator between 2013 and 2017, largely in response to the expansion of smaller operator Globacom. Mobile data prices in Nigeria have also fallen to very low levels.

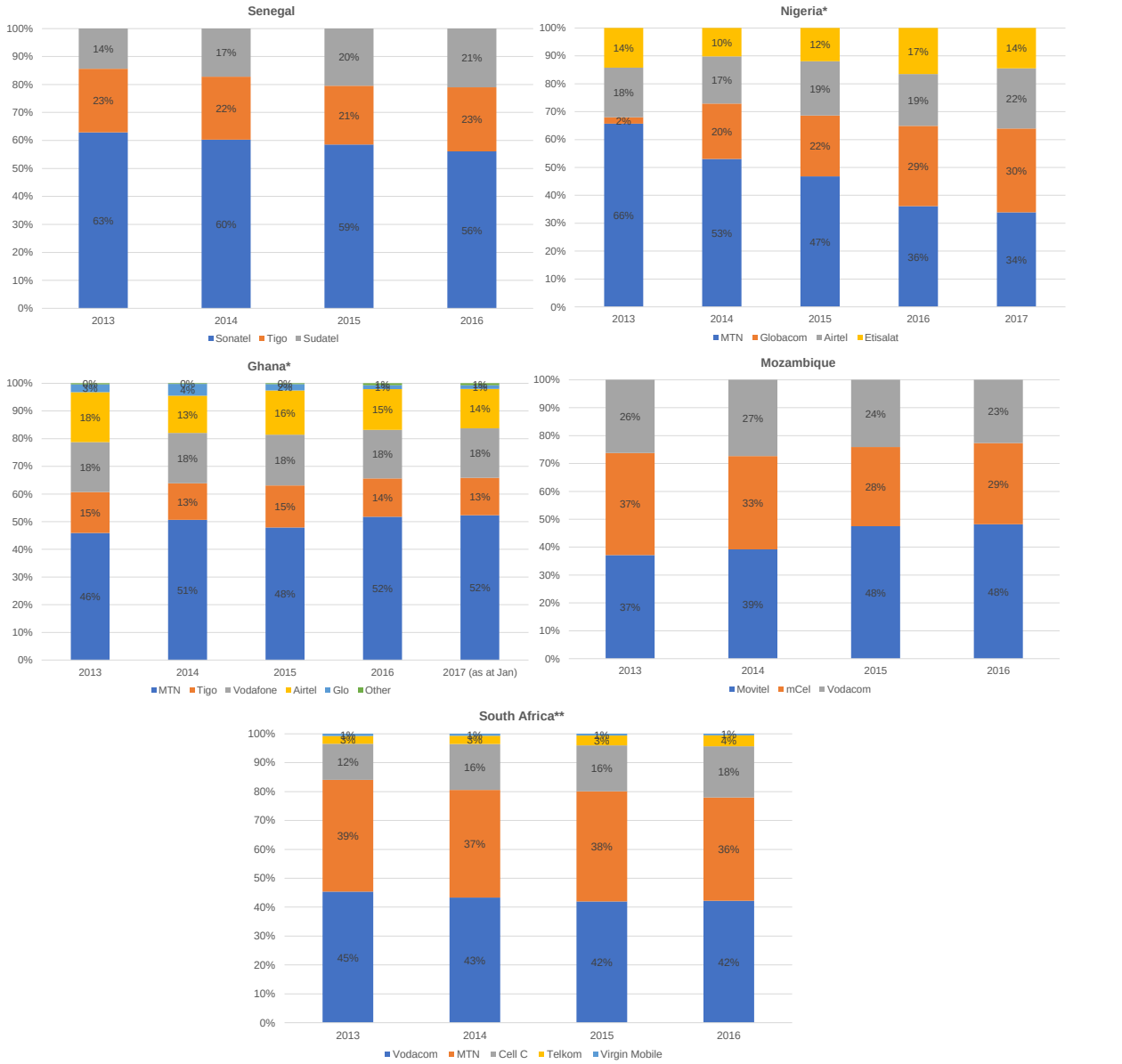
Ghana held an LTE auction in 2015 which attracted four bidders for the 800MHz spectrum. The largest operator with 50% of mobile data subscribers, MTN Ghana, was awarded one of the two lots of 2x10MHz.[9] The reserve price set was $67.5 million. The auction and high reserve price were controversial, but after the limited success of licensing 2600MHz spectrum to smaller operators a few years previously (as discussed above), the Ghanaian authority may have wanted to ensure the spectrum went to a player which would be able to invest in its network.[10] The Ghanaian auction produced the highest price per MHz per capita of any of the assignment processes for which we have pricing data. However, again it was only partially successful, assigning only half of the available spectrum and only to the largest operator.

