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Economic Analysis of Spectrum Pricing in the light of auction results in the first ten years of spectrum pricing

Summary

1. The very high prices achieved by spectrum when auctions were first introduced was an aberration. It is unlikely such high prices will be seen again in the future.
2. Auction conditions are a major determining factor in the prices achieved. Where a government has sought to set conditions to favour new entrants in order to stimulate competition, the prices have been lower than where existing operators have not had limits imposed.
3. Internationally harmonised spectrum for use by telecoms operators commands a high price; correspondingly, spectrum for which there is no harmonised international usage attracts a lower price.
4. 'Paired' spectrum commands a higher price than unpaired (although this differential might be eroded if an 'unpaired' version of LTE technology is being introduced to compete with WiMax).
5. 'Higher' UHF spectrum – 700MHz and 800MHz bands command roughly twice the unit price of 2GHz spectrum because of the savings in building infrastructure using UHF spectrum.
6. Although there is little data on which to base conclusions, 'lower' UHF spectrum commands significantly lower prices than other spectrum.
7. Unless utilities can persuade government to grant access to spectrum on preferential terms because of national safety considerations, utilities ought to be promoting auctions of spectrum in the band 400-470 MHz – the utilities traditional operating zone - in blocks of 500kHz to 1MHz - large enough to deter radio dealers and manufacturers – but too small to be of use to network operators.
8. The price at which such spectrum might be obtained on past evidence, and its value to utilities for facilitating new services, could be in the price bracket up to €1million for a 15 year licence in major European countries.

