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The value of spectrum and the impact of the breakthrough for mobile data: The case of India, Sweden and Thailand

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THE VALUE OF SPECTRUM AND THE IMPACT OF THE BREAKTHROUGH FOR MOBILE DATA – THE CASE OF INDIA, SWEDEN AND THAILAND

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**THE VALUE OF SPECTRUM AND THE IMPACT OF THE
BREAKTHROUGH FOR MOBILE DATA – THE CASE OF INDIA,
SWEDEN AND THAILAND**

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ABSTRACT

This paper presents an analysis of the marginal value of spectrum with a focus on mobile broadband and illustrated by three country cases: India, Sweden and Thailand. The paper use an engineering valuation approach, which refers to savings that can be achieved by acquiring appropriate amount of spectrum rather than to deploy additional sites, to estimate the marginal value of spectrum. It is complemented with a discounted cash flow valuation (DCF) in order to estimate the net present value of spectrum.

Valuation of spectrum is a complex issue given that the value is depending upon the availability of spectrum, national spectrum regulation, competitive situation on the market and expectations about the growth of the mobile business. The paper is addressing three research questions: 1) What is the engineering value of spectrum in two country cases, 2) what is the DCF value of 3G spectrum in Thailand, and 3) what do the paid levels at spectrum auctions imply for the marginal value of spectrum.

The methodology applied to calculate the engineering value is based on a comparison of different network deployment options using different amounts of spectrum. As spectrum and sites are substitutes it enables us to calculate how many additional sites that are required in order to compensate for an incremental allocation of spectrum. Moreover, the paper compare estimates of the marginal value of spectrum with prices paid at a number of spectrum auctions presented as the value per MHz per population. The contribution of the paper is the development of an approach and estimates of the marginal value for spectrum which could be of interest for regulators when setting reserve prices on spectrum. It could also be an input to corporate spectrum strategies and a contribution to the development of valuation approaches on spectrum.

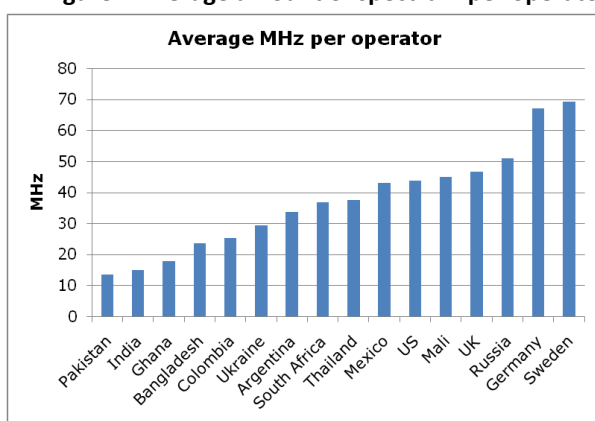
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INTRODCUTION – SPECTRUM ALLOCATION AND PRICES

As telecommunications is seen as a vehicle for growth most governments has set out broadband (including both fixed and mobile) targets. In October 2011, the Indian government published a National Telecom Policy which aims to reach broadband speeds of 2 Mbps by 2015 and at least 100 Mbps thereafter.² Europe has set out to provide fast broadband with speeds above 30 Mbps for all Europeans by 2020 and ultra-fast broadband with speeds above 100 Mbps for 50% of all European households by 2020.³ Thailand’s telecom master plan aims to achieve coverage of 85% of the population for data services before 2017.⁴

Given that it requires significantly more capital expenditures to deploy fiber access networks compared to mobile networks mobile communication is set to be instrumental in fulfilling the broadband targets. In markets with undeveloped fixed networks and limited deployment of fiber mobile is set to play a key role. This will reinforce the significance of spectrum, which is underscored by the global diffusion of smartphones, which will be available to larger segments of the market when prices are coming down under EUR 100. Access to spectrum for operators varies considerable between different countries, which is illustrated by the fact that operators in India on average have 2x15 MHz while operators in Sweden in average have 2x70 MHz. The enhanced role for spectrum turns spectrum allocation into decisive events for mobile operators.

Figure 1 Average amount of spectrum per operator (downlink)⁵



Source: NRAs, Cullen-International, operator reports, authors’ calculations

An estimate of the value of spectrum could be derived from auction prices paid by operators. The outcome of spectrum auctions regarding the 800 MHz-band show that operators in Germany and France paid EUR 1.54 and EUR 1.35 per MHz/pop⁶ respectively, while the Swedish operators in average paid EUR 0.68 per MHz/pop. Prices

² Government of India, Draft National Telecom Policy 2011, October 2011

³ EU-Commission, A Digital Agenda for Europe, 19.05 2010. Com(2010) 245

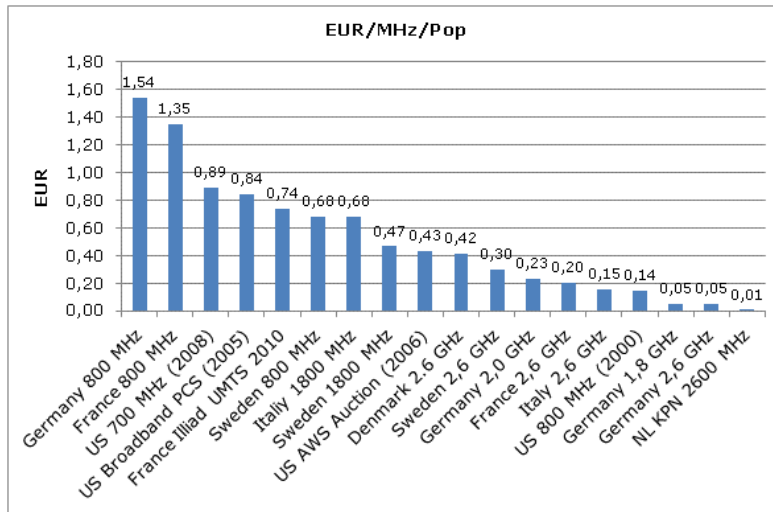
⁴ Thailand Telecommunications Master plan, <http://www.nbtc.go.th/wps/portal/Eng/Aboutus/History/MasterPlan>

⁵ The presented numbers are based on the total amount of spectrum mobile operators have in the different countries, and then calculated as a market share weighted average per country.

⁶ The amount and price of spectrum is presented using the metric “price per MHz normalized with the population” (EUR/MHz/pop)

for spectrum in the 2.6 GHz band reached considerable lower levels, see figure 2. Interestingly enough, prices paid at the Indian 3G auction in 2010 for the two main Indian cities (EUR 4.45 per MHz/pop) were not far off from prices paid at the 3G auctions in the UK (EUR 6.50 per MHz/pop) and Germany (EUR 10.68 per MHz/pop).