Unlike Senegal and Nigeria, Ghana's mobile data market shares remained extremely stable between 2013 and 2017, with MTN slightly increasing its market share to over 50%. In spite of this, mobile data prices fell between Q2 2014 and Q1 2017, particularly from Q3 2016 onwards. Ghana now has the third lowest mobile data prices in Africa. This is interesting given that it appears (on the basis of market shares) to be a less competitive market than the other countries discussed so far.

Mozambique attempted to hold an auction for five 2x5MHz blocks of 800MHz spectrum in 2013 (six blocks were available, but one was withheld to restrict supply).[11] The reserve price was high at USD 30 million per block or USD 0.10 per MHz per capita. None of the mobile operators chose to participate in the auction and the spectrum was left unlicensed. Like in Ghana, mobile operator market shares in Mozambique have been quite stable over time, with the share of the largest operator, Movitel, increasing slightly. At the same time, mobile data prices have fallen steadily.

[6] Mobile World Live, 24 May 2016. Nigeria's spectrum auction draws just one bidder. Available here.
[7] Nigeria Bureau of Statistics (2016). Nigerian Telecommunications (Services) Sector Report Q1 2016. Available here.
[8] All Africa, 20 October 2016. Nigeria: The Untold Story of NCC's 2600MHz Spectrum Auction. Available here.
[9] Teleography, 3 December 2015. MTN Ghana wins spectrum in 800MHz band. Available here.
[10] Ghana Business News, 12 January 2017. 4G spectrum pricing: politics vs industry, consumer interest. Available here.
[11] Many possibilities, 21 April 2017. The Failure of Spectrum Auctions in Africa. Available here.

Figure 2: Mobile data market shares in Senegal, Nigeria, Ghana, Mozambique and South Africa, 2013 – 2017



Source: Regulator statistics, operator annual reports, media reports and author's calculations

*Note: Reported shares are based on operator subscriber numbers except those marked with * which are based on mobile data subscriptions and ** which are based on active mobile subscriber numbers.*

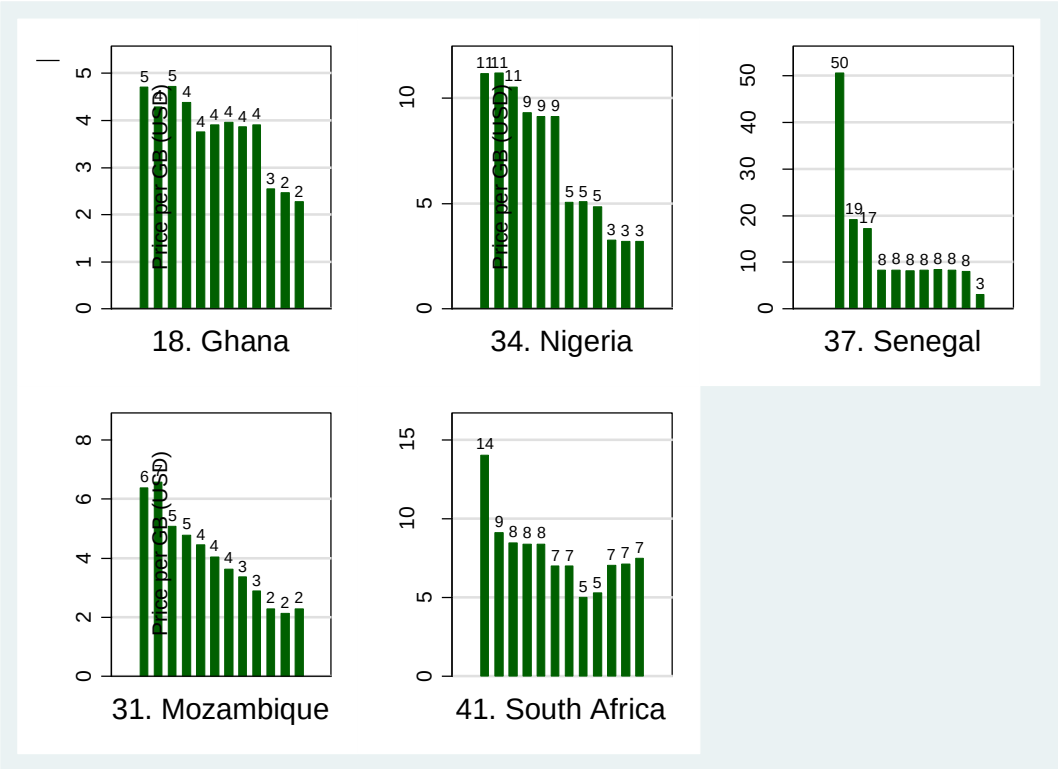
In July 2016, South Africa's regulatory authority (ICASA) published an invitation to apply to participate in a spectrum auction for four pre-determined lots of 700/800MHz spectrum bundled with 2600MHz spectrum, each with a reserve price of R3 billion or around USD214 million.[12] Each operator was eligible to purchase only one lot and there are four existing mobile operators in South Africa. If all four lots had been sold at the reserve price, this would have implied a price per MHz per capita of USD 0.07. The ITA was challenged by the Department of Telecommunications and Postal Services on various grounds and postponed pending a review hearing. The spectrum therefore remains unassigned. One of the reasons the government cited as motivation for blocking the ITA is that the reserve price is "onerous" and

[12] Government Gazette No.40145, 15 July 2016.

would favour large players.[13] Meanwhile, operators are forced to re-farm their existing spectrum assignments in order to provide LTE services.