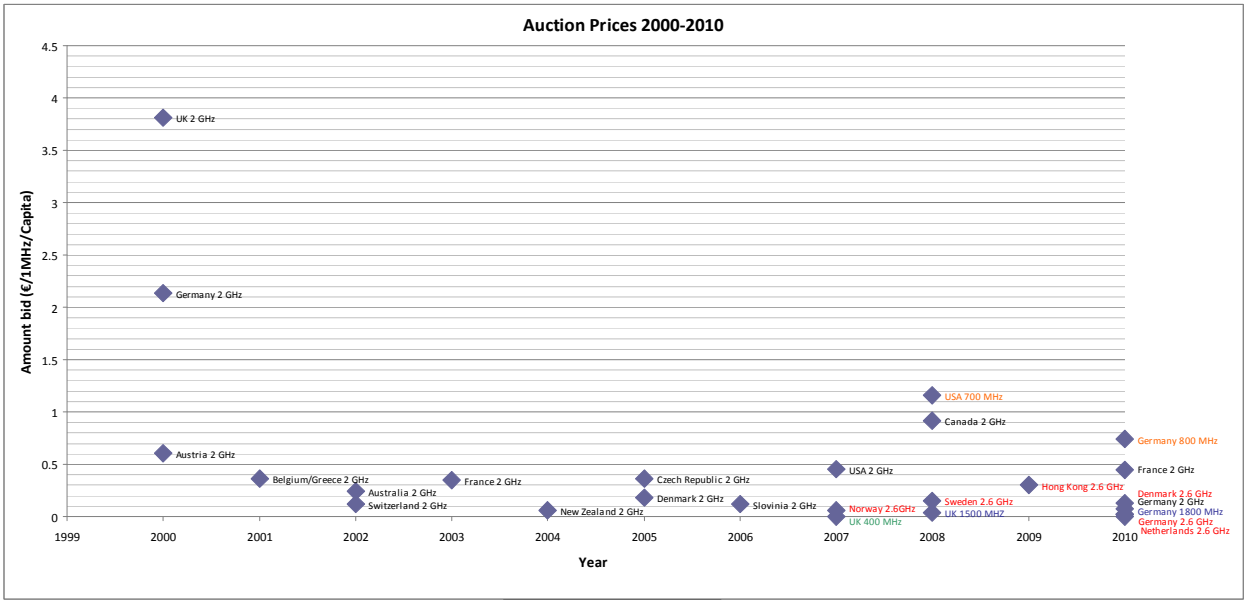


Figure 1

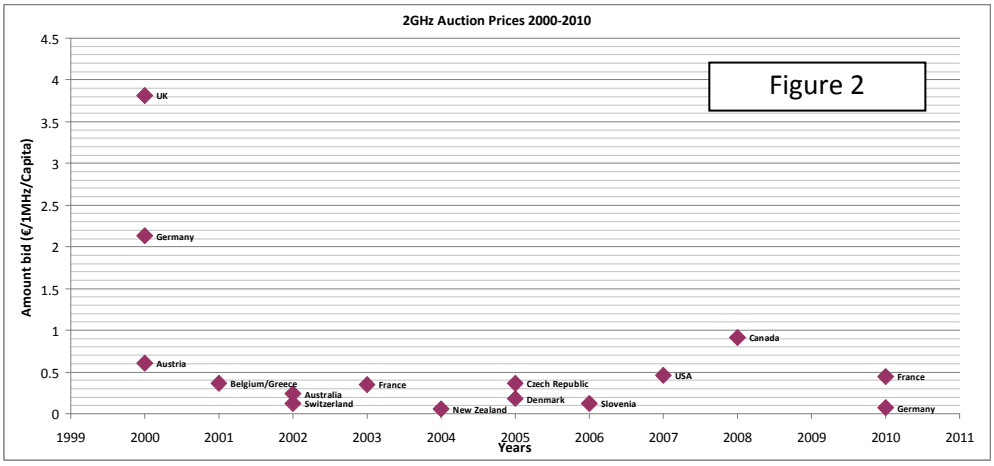
Introduction

9. In 2000, the UK held what was to be not only the first European auction of radio spectrum, but also, the World's first 3G auction[1]. Despite the controversy and arguable damage to the radio industry, auctions have now become far more common not only in Europe but around the World, supported by regulatory bodies, such as Ofcom, as the preferred free market method for the allocation of spectrum. Twenty six major spectrum auctions have taken place in the last decade, producing a workable database which has shed light on how the market may develop in the next 10 years.

10. The most obvious revelation is in the trend rates for spectrum, relating to the price structure of the market. With auctions remaining the preferred method of allocation by regulatory bodies for the foreseeable future, tactical bidding is the key. This is of primary importance to organisations, such as utilities, in industries which are not telecommunications themselves, but rely heavily on spectrum to discharge their primary function. These organisations would benefit from an accurate pricing model so as to maximise their options for acquiring auction through auctions, minimising costs and accumulating spectrum in anticipation of future requirements.

11. Furthermore, it is important to understand the difference between the bands of spectrum and how this has affected and will continue to affect their value at auction. The sample provides data prominently for spectrum in the 2 GHz band, most commonly associated with 3G connections. However, conclusions can also be reached for price changes in a number of other bands featured in the sample range, namely the 2.6 GHz and 800 MHz groups. Data for other bands, for example 1800 MHz, 1500 MHz and 400 MHz ranges is, by comparison, fairly limited. Nevertheless, conclusions can still be inferred. Understanding the difference in the micro-market structure is critical so as not to potentially overbid or underbid for spectrum.

12. Finally, a number of what can only be described as extraordinary auctions are to be found in the data range, most notably the UK auction in 2000 and the Dutch auction in 2010, both of which have been well studied in the radio industry. Whilst this report cannot necessarily add detail to the argument, it aims to understand further the impact of stipulation and regulation in the radio spectrum market. As has been proven, these cannot be ignored and to do so would put the reliability of the concluded model at risk. This factor therefore must also be taken into consideration when predicting the pricing levels future movements.



[1] 'The auction team was also very keen to maintain the advantage of being the first of the 3G auctions.'
'The Biggest Auction Ever: The Sale of the British 3G Telecom Licences' – Ken Binmore and Paul Klemperer: Page 17, Line 28

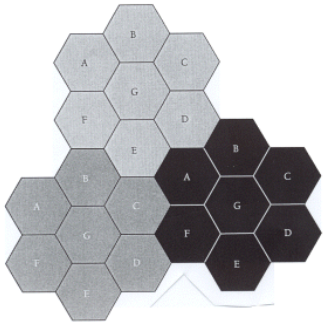
Analysis of General Tends

13. This reports essentially aims to amalgamate the data possessed and create an accurate prediction of how these factors affect the market and as a result, how the market will develop in the forth-coming years. As such, the prices will be compared in the cost per MHz per capita (€ MHz^{-1} per capita) so that prices in different countries and for different size packages of spectrum can be compared, enabling a greater analysis of a wide range of figures. Whilst it is not possible to quote how accurate the following report may be, it should at the very least give detail of the scale to which the price levels are declining in the market and how these levels can be grossly affected by the presence, or lack thereof, of the regulatory framework surrounding each auction.

14. Naturally, when observing the price trend rate and its structure, it is imperative to look at the data and interpret it carefully. More importantly however, the facts behind the figures need to be investigated if true representation is to be gained. By just quoting the figures or, even worse, omitting them, the picture can be distorted, especially in a market so deep rooted not only in technology, but in regulation and politics.

15. The data sample is, unfortunately, limited to the 2 GHz band until 2007 when a wider variety data for different bands of spectrum becomes present (see Figure 1), but even this is key to understanding basic elements of the analysis. In 2000, where the auction data begins, there is a vast difference between the winning bids in the UK, Germany and Austria using this measurement. This clearly demonstrates poor modelling when calculating the values to bid; the totals for the bid exceeding the media predictions in the UK by 5-10 times[2]. The Austrian model would seem to more accurately reflect its real value, although it still exceeds the range of values which are now commonly achieved. However, whilst these figures can be ignored on the grounds of the wildly exacerbated prices, they show the influence of regulation and stipulations (to be discussed further in the report) and explain prices in 2005.