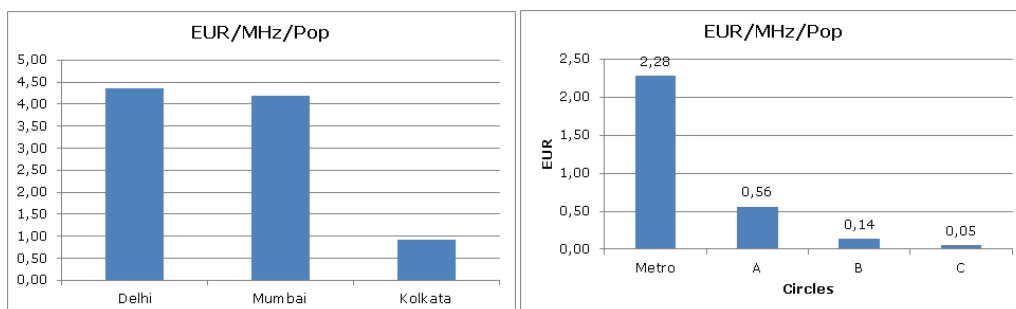
Figure 2 Prices paid per MHz/pop in auctions in Europe and US



Source: NRAs, Cullen-International, authors' calculations

However, prices paid at the 3G auction in India in 2010 varied significantly between the four service areas. The average price in circle A, which comprise five states/regions with 360 million inhabitants, reached EUR 0.56 per MHz/pop, the price in Circle B, which comprise eight states with 525 million inhabitants, was EUR 0.14 per MHz/pop, and in circle C, which consist of 4 states with 205 million inhabitants, operators paid EUR 0.05 per MHz/pop.

Figure 3 Prices paid per MHz/Pop for 3G licenses in the four circles/telecom service areas in India



Source: Department of Telecommunications (DoT) India

This paper address an issue that is of great interest for regulators in the process of spectrum allocation and setting reserve prices and for operators in developing spectrum strategies. But it is also of interest for the academic research as it provides a techno-

economic approach to an interesting issue and applies it to a current situation on the market and addresses a research topic that would benefit from contributions.

RESEARCH QUESTION AND METHODOLOGY

The outcome from recent spectrum auctions in India and Sweden is used as a point of departure for the valuation. Key concepts in the analysis are the marginal value of spectrum, which cover the engineering and strategic value of spectrum, and the willingness to pay for spectrum. This is complemented with an examination of spectrum holdings for Swedish mobile operators, and an assessment of the intrinsic properties of spectrum which altogether determine the conditions for network deployment. The research question is: *What do the paid levels for spectrum imply for the marginal value of spectrum and willingness to pay?* Key aspects in the analysis are: 1) to identify factors for competitive advantage in relation to spectrum; impact on production cost depending upon the amount of spectrum, 2) to analyze ranges of engineering and strategic value of spectrum, 3) to identify factors that determine the willingness to pay for spectrum, and 4) to explore a potential deviation of estimated value and the willingness to pay for spectrum.

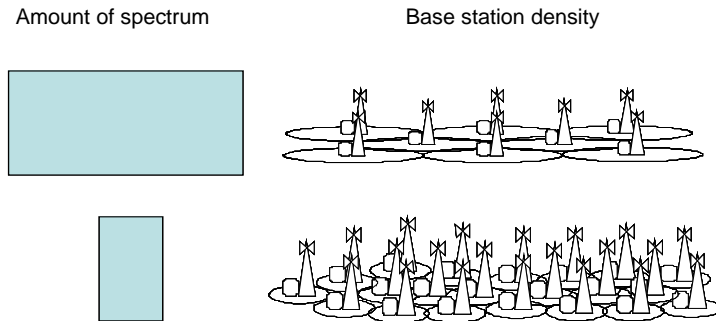
The first step in the analysis is to identify key technical factors and network performance parameters related to the amount of spectrum of individual operators. The engineering value of spectrum is related to network costs using the approach developed by Marks et.al. (1996, 2009) where the value of spectrum is derived from additional cost or cost savings depending upon if operators are allocated spectrum or not, and how much spectrum that are allocated. In addition to cost related aspects we also discuss factors like market position of mobile operators due to offered data rates and time to market.

The paper present empirical data on spectrum allocation of different bands in Sweden and data for India regarding spectrum holdings and analyze the value of spectrum in ten service areas. The analysis of the engineering value of spectrum uses alternative deployment scenarios and compares these numbers with prices paid at the auctions for the 800 MHz and 2.6 GHz bands. The drivers for how operators have acted in spectrum auctions are identified and analyzed based on the market position and spectrum allocation for different mobile operators. Finally, we discuss two main implications of the analysis. The first aspect is the financial situation for different operators, and the second aspect is the overall role of the amount of spectrum.

COVERAGE, CAPACITY AND COST

Capacity in mobile networks can be increased by replacing existing radio equipment with more efficient systems, by deploying new base stations or by adding more radio equipment to existing base station sites and additional spectrum. Operators that are unable to obtain additional spectrum are forced to deploy more base stations which require more capital investments compared to competitors who can add more spectrum and re-use existing base stations sites, see figure 4.

Figure 4 Capacity could be provided by a large number of sites or with large amount of spectrum



The basic relation between network costs, capacity, bandwidth and service area is derived by Zander (1997), and stipulates that for a specific amount of spectrum and radio access technology it can be formulated as “*the deployment of N times more capacity requires N times more base stations*”. The frequency band is essential as lower frequency bands like 800 and 900 MHz provide better coverage compared to the 2.1 and 2.6 GHz bands.

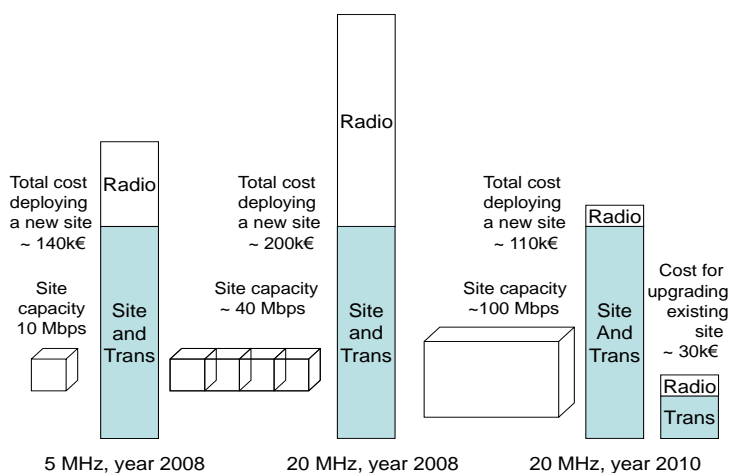
Cost and cost structure

The fierce competition among equipment manufactures in combination with technology advancement has pressed down prices on network equipment during the last decade, improving the cost-capacity ratio significantly. This enables operators to replace existing radio equipment with new equipment (LTE) for approximately EUR 10K per base station.⁷ The most recent base station equipment supports multi-standard solutions, e.g. GSM, WCDMA and LTE⁸, further improving the cost efficiency. It is, however, not the cost of radio equipment that is decisive as the dominating component in the cost structure of radio access networks is cost associated with base station sites, as illustrated by figure 5. This includes costs for towers, masts, non-telecom equipment, power, installations and site leases. The capacity is related to the amount of radio equipment, and the main cost driver is the amount of new sites that needs to be deployed. More spectrum means that operators can re-use existing sites and hence capitalize on existing infrastructure investments.