The market share of South Africa's largest operator, Vodacom, decreased slightly from 2013 to 2016, while the share of smaller rival Cell C increased. Overall however, the market remains dominated by large operators Vodacom and MTN with Cell C and Telkom Mobile struggling to compete effectively. In terms of pricing, the price of mobile data fell until Q1 2016, before starting to rise again. South Africa has relatively expensive mobile data compared to the other countries in the sample.

Figure 3: Cheapest price for 1GB basket by country, Q2 2014 – Q1 2017, USD per GB



Source: author's own analysis of Research ICT Africa dataset, available here

It is difficult to draw conclusions from such a diverse set of experiences; however, the discussion does suggest a number of important factors to bear in mind when deciding spectrum policy. Before summarising these, it is important to note that we have presented a rather simplistic overview of competitive dynamics in each country and that there is likely to be a great deal of important nuance relevant to each experience which we have not been able to cover here. In particular, we have not been able to compile data on the speed and quality of mobile data offerings in each country, which would be an important additional factor to consider in trying to explain the trends observed.

In terms of the mechanism for spectrum assignment it seems that countries which have used an auction approach have generally received higher revenue from the process, but have been able to assign less spectrum and spectrum has been left unassigned in all cases (again, this is based on a small sample of countries). This is not optimal from an efficiency perspective

[13] All Africa, 11 August 2016. South Africa: Why Minister Siyabonga Cwele is Suing ICASA. Available here.

and may suggest that reserve prices have been set at too high a level in some cases. On the other hand, where spectrum has been assigned on a non-competitive basis at much lower prices, spectrum may have been undervalued to some extent, and, based on the principles outlined in section 2, may have resulted in spectrum being used less efficiently than would be optimal. There is a lack of transparency in the assignment process in some cases (Rwanda, Uganda and Tanzania) which makes it difficult to assess the process from a competition perspective. However, mobile data prices in these countries are also low.

What is clear from the data presented is that countries which have assigned more spectrum (particularly the attractive 800MHz spectrum) seem to have cheaper data prices on average. This is merely an observed correlation, and there could be other factors driving the result, but it does concur with the intuitive argument that regulators should seek to assign as much spectrum as possible to mobile operators (while attempting to do so in a pro-competitive way) in order to bring about increases in the quantity and speed of data which can be carried on the mobile networks at a lower cost.

What is striking from the examples presented, is that data prices have fallen even where conditions do not appear to be optimally competitive, suggesting either (or both) that market shares are not adequately accounting for competitive conditions in these countries, or that competition is not the only factor driving data prices. Where 4G spectrum has been assigned to one large operator, this does not appear to have had a negative impact on competition or led to higher pricing, however, sufficient time may not have passed in some cases for such effects to be observed.

6. Lessons for spectrum assignment for competition

It is clear from the discussion above that while spectrum auctions are theoretically the most efficient way to assign spectrum, their success or failure is highly dependent on the detail of their design and the context of the relevant market. International experience illustrates that in some instances, auctions are effective at meeting some objectives and not others. The experience of African countries in particular suggests that reserve prices may have been set at a high level with the objective of maximising revenue rather than ensuring participation and competition. By contrast, non-competitive assignment may be more effective at ensuring all available spectrum is assigned and shared between operators. However, beauty contests lack transparency as we see in the examples of Uganda, Rwanda and Tanzania, which is also problematic from a competition perspective. Where spectrum has been assigned by non-competitive means, it is also possible that an important national resource has been undervalued.

Where auctions are used in future, it will be important to design the process carefully to promote both competition and price discovery, and particularly to ensure that reserve prices are realistic and do not deter participation and entry. It is also important to balance the encouragement of entry with ensuring spectrum is efficiently used. Ghana's example illustrates that it can be difficult to achieve both simultaneously. In this context, auctioning multiple small lots and setting affordable reserve prices may be the best approach to optimising participation while still ensuring an efficient outcome.

The foregoing discussion highlights most critically the importance of licensing as much spectrum as possible in order to lower operators' costs and encourage falling mobile data prices. On the face of it, it seems that even where spectrum has been awarded only to one

large operator, this has not had an adverse effect on competition. While this may suggest that it does not matter much how you assign spectrum as long as it goes to operators who will use it effectively, for the longer term it is still important to avoid creating positions of entrenched dominance which will be hard to reverse and may lead to gains to consumers being undermined. The example of South Africa, with an entrenched duopoly and relatively high mobile data prices, bears this out.

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