16. Following on from 2000, prices globally became more aligned, tending towards similar prices, and fell until 2004, from the €3.80 MHz^{-1} per capita high in the UK in 2000 to €0.05 MHz^{-1} per capita in New Zealand in 2004[3]. This fall is evident even if the comparison removes the 2000 prices. This fall in the 2 GHz spectrum can be blamed on a loss of confidence in 3G as the winning bidders had managed to effectively 'outbid' themselves[4]. This effectively destroyed the value of the spectrum to the winning bidders in the short term as they not only struggled to cover the 'losses' from the auction but could not afford to build networks to exploit the spectrum won; and with the early 2000 recession in the US, was a guaranteed way for confidence to be lost.



17. However, the seeds of the recovery in the latter part of the 2000's began in 2003 with Hutchinson 3G. As the first company to roll out 3G following the auction debacle, it demonstrated the commercial benefit of 3G which was adopted in 2005 by firms such as Vodafone joining the 3G communications market. By

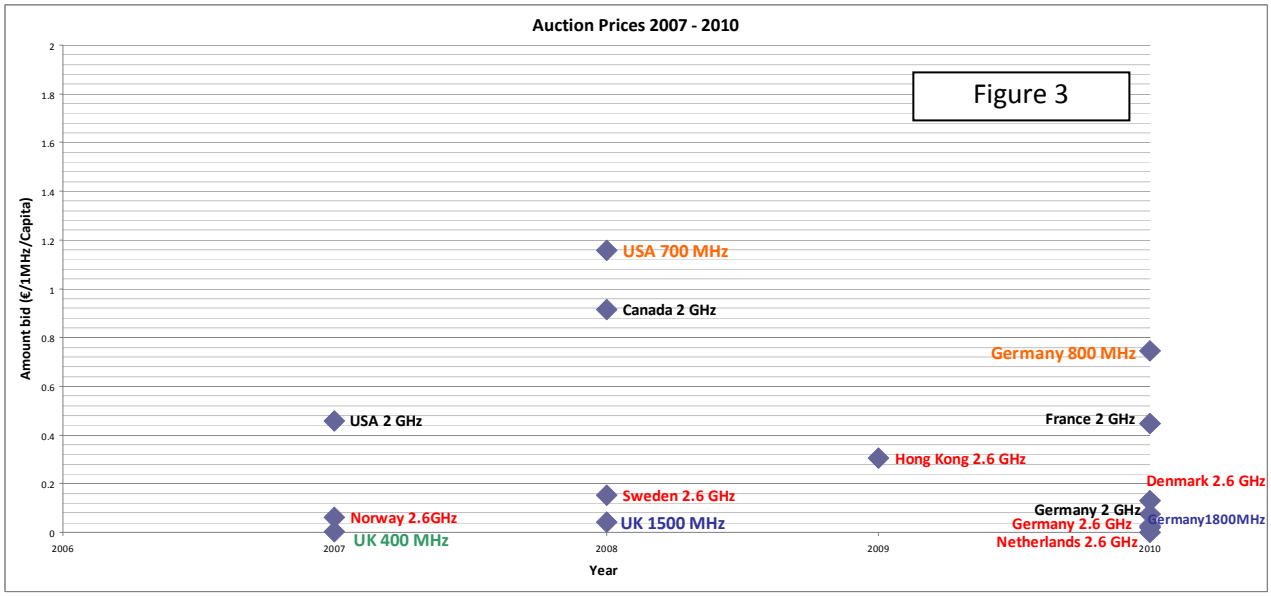
[2] 'The final bid took the cheapest licence price past £4 billion ($6 billion), and after 150 rounds of bidding the auction finished on 27 April, 2000 with a total of about £22 ½ billion ($34 billion) on the table–five to ten times the initial media estimates.'
'The Biggest Auction Ever: The Sale of the British 3G Telecom Licences' – Ken Binmore and Paul Klemperer: Page 17, Line 36

[3] See diagram 1

[4] 'Although 3G's prospects look a lot less rosy a year after the auction, and many people now believe that the winners of the British 3G auction "paid too much", only time will tell whether their gamble was a good one'
'The Biggest Auction Ever: The Sale of the British 3G Telecom Licences' – Ken Binmore and Paul Klemperer: Page 5, Line 6

2006, European 3G coverage had reached over 70%[5] – suggesting that the launch of 3G had been pushed back about 5 years due to the UK auction. This development in mobile communications saw spectrum prices rise again from 2005, with Czech Republic paying €0.37 MHz^{-1} per capita and Denmark €0.18 MHz^{-1} per capita, to the high point in 2008 with Canada paying €0.91 MHz^{-1} per capita[6]. This price is higher than other figures would suggest the value of the spectrum was. In this case, firms in Canada would seem to have been trying to roll out 3G before the Winter Olympics in 2010, artificially increasing the price. Although Slovenia[7] experienced low sales in this 'growth period, the price did still tend to rise.