⁷ This is an approximation of the market price supported by statements by TeliaSonera and Ericsson. The first indication of these price levels appeared in 2009 when Telenor signed an agreement with Huawei for the replacement of approximately 6 000 base stations for EUR 63 million. Source: <http://www.telenor.com/en/news-and-media/press-releases/2009/telenor-to-replace-its-infrastructure-for-mobile-services-in-norway>

⁸ An example (NSN): <http://www.nokiasiemensnetworks.com/portfolio/products/mobile-broadband/single-ran-advanced/lexi-multiradio-10-base-station>

Figure 5 Site capacity and deployment costs⁹



Source: Authors' calculations (Markendahl, 2011)

Data rates

The level of peak and average data rates depends on system bandwidth (MHz) and spectral efficiency of the radio access technology. Spectral efficiency, expressed as bps per Hz, is the result of the signal strength and a function of the distance to the base station and, if indoor, wall penetration losses. Operators with higher system bandwidth than competitors can claim that they are able to offer higher data rates. Technically, higher bandwidth influences the user experience in two ways: 1) higher peak data rates can be provided, and 2) more users can be served at a given data rate when the network is loaded.

Peak data rates, predominately used by operators in their marketing, can only be achieved close by base stations assuming that the user is alone in the cell. The average data rate is what users should expect taking into account an average location and multiple users in the cell. Network performance in terms of data rates and coverage are considered to be very important by the operators.¹⁰ Operators use similar type of radio access technology, the same system bandwidth and in many cases share networks. Hence, operators have so far had difficulties to offer different bit rates, but it will change when carrier aggregation is introduced.

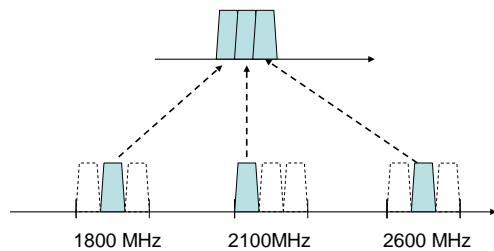
The introduction of LTE and the forthcoming LTE-advanced, which facilitates carrier aggregation, will influence the market position of mobile operators depending on how much spectrum different operators can use in different bands. For 3G with a single 5 MHz carrier and the same release of WCDMA or HSPA the similar bit rates could be offered provided a similar network deployment. Regardless of the total amount of spectrum the performance depends on what can be achieved for a single 5 MHz carrier.

⁹ The calculation is based on assumptions of 3 sector sites and cell average spectral efficiency of 0.7 bps per Hz (using HSPA year 2008) and 1.5 bps per Hz (using LTE year 2010).

¹⁰ "The fastest Mobile Broadband in Sweden - according to information retrieved from Bredbandskollen.se, November 25, 2010" (Telenor)¹⁰ "Today the best Mobile Broadband in Sweden was nominated and the winner is Tele2. This means that you can do web surfing at higher speeds with Tele2 compared to any other operator."

LTE supports system bandwidth from 1.4 MHz up to 20 MHz. Hence, operators with different amounts of spectrum will be able to provide different peak data rates. Moreover, with band aggregation higher system bandwidths and data rates can be provided, implying that operators with spectrum bands suitable for aggregation will have an advantage. In figure 7 an example is shown where an operator combines spectrum from the 1.8 GHz, 2.1 GHz and 2.6 GHz bands. This implies that operators that share networks will be able to combine their spectrum resources and hence have a competitive advantage compared to operators running their own networks.

Figure 6 Band aggregation of 1800, 2100 and 2600 MHz resulting in higher system bandwidth



INDIA: SPECTRUM ALLOCATION AND ANALYSIS

Mobile communications in India has grown immensely during the last couple of years by adding up to 20 million new subscribers per month, but the influx of new mobile subscribers dropped to 5-7 million per month during the latter part of 2011 and first half of 2012, implying lower growth rates.¹¹ India had a mobile customer base of 935 million by mid 2012, translating into a mobile penetration of 81%, but it varies considerable between urban and rural areas.¹² The average revenue per user is around EUR 2-3 per month, and call charges are around INR 0.9-1.5 per minute (1.2-2.2 euro cent). The Indian mobile operators in average have access to 2x15 MHz of which 5 MHz is 3G spectrum, but it differs between service areas and operators. Although 3G licenses were auctioned in 2010 and networks have been deployed the growth of 3G has so far been limited, and India had about 18 million 3G subscribers' by mid 2012, representing 2% of the total amount of mobile subscribers.¹³ The slow start for 3G is, according to the industry, explained by the lack of affordable handsets and smartphones.¹⁴

The Indian authorities allocated three 3G licenses with 5 MHz per license in most service areas. But given that there are at least six 2G operators in most service areas the major operators have entered into roaming agreements, so called intra circle roaming (ICR) agreements, with holders of 3G licenses, in order to be able to provide 3G services nationwide. But the Department of Telecommunications (DoT) has questioned the

¹¹ Sources are data from TRAI, DoT, analyst report from investment banks IIFL, Antique, Nirmal Bang, Iventure, AMBIT, transcripts from conference calls with Bharti and Idea Cellular

¹² Batlivala & Karani, B&K Securities, Monthly update 31 July 2012

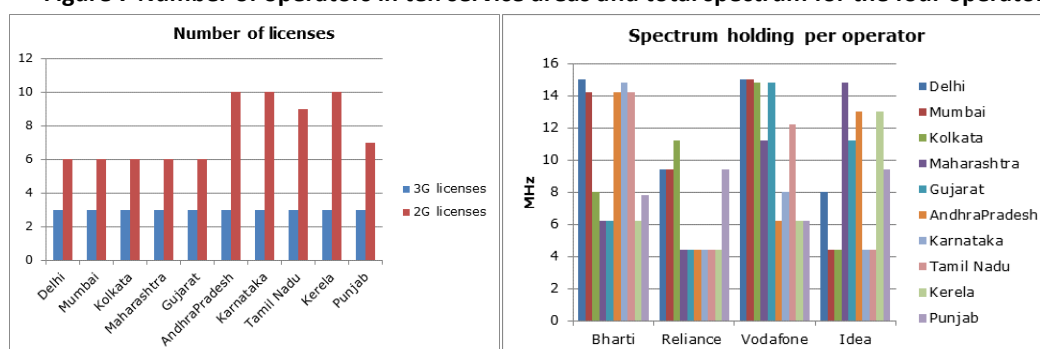
¹³ Source: IIFL Institutional Equities

¹⁴ Smartphones cost around INR10 000 (EUR 145), but operators would like to see smartphones down to INR 3 000 (EUR 43) in order for 3G to take off in India.

roaming agreements which initiated legal processes by the end of 2011. On back of a limited availability of fixed broadband, 2G data with GPRS and EDGE have been the primary carriers for mobile data. But given that non-voice revenues generates 15% of total mobile revenues, of which SMS makes up the half, the revenue stream from the estimated 350 million mobile internet users have so far been limited.

The limited availability of spectrum for the Indian operators is explained by that there are a large number of operators that share a limited amount of spectrum. We focus on ten service areas which altogether cover 42% of the Indian population and which have between 6 and 10 operators with 2G licenses and three operators with 3G licenses.