18. In 2007 the first data for the 2.6 GHz band and, although a smaller sample, from 2008 the 800MHz range had been produced and followed the same pattern. The price Hong Kong paid in 2009 (€0.30 MHz^{-1} per capita) was 500% of the value that Norway paid in 2007 (€0.06 MHz^{-1} per capita). From 2000 to 2009, the market seems to have experienced a depression, slump, growth and boom - common features of a Business or Economic Cycle and, with prices falling in 2010 towards price levels similar to 2002/2003; it would be a reasonable assumption that further comparisons may be drawn. With another decade of data, it should become apparent whether this is a valid statement or not.



19. When analysing this data, despite numerous differences to other markets such as the inelastic supply, sole reliance on derived demand and lack of a trade off (radio spectrum can only be used for radio), it would be safe to assume it has this in common.

20. With the analysis concluded on preceding events, although more complex issues will be viewed in greater depth further in the report, figures can now be potentially formed for a future pricing structure. It can be seen that the 2.6 GHz, 2 GHz and 800 MHz figures have fallen from 2009 (2008 for 800MHz) to 2010. If the 2 GHz band is taken to represent general prices through-out the period, the price levels at present are similar to 2002/2003, before the emergence of 3G, and 2005/2006, following 3G. As 2004 marks the slump period, tied in with the fuel crisis and 2001 recession which would have affected capital investment, it can be assumed

[5] http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/broadband_coverage_10_2007.pdf on 26/08/2010
[6] See diagram 1
[7] €0.12 MHz^{-1} per capita

that the spectrum market follows the economic cycle with a 2-3 year time lag. Other figures (2008 - 2010) bring the figure closer to 2 years, suggesting the slump in spectrum prices may extend in 2011.

21. The likelihood of the 'spectrum slump' continuing into 2012 is remote as the positive movements, particularly in the banking sector, have reduced the impact of the downturn, especially when compared to that of the 2001 recession and fuel crisis, which arguably had a wider sphere of influence. Much like the previous spectrum market downturn, prices continuing from 2010 to 2011 are likely to be, if using the figures from the 2002 – 2006 years, between €0.35 MHz^{-1} per capita and €0.06 MHz^{-1} per capita - the average was €0.21 MHz^{-1} per capita[8], although at that point, it was only 2 GHz spectrum.

22. In the long run however, prices will undoubtedly rise. Although the data supply is fairly limited and the market is susceptible to 'economic shocks', the rise in the price of 2 GHz spectrum by USA 2007 from €0.21 MHz^{-1} per capita to €0.45 MHz^{-1} per capita, along the Hong Kong 2.6 GHz data, would suggest price movement up towards €0.45 MHz^{-1} per capita, giving a price range between €0.60 MHz^{-1} per capita and €0.40 MHz^{-1} per capita. This prediction is not for any specific band of spectrum, but for the market as a whole. The weighting of the data towards 2 GHz, which comprises 60% of the data sample, means that pricing for each band of spectrum is required and will be expanded upon later in the report.

23. What this data does provide, however, is a general consensus on pricing in the market. Prices will fluctuate, at least according to 88% of the present data, between €0<x≤€1.00 and 80% between €0<x≤€0.60.

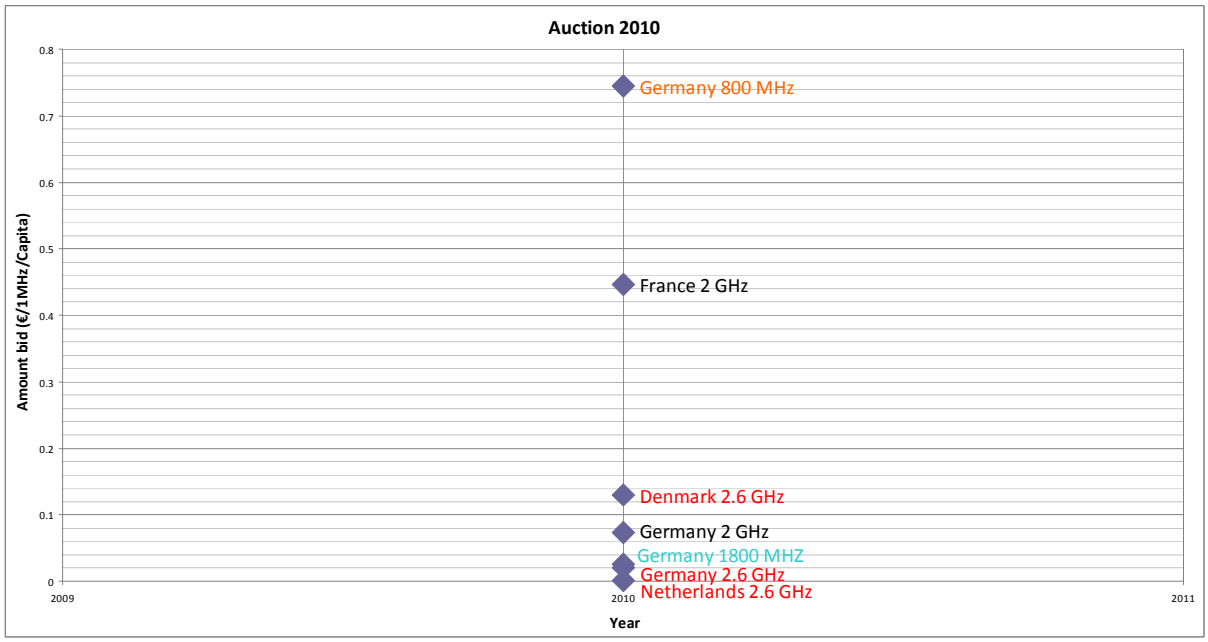


Figure 4

[8] Actual value €0.206834 MHz^{-1} per capita

The price changes also mirror that of the general economy with a 2 year time lag (this time lag may be related to the period of effect after the implementation of monetary policy such as changes in the base rate of interest). Finally, the immediate future would seem to have spectrum prices remaining constant, followed by an increase in late 2011/early 2012. This general view is an indicator of pricing changes to come and could be currently particularly useful for bands such as the 400 MHz and 1800 MHz although there is not enough data to create any firm trend analysis.

Specific Characteristics

24. As general trends have now been established in the spectrum market, the value of specific characteristics must be taken into account. The data clearly shows how bands fetch different prices at auction but this variation is not just limited by the band of the spectrum. The matter of paired spectrum, internationally harmonised bands, and size of the block of spectrum available are further components of price and could reduce an organisation's expenditure on spectrum drastically if the auction structure could be influenced.

25. To ensure the best use of a firm's investment in spectrum, the price between the different band groups is paramount. If an order can be completed on two different bands of spectrum with relatively minor capital setup differences, then both must be considered in their entirety. The data suggests a similarity in pricing for the 2.6 GHz and 2 GHz bands. They are both used as carrier channels for commercial companies, used to support data transfers such as 3G/LTE and WiMax for example. The price for 2 GHz may be slightly higher due to its incorporation into existing 3G networks and the greater market for 3G; but otherwise, the two bands can be treated as similar. This is not the case for UHF.

26. UHF is the collective term in this report for Upper UHF (700 MHz – 900 MHz) and Lower UHF (≤ 500 MHz). Despite the fairly limited data available for UHF as a whole, it still paints a clear picture. The Upper UHF is the most expensive band for spectrum. If the extraordinary cases of the UK and Germany bids in 2000 are discounted, then the price for Upper UHF spectrum would be the highest value auctions of spectrum in the data sample, irrespective of year. If the mean is calculated for all 2 GHz spectrum sales, including the high cost auctions of 2000, it is still out-done by the Upper UHF, the mean value of which is €0.95[9] compared to just €0.68[10] of 2 GHz, a rise of 39%. If the price of Upper UHF is compared to the highest valued piece of spectrum in that year, the USA auction in 2008[11] raised 126% of Canadian 2 GHz auction[12] and the German auction in 2010[13] 167% of the French 2 GHz[14].

27. Conversely, Lower UHF spectrum, based on the UK auction in 2007 (which JRC was a part of), was the lowest that year and indeed the lowest of the present data except for the Dutch auction in 2010. Compared to the 2 GHz auction that year from the USA, the 400 MHz auction fetched just 0.004% of the value of the 2 GHz

[9] Actual value €0.95192837 MHz^{-1} per capita
[10] Actual value €0.684048756 MHz^{-1} per capita
[11] Actual value €1.158564083 MHz^{-1} per capita
[12] Actual value €0.914655855 MHz^{-1} per capita
[13] Actual value €0.745261591 MHz^{-1} per capita
[14] Actual value €0.446108149 MHz^{-1} per capita

spectrum. Whilst there is not enough evidence to draw a firm conclusion for Lower UHF or for Upper UHF, definite characteristics can be reached for both. Upper UHF, the bands 700 MHz, 800 MHz and 900 MHz, will attract premiums of up to 200% of the value of 2 GHz spectrum potentially. The data suggests a rough guide price of around 1.5 times that of 2 GHz spectrum although this will become more refined in years to come and could possibly be revised.