Figure 7 Number of operators in ten service areas and total spectrum for the four operators



Source: DoT

The spectrum holding for the four major operators in the ten service areas varies from 4.4 MHz to 15 MHz, with an average of 10 MHz. A detailed table of spectrum holdings for ten service areas shows that the total amount of spectrum in these areas is around 50-70 MHz.

Table 1 Spectrum holdings in 10 out of 20 service areas in India

Service Area	Delhi Metro	Mumbai Metro	Kolkata Metro	Maharashtra A	Gujarat A	Andhra Pradesh A	Karnataka A	Tamil Nadu A	Kerala B	Punjab B
Pop (m)	22,7	23,1	17,8	89,3	58,7	83,4	59,5	68	34,6	28,6
Spectrum 3G										
Bharti	5	5	0	0	0	5	5	5	0	0
Reliance	5	5	5	0	0	0	0	0	0	5
Vodafone	5	5	5	5	5	0	0	5	0	0
Idea	0	0	0	5	5	5	0	0	5	5
Tata	0	0	0	5	5	0	5	0	5	5
Aircel	0	0	5	0	0	5	5	5	5	5
Stel	0	0	0	0	0	0	0	0	0	0
Total 3G spectrum	15	15	15	15	15	15	15	15	15	20
Spectrum 2G										
Bharti	10	9,2	8	6,2	6,2	9,2	9,8	9,2	6,2	7,8
Vodafone	10	10	9,8	6,2	9,8	6,2	8	7,2	6,2	6,2
Idea	8	4,4	4,4	9,8	6,2	8	4,4	4,4	8	4,4
Reliance	4,4	4,4	6,2	4,4	4,4	4,4	4,4	4,4	4,4	4,4
Aircel	4,4	4,4	4,4	4,4	4,4	4,4	4,4	9,8	4,4	4,4
BSNL	0	0	10	8,2	9,8	6,2	10	9,2	10	6,2
MTNL	12,4	12,4	0	0	0	0	0	0	0	0
Datacom	0	0	0	0	0	4,4	4,4	0	4,4	4,4
TTSL	0	0	0	0	0	4,4	4,4	4,4	4,4	0
Unitech	0	0	0	0	0	4,4	4,4	4,4	4,4	0
Loop	0	0	0	0	0	4,4	4,4	4,4	4,4	0
Total 2G spectrum	49,2	44,8	42,8	39,2	40,8	56	58,6	57,4	56,8	37,8
Total spectrum	64,2	59,8	57,8	54,2	55,8	71	73,6	72,4	71,8	57,8

Source: DoT

On back of the limited availability of spectrum and with only three 3G licenses available in most circles it was a fierce competition on spectrum which resulted in auction prices significantly higher than the reserve price set by the authorities. The mobile operators paid the equivalent of EUR 0.27 up to EUR 4.36 per MHz/pop.

Table 2 Prices paid at the 3G auction in India October 2010

	Delhi	Mumbai	Kolkata	Maharashtra	Gujarat	Andhra Pradesh	Karnataka	Tamil Nadu	Kerela	Punjab
Population m	22,7	23,1	17,8	89,3	58,7	83,4	59,5	68	34,6	28,6
Operator	Vodafone Bharti Reliance	Reliance Vodafone Bharti	Vodafone Aircel Reliance	Tata Idea Vodafone	Tata Vodafone Idea	Bharti Idea Aircel	Tata Aircel Bharti	Bharti Vodafone Aircel	Idea Tata Aircel	Idea Reliance Tata, Aircel
Price EURm	495	485	81	188	161	205	236	219	47	48
MHz per op	5	5	5	5	5	5	5	5	5	5
EUR/MHz/pop	4,36	4,20	0,91	0,42	0,55	0,49	0,79	0,64	0,27	0,34

Source: DoT

INDIA –ENGINEERING VALUE

On back of the prices paid at the 3G-auction in 2010, the intense debate about 2G spectrum and the value of spectrum in India it is motivated to calculate the marginal value of spectrum for the Indian market. The analysis is explorative as it is based on a number of assumptions, like the number of cell sites in each service area and the share of geographical area that networks in different service areas covers. We therefore incorporate a sensitivity analysis on key parameters.

First, in order to calculate the capacity of 5 MHz we assume a spectral efficiency of 1.5 bps/Hz, and three sectors per site, which translates into a capacity of 22.5 Mbps per site. We assume a usage of 5 GB per month and user (average usage in Sweden was 3.7 GB during 2011) and the usage is spread out over 8 hours, which is the equivalent of a continuous demand of 0.05 Mbps per user.¹⁵ This means that each site can provide services for up to 450 subscribers. This translates into that, in for example New Delhi, where we estimate that a major operator has 5 673 sites and 5 MHz could provide mobile broadband services to 2.63 million subscribers, representing 12% of the local Delhi market.

Table 3 Capacity estimates

Capacity base case	Delhi	Mumbai	Kolkata	Maharashtra	Gujarat	Andhra Pradesh	Karnataka	Tamil Nadu	Kerela	Punjab
Cell radius	0,25	0,25	0,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
Number of sites	5 673	2 918	1 671	21 748	13 869	19 459	13 582	9 201	2 750	3 563
Capacity Mbps	127 650	65 656	37 607	489 330	312 050	437 830	305 597	207 033	61 864	80 169
Capacity Mbps per km2	114,6	114,6	28,7	3,2	3,2	3,2	3,2	3,2	3,2	3,2
Capacity number of users m	2,63	1,35	0,77	10,08	6,43	9,02	6,30	4,26	1,27	1,65
Share of population	12%	6%	4%	11%	11%	11%	11%	6%	4%	6%

Given that the estimated capacity is dependent upon the range of the cell radius we have conducted a sensitivity analysis with three different cases: 1) base case, 2) a dense network with shorter cell radius increasing the number of sites considerable, and 3) a sparse network (referred to as a thin network in the tables) case requiring considerable

¹⁵ The estimate of 0.05 Mbps per user is based on a usage of 5 GB per month and is calculated as follows: $5 \cdot 1024 \cdot 1024 \cdot 8 = 4194304000/30 = (1398101333/24/3600) \cdot 24/8 = 49 \text{ kbps} = 0.05 \text{ Mbps per user}$

fewer sites. The following table illustrates that the sparse network could provide services for up to 2% of the Delhi market while the base case could support 12% and the dense network case could provide services for up to 32% of Delhi market.