28. Lower UHF, although even more difficult to estimate than Upper UH, is likely to achieve 0.001% - 0.01% the value of 2 GHz spectrum. This is difficult to guage at present due to the paucity of data, but the UK spectrum figures suggest that if a monetary value was to be placed it would be approaching £250,000 (approximately €300,000) for a single national licence. If a firm had placed a bid of £250,000 in the UK auction, they would have received a single licence of 2x500 kHz at 400 MHz, although a scale factor to 4 would not have worked as the winning bid was £1.5 million for all four licences. However the ultimate winner's bid for the first licence of 2x500 kHz was £750,000 (approximately €900,000), which would suggest they added a £500,000 reverse to guarantee at least one licence at least. The estimate of £250,000 is a very approximate figure and should not be taken as a definitive answer.

29. As this has shown, the band of spectrum is a very important characteristic to take into account when estimating value, but at least three further characteristics are similarly important as discussed further below.

Paired and unpaired spectrum

30. Paired and unpaired spectrums operate with different functions which can be utilised by different firms. Paired spectrum has been the traditional home for two-way communications, traffic in each direction being allocated its own frequency slot. However, this requires a structured spectrum allocation to provide different bands for the 'uplink' and the downlink' with a fixed allowance for the amount of traffic in each direction. Unpaired spectrum places less restraint on regulatory co-ordination, and can be configures for asymmetry in the uplink and downlink data rates. However, unpaired spectrum faces more technical restraints.

FDD vs. TDD Technical Comparison

	TDD	FDD
Coverage	Poorer coverage for a sustainable rate due to "off" periods.	Better coverage for a sustainable rate since can transmit continuously in UL and DL.
Spectrum	Can be deployed in unpaired spectrum	Requires paired spectrum
Hardware cost	No duplexer required since transmitter and receiver operate on the same frequency but at different times. Switching matrix is required.	Duplexer is required as it is operating in two frequencies simultaneously. Switching matrix is not required.
Channel reciprocity	Channel propagation is the same in both directions. This benefits beamforming techniques. Helps DL Cooperative Multi-Point (CoMP) in Rel'10 LTE.	Channel characteristics different in both directions as a result of the use of different frequencies thus requires explicit feedback.
Synchronization	Tight synchronization required between base stations to avoid BS-to-BS & UE-to-UE interference	Loose synchronization acceptable
Engineering	More engineering required due to guard time for optimization and coexistence	Less engineering required to optimize
Spectral Efficiency	Spectral efficiency impacted by guard period (larger for larger cell sizes)	Guard band required for two bands (DL & UL)
Asymmetric traffic	DL:UL ratio can be changed to match asymmetric demands, but must bet set network wide.	DL/UL spectrum allocation fixed

Both FDD and TDD have their benefits. Its applicability governed entirely by Spectrum Allocation

12 - Ashok Rudrapatna
22 Sept. 2010

Alcatel·Lucent

31. Whilst the data sample is not expansive enough in its detail to identify price differentials between paired and unpaired spectrum, general statements can be made and should if the report is to attempt to be comprehensive.

32. In commercial enterprises, the large capital costs involved in entering the industry creates barriers to entry, limiting the structure to an oligopolistic design, pushing prices up. Although this defies initial economic thought, as less firms should lower competition and cause spectrum prices to fall, the oligopoly theory of competition states that such firms would not undercut on the price of their services and risk a industry price war, but would prefer 'non-price' competition.

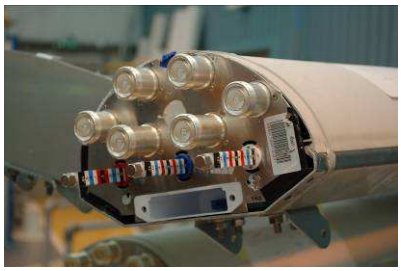
Therefore, outbidding the competition on spectrum would enable both firms to keep sales costs fixed; preventing new firms entering the market and protecting their market share, but the winning firm would appear the more dominant market player and would be able to offer additional expansive services. As such, prices throughout the data have remained higher in commercial spectrum than that of business spectrum. Business spectrum is less competitive as the radio systems do not provide the end product, rather they are used to lower production costs such as remote access or a technological replacement for labour. The lack of competition generates a lower price range and is therefore preferable if the capital is available to make use of the spectrum is available at a cost effective level. The situation is fluid however, and open to change as technologies emerge to exploit such production methods.

Size of auction block

33. A further parameter which influences the price achieved by spectrum at auction is block size. Networks operators using new commercial broadband technologies usually need channel sizes in the region of 1 MHz, generating a need for several tens of MHz to construct a national or even regional network. The draft European Radio Spectrum Policy Programme therefore postulates a minimum size for a block of spectrum to be auctioned as 10MHz to facilitate national roll-outs for new radio networks.

34. The implication of a minimum size of a block of spectrum for a viable telecommunications networks is that spectrum offered in block sizes of less than 1 MHz will attract less money, making them more attractive to non-telecoms organisations. However, if channel block sizes are reduced to the level of a new tens of kHz, then a different situation might arise where lots of small players can afford to compete for spectrum, potentially driving up the price once more.

Internationally harmonised spectrum



35. The final characteristic causing the variance in price between groupings of spectrum is the issue of international harmonisation. Unfortunately, it suffers the same lack of data present for the paired/unpaired argument. However, it is fair to say that internationally harmonised spectrum commands a premium over non-harmonised spectrum due to its greater range of use and reduction in the need for capital spending. Conversely then, the non-harmonised spectrum has a lower value to commercial operators and as such attracts lower prices, devoid of the high levels of investment present in commercial industries.

Effects of competition on price

36. In commercial enterprises, the large capital costs involved in entering the industry creates barriers to entry, limiting the structure to an oligopolistic design, pushing prices up. Although this defies initial economic thought, as less firms should lower competition and cause spectrum prices to fall, the oligopoly theory of competition states that such firms would not undercut on the price of their services and risk a industry price war, but would prefer ‘non-price’ competition. Therefore, outbidding the competition on spectrum would enable both firms to keep sales costs fixed; preventing new firms entering the market and protecting their market share, but the winning firm would appear the more dominant market player and would be able to offer additional expansive services. As such, prices throughout the data have remained higher in commercial spectrum than that of business spectrum.

37. Business spectrum is less competitive as the radio systems do not provide the end product, rather they are used to lower production costs such as remote access or a technological replacement for labour. The lack of competition generates a lower price range and is therefore preferable if the capital is available to make use of the spectrum is available at a cost effective level. The situation is fluid however, and open to change as technologies emerge to exploit such production methods.

38. To counter the effects of competitive pressure, and in some cases to foster competition in the telecommunications services market, regulators will impose other constraints, such a maximum spectrum holding allowance for existing telecommunications operators, or in the extreme, a prohibition on existing operators from entering the auction. This distorts competition and depresses prices as the incumbent operators are likely to use the financial resources which would otherwise be used to buy more spectrum to compete more fiercely with any new entrant, thereby discouraging new players from entering the market. This explains the low prices obtained in the 2010 Dutch 2.6 GHz auction.

Figure 5

Non-spectrum related influences

39. The final cause of shifts in spectrum price is the condition in which they are sold, either stipulations relating to the manner in which they are to be sold or to what use they may be put. The extraordinary results in 2000 for the UK auction, 2008 with the USA and Canadian auctions and the 2010 Netherlands auction show the best examples of how such 'add-ons' can affect the price.

40. When observing the impact of regulation on spectrum pricing, the UK auction in 2000 and the Dutch auction in 2010 should be, and have been scrupulously, observed. The two auctions, despite their conflicting outcomes, were both setup with a primary objective of attempting to foster competition in the market by favouring new firms who were trying to enter the market. It was the stipulations however, that caused the drastic difference in prices across the 10 years. The UK limited firms to just one licence, similarly, the Dutch limited the existing operators to 2 x 25 MHz spectrum. The UK auction on the other hand, tied in the firms attempting to adopt the new technology with the bidding system. Firms had to bid

in each round above the maximum price in the last round or be eliminated, although the deposit to enter only ever reached £100 million, a fraction of the total cost in the end. The major 2G providers were unwilling to leave bidding, causing inflationary bids across a protracted 7½ weeks of bidding, with the winning bids ultimately exceeding estimates by up to 10 times what was expected[15].

41. The Dutch auction on the other hand, featured just a fraction of the number of firms who had been present for the UK auction (down from 13 in the UK to only 5 in the Netherlands). Despite these differences, the UK auction had been a harsh warning to the industry about this manner of allocation and this kind of investment in new technology and the outcome was very different. Nevertheless, the effects of over-regulation were very clear. Forcing firms through regulation into such high bidding had been damaging for the industry, with thousands of jobs lost in the UK[16]. The lack of confidence therefore existed so that the Dutch auction, although a much smaller operation, still caused a certain amount of nerves and an adversity to any large investments, especially in potentially unusable 2.6 GHz and unpaired spectrum. The unpaired spectrum remained unsold and the 2.6 GHz paired was sold at the lowest price of any auction. The over-regulation had reduced the value of spectrum as profits could not be guaranteed.