Table 4 Sensitivity analysis: cell radius, number of sites and share of the population

Cell radius km	Delhi	Mumbai	Kolkata	Maharashtra	Gujarat	AndhraPradesh	Karnataka	Tamil Nadu	Kerela	Punjab
Base case	0,25	0,25	0,50	1,50	1,50	1,50	1,50	1,50	1,50	1,50
Dense case	0,15	0,15	0,25	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Thin case	0,50	0,50	1,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
Number of sites										
Base case	5 673	2 918	1 671	21 748	13 869	19 459	13 582	9 201	2 750	3 563
Dense case	15 759	8 106	6 686	48 933	31 205	43 783	30 560	20 703	6 186	8 017
Thin case	1 418	730	418	12 233	7 801	10 946	7 640	5 176	1 547	2 004
Support share of pop										
Base case	12%	6%	4%	11%	11%	11%	11%	6%	4%	6%
Dense case	32%	16%	17%	25%	25%	24%	24%	14%	8%	13%
Thin case	2%	3%	16%	25%	25%	26%	26%	45%	76%	48%

Consequently, the three cases require different levels of capex for network deployment. By assuming an capex of EUR 25K per site the total capex for each of the three cases varies considerable, like for example in Delhi the range is from EUR 35 m to EUR 394 m.¹⁶

Table 5 Capex in mEUR for the three cases

	Delhi	Mumbai	Kolkata	Maharashtra	Gujarat	AndhraPradesh	Karnataka	Tamil Nadu	Kerela	Punjab
Base case	142	73	42	544	347	486	340	230	69	89
Dense case	394	203	167	1223	780	1095	764	518	155	200
Thin case	35	18	10	306	195	274	191	129	39	50
3G spectrum price mEUR	495	485	81	188	161	205	236	219	47	48
Capex per site mEUR	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025

This gives us the basis to calculate the engineering value. The three different cases use 5 MHz each, but given that the dense network case has significantly more sites the capacity is significantly higher. Alternatively, this capacity could be achieved by having access to more spectrum. We have therefore made an implied calculation in order to estimate how much spectrum would be required to provide the same amount of capacity. The difference in capacity for the base case and dense case give us a result, which show that it is equivalent to 6-9 MHz. By calculating the incremental capex, which is the difference between the dense case and base case, and divided it with the estimated MHz and subsequently divided it with the population the result is the engineering value of spectrum.

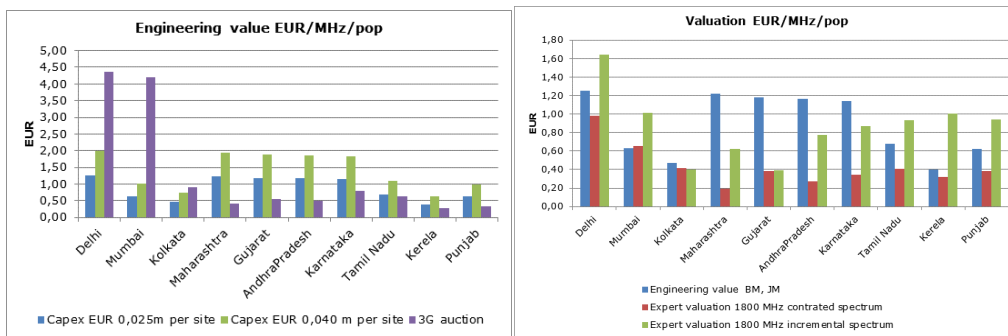
¹⁶ Capex per site varies considerable depending upon if it is a ground based site or roof top site. Based on reports from Idea Cellular we have calculated that the average capex per site during FY 2009-2012 was EUR 37 000. The infrastructure company GTL report that average capex is EUR 39 000 per site (excluding active equipment). Given that passive network sharing is established we have applied a more conservative estimate which also is based on the lower equipment prices.

Table 6 Calculation of engineering value of spectrum

	Delhi	Mumbai	Kolkata	Maharashtra	Gujarat	AndhraPradesh	Karnataka	Tamil Nadu	Kerala	Punjab
Population m	22,70	23,10	17,80	89,30	58,70	83,40	59,50	68,00	34,60	28,60
Number of sites	5 673	2 918	1 671	21 748	13 869	19 459	13 582	9 201	2 750	3 563
MHz	5	5	5	5	5	5	5	5	5	5
Bits/Hz	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Capacity	127 650	65 656	37 607	489 330	312 050	437 830	305 597	207 033	61 864	80 169
Dense case sites	15 759	8 106	6 686	48 933	31 205	43 783	30 560	20 703	6 186	8 017
Capacity	354 585	182 378	150 430	1 100 992	702 113	985 118	687 593	465 824	139 194	180 380
Deviation capacity	226 934	116 722	112 822	611 662	390 063	547 288	381 996	258 791	77 330	100 211
per site Mbps	40	40	68	28	28	28	28	28	28	28
per sector	13	13	23	9	9	9	9	9	9	9
Equivalent to MHz	9	9	15	6	6	6	6	6	6	6
Incremental capex	252	130	125	680	433	608	424	288	86	111
Value EUR/MHz/pop	1,25	0,63	0,47	1,22	1,18	1,17	1,14	0,68	0,40	0,62
3G auction EUR/MHz/pop	4,36	4,20	0,91	0,42	0,55	0,49	0,79	0,64	0,27	0,34

The estimated engineering value of spectrum is a function of the applied level of capex per site. This motivates us to add a sensitivity analysis by applying an additional level of capex per site. The base case assumes an average capex of EUR 25K per site, but in order to explore the consequence of a higher capex we also apply a capex level of EUR 40K per site. As a consequence of the higher capex level the engineering value increase with 60%. On back of the intense debate in India it is interesting to compare the estimated engineering value with the values that the expert report commissioned by the Indian regulator TRAI presented in early 2011, labeled as expert valuation in the following figure. The outcome of our analysis is comparable with the expert valuation in metro areas, but differs in four services areas, as it is exhibited in figure 10.¹⁷

Figure 8 Comparison auction price with engineering value, and expert valuation



INDIA – GSM LICENCES CANCELLED DUT IRREGULARITIES

On February 2, 2012, the Indian Supreme Court cancelled 122 mobile licences for GSM allocated to 6-7 operators in 22 Service Areas after October 2008 due to irregularities in the allocation process which was conducted through a skewed first-come-first-serve basis.¹⁸ The price that the licensees had paid was in line with the outcome of the auction for the 4th GSM license in 2001, and equivalent to EUR 0.049 per MHz/pop,

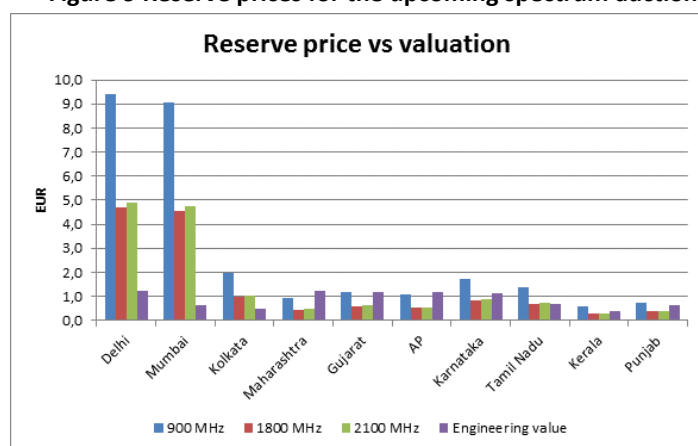
¹⁷ Report on the Value of Spectrum in the 1800 MHz band, January 30, 2011, report commissioned by TRAI and conduct by Prof. D. Manjunath, Prof. R.V. Raja Kumar, Prof. Rajat Kathuria and Prof. Rohit Prasad

¹⁸ The Supreme Court of India, Civil Original Jurisdiction, Writ Petition (civil) No 423 of 2010, Judgment Supreme court decision, February 2, 2012. The irregularities has been labeled the 2G scam and been extensively covered in the press. See Subramanian Swamy "2G Spectrum Scam", Har-anand Publications, 2011

comparing to the average EUR 0.44 per MHz/pop that the 3G auction reached in 2010. The Supreme Court's decision stated that the spectrum holders could hold the spectrum for another four months when the spectrum should be re-auctioned. But the process has been delayed and the auction is due to occur in the latter part of 2012. The Telecommunication Regulatory Authority (TRAI) was assigned by the Supreme Court to make recommendations for the auction and present reserve prices, which makes up a price floor for the spectrum.

TRAI's view on the value of spectrum is that it "is a function of the business potential and profitability outlook for the services that are to be offered using the spectrum. For determining the true economic value of spectrum through auction, fixing reserve price for various spectrum bands closer to their fair market value is crucial."¹⁹ TRAI presented reserve prices in April 2012. TRAI determined that the reserve price for spectrum in the 1800 MHz band should be a factor 0.8 of the price reached in the 3G spectrum auction in 2010. But as the number of base stations required for the coverage of the same area is lower in UMTS 1800 compared to UMTS 2100 the price should, according to TRAI, be adjusted with 1.2. Given that UMTS 2100 compared to UMTS 900 require 2.1 more sites to cover the same area compared to UMTS 2100 the reserve price in the 800 and 900 MHz bands should, according to TRAI, be at least 2 times that of the 1800 MHz band. And the reserve price for the 700 MHz band should, according to TRAI, be around 4 times that of 1800 MHz.²⁰ Altogether, the proposed reserve prices range from EUR 0.29 per MHz/pop in the 1800 MHz-band in Kerala to EUR 9.43 MHz/pop in the 900 MHz-band in Delhi, representing a major deviation to the engineering value in the metro areas, and a more similar levels in the other service areas.

Figure 9 Reserve prices for the upcoming spectrum auction



Source: TRAI, authors' calculations

FINANCIAL FACTORS WILL HAVE AN IMPACT ON SPECTRUM PRICES

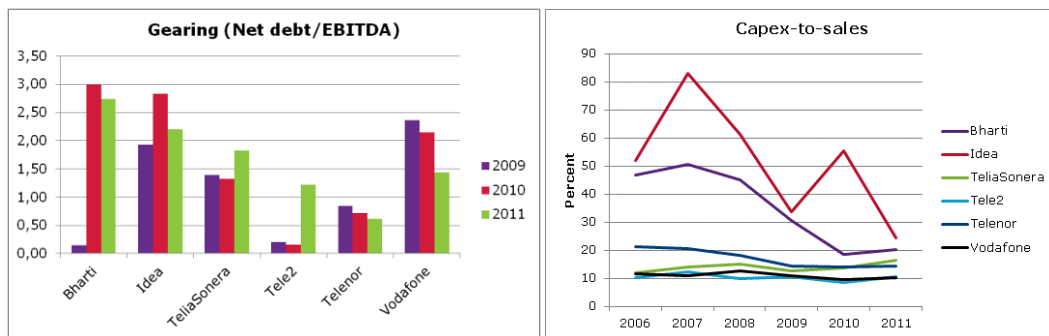
Given the high mobile penetration in urban areas in India the major growth opportunities are found in rural areas. This requires an extension of networks in order to

¹⁹ TRAI, Recommendations on Auction of Spectrum, 23 April 2012, <http://www.trai.gov.in/WriteReadData/Recommendation/Documents/Finally%20final%20recommendations230412.pdf>

²⁰ ibid

improve coverage and capacity demanding more capex. The slow start for 3G indicates that India is lagging behind within mobile data, but with a limited availability of fixed broadband mobile is set to be the primary vehicle for digital broadband access. The analysis shows that 5 MHz can support a first stage for mobile broadband, but in order to provide sufficient with capacity for supporting smartphones as well as dongles facilitating considerable higher data volumes more spectrum are required. The high gearing levels for the Indian operators in combination with extensive capex requirements and high prices for spectrum makes this challenging for the companies. Ultimately, the willingness for the Indian consumers to pay for mobile data will determine how the market will develop. Although capex in relation to sales have come down for the Indian operators they are facing lower growth as the mobile voice market is maturing, and they are experiencing high cost for capital as their financial flexibility are impacted by the financial turmoil.

Figure 10 Gearing and capex-to-sales

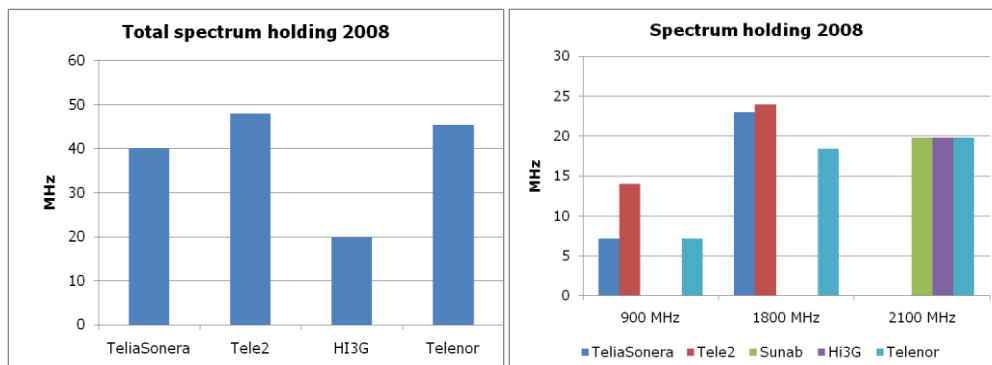


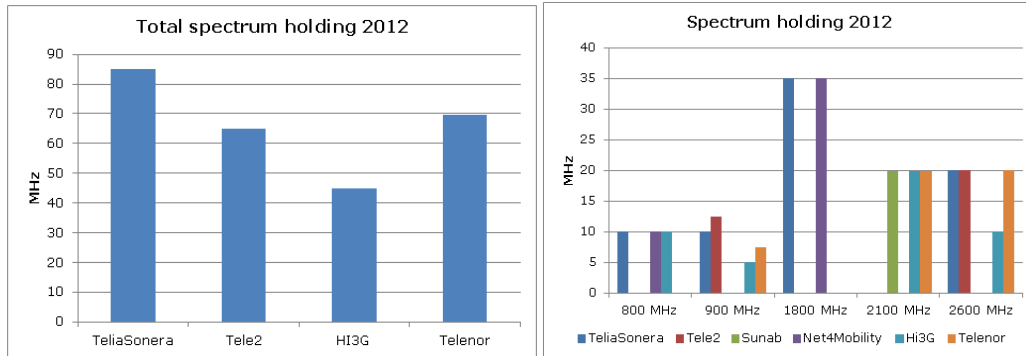
Source: Bloomberg

SWEDEN: SPECTRUM ALLOCATION AND ANALYSIS

The analysis considers the spectrum allocation in Sweden with a focus on the situation ahead of the spectrum auctions in 2008 and after auctions in 2012, and compared with an analysis of the value of spectrum in India. The analysis is made per operator consider network deployment options. The Swedish operators, TeliaSonera, Tele2 and Telenor have around 2x70 MHz each, while HI3G have 2x45 MHz. During the period 2008 to 2012 the Swedish operators captured 107 MHz of additional spectrum of which TeliaSonera obtained 32.8 MHz, HI3G 25 MHz, Telenor 23.3 MHz and Tele2 23.5 MHz.