42. Features of the USA auction and, to a lesser extent, the Canadian auction in 2008 explain the benefits therefore of less regulation. The USA auctions had half of the initial stipulations placed with the national wireless network removed; becoming 'rentable' and compatible with a wider range of equipment[17] and the auction achieved a net value of $18bn. The Canadian auctions split a range of useful channels between existing and potential 3G operators. With the promise of high profits to be gained from exploiting roaming charges in the 2010 Winter Olympics, a similarly high price was achieved.

43. The main difference between the two North American auctions and the European auctions was therefore the certainty of profits to be made. Over-regulation in Europe had scared the firms, with memories of the UK auction in mind, into a very timid state by the Dutch auction. European markets had become severely depressed in some circumstances, whereas the freer trade in North America enabled a wider range of use and therefore achieved higher spectrum values.

44. When looking at the affects of regulation on the price of spectrum, there is a significant trade off for the firm which, once again, depends on what the firm is hoping to achieve. Highly regulated auctions favour smaller firms. The limits placed on the existing market members prevents them from bidding for all the spectrum on offer, thus allowing smaller firms into the market, admittedly on less-valued bands. However, the small firms are also limited in their choice of spectrum by the quotas imposed. A free auction allows firms a greater diversity of

[15] 'The final bid took the cheapest licence price past £4 billion ($6 billion), and after 150 rounds of bidding the auction finished on 27 April, 2000 with a total of about £22 ½ billion ($34 billion) on the table–five to ten times the initial media estimates.'
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[16] http://www.guardian.co.uk/technology/2002/may/24/internetnews.guardiananalysispage on 26/08/2010

[17] http://www.pcmag.com/article2/0,2817,2164661,00.asp on 26/08/2010

choice and the ability to bid on all bands. However, this generally causes higher prices as more firms compete and so small firms are out-bid.

45. The affects of regulation on an auction are, therefore, similar to that of the effect of different bands. In a regulated auction, a firm faces less competition and so is more likely to gain spectrum at a lower price. However, they cannot buy much spectrum in any one regulated auction. The trade off that exists in the spectrum market is therefore to pay higher rates for spectrum in a free auction with the potential to buy the total supply; or pay lower prices but have the total amount of spectrum that can be bought capped.

46. When trying to make future predictions for spectrum pricing from the data present, the national economy as a whole, the characteristics about the specific auction for sale and finally the manner in which it will be sold must all be taken into account when formulating a conclusion. The advances in technology have caused the prices in the general spectrum market to fall but they still follow a trend similar to the national economy due to factors such as inflation and consumer welfare, although with a two year time lag. However, the prices, which are stable, vary significantly from band to band.

47. Upper UHF is valued at about 1.5 times the market rate whilst 2 GHz spectrum follows the market rate closely. Lower UHF achieves a far lower value due to its non-commercial functions. 2.6 GHz and 1500 MHz – 1800 MHz are very unclear, but are most likely to be found between the 2 GHz and Lower UHF values. Furthermore, spectrum which is internationally harmonised or paired is likely to attract a high premium over the non-harmonised or unpaired spectrum, although emerging technological advances could reduce the gap between paired and unpaired spectrum.

48. The final factor affecting the value spectrum achieves at auction is the conditions under which it is auctioned. A regulated auction keeps prices low as quotas enable competition between small or new firms for limited amounts of spectrum whilst a free auction attains higher values for spectrum, but the spectrum may become monopolised. While the data is not extensive enough to formulate more in-depth figures with precise price estimations, it has given clear indications on movement within the industry.

49. Prices may also vary due to changes within the industry, such as foreign investments or developments for a band of data – Smart grids using 2.6 GHz spectrum for example. Nevertheless, developments such as these can still be forecast using the ability to compare current spectrum market data with that of other markets. The market analysis contained in this report should be able to give an insight into what has caused the spectrum industry to develop in such a way and from that, develop the view of the potential future of the spectrum market price.

Conclusions

50. Overall then, the price of spectrum is not only controlled by market trends and fashions but by the actual characteristics of the package in question. If 2 GHz is said to sell at the 'standard market price', then Upper UHF is high value spectrum and Lower UHF low value. Moreover, paired spectrum fetches a high price due to its applications in commercial industries than unpaired spectrum which can still be effectively used for business if capital investment can be met. Finally, spectrum which is internationally harmonised is more valuable than the non-harmonised. Depending on a firm's requirements therefore, the investment in spectrum can be reduced by compromising on the spectrum they use or using more specified spectrum. Firms such as utilities could benefit from certain characteristics. Could the electricity industry, for example, fulfil their duties with unpaired spectrum and purchase the necessary capital for less than the cost of paired spectrum? An in-depth analysis of the tasks required of a particular band of spectrum would be essential for firms therefore as this report has shown that the characteristics of the spectrum types can greatly vary costs for better or for worse.

Joseph Grilli
Economics Associate
JRC Ltd
London, UK
September 2010