Figure 11 Spectrum holding for Swedish operators 2008 and 2012



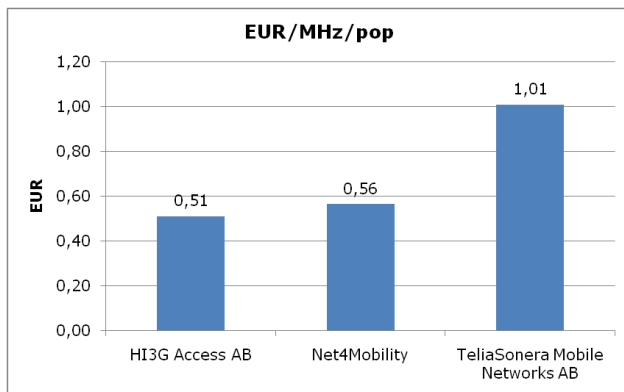


Source: PTS

Spectrum allocation in Sweden covering the 2.6 GHz auction in 2008, the renewal and re-allocation process of the 900 MHz licenses 2009-2011, the 800 MHz and 1800 MHz auctions in 2011 will be covered in this chapter.

The Swedish Post and Telecom Authority (PTS) held an auction for LTE spectrum in the 2.6 GHz band in 2008 where 2x70 MHz for FDD and 50 MHz for TDD were allocated. The auction resulted in prices in the range of EUR 0.32-0.35 per MHz/pop for paired spectrum, while the TDD spectrum reached EUR 0.04 per MHz/pop. PTS decided to renew the operators' 900 MHz licenses in March 2009 based on a common application from the operators including HI3G, which previously only had spectrum for 3G, and was allocated 5 MHz. The allocation decision was based on the presumption that existing licensees had the right to maintain as spectrums holder of the allocated spectrum as the demand of spectrum was in line with the available spectrum and gained legal force after some legal wrangling. The limited amount of available spectrum in the 800 MHz band with a total of 2x30 MHz, divided into 5 MHz slots, motivated PTS to impose a spectrum cap of 10 MHz in the auction that took place in March 2011. Prices paid by HI3G, TeliaSonera and Net4Mobility were in the range of EUR 0.51-1.01 per MHz/pop. TeliaSonera paid almost the double amount compared to HI3G, as the lowest block requires that the licensee take action in order to avoid interference with terrestrial TV. This requires special arrangements for the radio access network, like inserting filters and vertical antennas. The last block requires that the licensee provide special solutions in rural areas in order to establish coverage to specific households that PTS identifies.

Figure 12 Price per MHz and population,



Source: PTS and authors' calculations

In February 2010 PTS decided to renew the existing licenses for the 1800 MHz-band, but only with half of the existing spectrum in order to release spectrum that could be sold in an auction, which took place in October 2011. Ahead of the auction, Tele2 and Telenor received an approval from PTS to transfer their respective spectrum in the 1800 MHz band to their jointly owned network sharing company Net4Mobility. This resulted in that Net4Mobility had 2x25 MHz and TeliaSonera 2x10 MHz ahead of the spectrum auction. The auction consisted of seven blocks of 5 MHz, altogether 2x35 MHz, moreover, 2x5 MHz is unlicensed creating opportunities for indoor solutions by new service providers. The outcome of the auction was that TeliaSonera acquired 2x25 MHz and Net4Mobility 2x10 MHz paying the equivalent of EUR 0.51 and EUR 0.43 per MHz/pop respectively.

Deployment options

The engineering value of spectrum is calculated as the cost savings provided by the spectrum band that was acquired. Hence, a comparison is made requiring a different network deployment options that could be used assuming that the spectrum band of interest was not acquired. Regarding the 2.6 GHz band it could be used for LTE mobile broadband services and one option could be to use the 2.1 GHz band and 3G in order to provide additional capacity. This implies a denser 3G network and requiring that at least two times more sites are deployed in order to double the capacity. Taking into account the higher spectral efficiency of LTE compared to HSPA an even denser network needs to be deployed. The calculation assumes four times denser network in capacity limited areas. For Hi3G with 10 MHz of 2.6 GHz spectrum twice the number of sites is needed in order to offer the same capacity as operators with 20 MHz of spectrum. For wide area coverage of mobile broadband using the 800 MHz band there are two options to be used for the comparison: 1) to build a denser 3G network using the 2.1 GHz band, or 2) to allocate part of the 900 MHz band for mobile broadband services. A 2.1 GHz network providing the same capacity would require at least four times the number of sites in order to provide the same coverage as an 800 MHz network as demonstrated by Azcoitia et. al (2010). When the 900 MHz band is used for mobile broadband existing 2G and 3G sites could be re-used and the existing site grid would be sufficient to provide coverage. Hi3G have 5 MHz and other operators use the 900 MHz band for GSM voice services. For comparison we can assume that 5 MHz will be used implying twice the site density in order to provide the same capacity.

Estimated engineering value

The basis for estimating the value of spectrum is to measure the engineering value, which according to Sweet et.al (2002) is determined by the cost savings in the infrastructure of an operator's network obtained by having access to additional spectrum. The nine cases listed in table 7 are recent spectrum allocation cases in Sweden, and where the calculation is based on a geotype classification of Sweden in geotype urban, which covers 1% of the country and 29% of the population, suburban which covers 27% of the

country and 59% of the population and rural which cover 73% of the geographical area and 12% of the population.

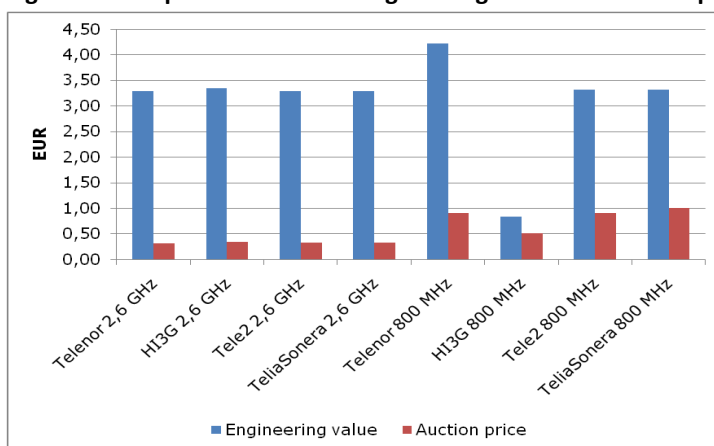
Table 7 Estimation of engineering value for nine Swedish cases

Operator	Case	Basis for engineering value	Engineering value EURm	MHz	EUR/MHz/pop	More sites
Telenor	Value of 20 MHz in 2600 MHz	Denser 2100 MHz network	618	20	3,3	2,6
	Value of 10 MHz in 2600 MHz (to have 20 MHz rather than 10 MHz)					
HI3G		Denser 2600 MHz network	314	10	3,3	2,0
Tele2	Value of 20 MHz in 2600 MHz	Denser 2100 MHz network	618	20	3,3	2,4
TeliaSonera	Value of 20 MHz in 2600 MHz	Denser 2100 MHz network	618	20	3,3	2,4
Telenor	Value of 10 MHz in 800 MHz	Denser 2100 MHz network	397	10	4,2	3,4
		900 MHz network and denser				
HI3G	Value of 10 MHz in 800 MHz	2100 MHz network	78	10	0,8	1,7
Tele2	Value of 10 MHz in 800 MHz	Denser 2100 MHz network	312	10	3,3	3,4
TeliaSonera	Value of 10 MHz in 800 MHz	Denser 2100 MHz network	312	10	3,3	3,4

Source: PTS, authors' calculations

The estimated capex levels for sites in the different geotypes urban, suburban and rural are EUR 0.04m, EUR 0.089 and EUR 0.11m respectively. The cell radius is from 0.6 km up to 12 km depending upon frequency band and geotype. The spectral efficiency is assumed to be 1 bps/Hz for HSPA and 1.5 bits/Hz for LTE.²¹ The estimated engineering value is from EUR 0.8 to EUR 4.2 per MHz/pop. Auction prices are what operators actually have paid for spectrum, which besides the engineering value or project value also incorporates a market power value and an option value.²² The following figure presents the engineering value and auction prices expressed as EUR/MHz/pop.

Figure 13 Comparison between engineering value and auction prices



Source: PTS, authors' calculations

²¹ The basis for geotypes and cell radius are based on an LRIC model developed by Analysys Mason concerning for a generic mobile operator in Sweden, see <http://www.pts.se/upload/Remisser/2011/Telefoni/10-8320-pts-mobil-lric-final-model.zip>

²² Australian Communications and Media Authority. (2009). Opportunity Cost Pricing of Spectrum, available at: http://www.acma.gov.au/webwr/_assets/main/lib310867/ifc12-09_final_opportunity_cost_pricing_of_spectrum.pdf

In order to explain the deviation between the engineering value and auction prices, which is a factor from 1.5 up to 10, three arguments could be highlighted: 1) The value of spectrum that are derived from spectrum auctions depends, according to Beard et al. (2011), critically on allocation choices, like for example rules decided by the regulator to exclude incumbents or formal spectrum caps. This implies that auction prices only partly reflect the underlying value of spectrum. 2) The transition from the regime of control and command to spectrum trading has only partly taken place. This limits competition on spectrum and thereby prices on spectrum auctions. 3) Operators' valuation of spectrum and their willingness to pay for spectrum are influenced by network strategy where network sharing and potential spectrum sharing contribute to hold down auction prices on spectrum. And research conducted by Bulow et al (2009) has found that the levels of the allocated budgets for auction teams appointed by operators predominately influence the outcome of the final price. Altogether, the analysis of the engineering value gives an input to the valuation of the marginal value of spectrum. The deviation between auction prices, which could be seen as the level of operators willingness to pay for spectrum, and the estimated engineering value indicate that the auction prices for the Swedish case does not truly reflect the marginal value of spectrum as the calculation of the engineering value of spectrum indicate.

Swedish operators in good shape

The profitability for the Swedish mobile operators TeliaSonera and Tele2 has been on par, while Telenor and HI3G continuously have improved its profit margin. The ratio between revenues and capex has gradually decreased for TeliaSonera and Tele2 during 2008-2010, while HI3G is still on very high levels, although it has declined, and Telenor is investing around 10 % of its revenues.

Figure 14 Operating profit margins, Capex-to-sales



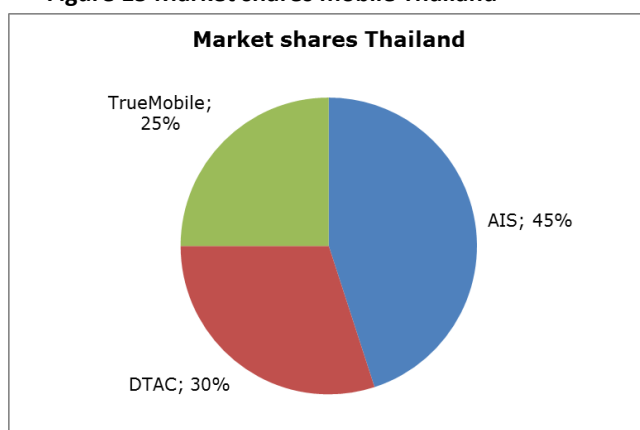
Source: Company reports

When combining the financial conditions, as summarized above, with spectrum allocation we can conclude that Hi3G has a more challenging situation than the other operators. The total amount of spectrum is less than the others implying higher network deployment costs in order to offer the same amount of capacity, coverage and data rates.

THAILAND – SPECTRUM ALLOCATION AND ANALYSIS

The mobile market in Thailand is developing strongly with a growing demand for smartphones. Although Thailand has been late to allocate 3G spectrum in the 2.1 GHz-band services based on 3G has been launched on the 850 and 900 MHz-bands. The market is dominated by three major operators Advanced Info Service (AIS), Total Access Communications (DTAC) and True Corp. But due to national regulation the existing operators are running their networks on long term agreements, so called BTO (build-transfer-operate) contract with one of the two state owned operators Communication Authority of Thailand (CAT) or Telecom of Thailand (TOT). The mobile operators have been required to build and raise capital for investment in cellular network and transfer the network ownership to the state operator which has granted the concession. A vital part of this set up is that mobile operators have to pay 30% of its revenues to respectively state operator partner.

Figure 15 Market shares mobile Thailand



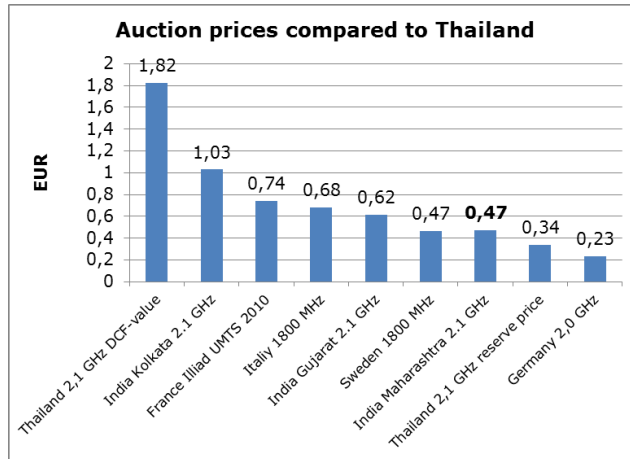
Source: AIS report Q2 2012

But the National Broadcasting and Telecommunications Commission (NBTC) is conducting a spectrum auction in the latter part of 2012 where it will release 2100 MHz spectrum, in total 2 x 45 MHz, which will be auctioned in nine slots of each 2 x 5 MHz. There will be a spectrum cap on a maximum of 2x15 MHz, implying that the allocated spectrum is sufficient for the three major operators.²³ This means that Thailand is moving from a concession to a license regime, but given that it initially will only be the 2.1 GHz spectrum that is under the license regime it will be a mix of the two until the concession regime is phased out. Under the new regime the annual regulatory cost will decrease from 30% to 5.75%.²⁴ The National Broadcasting and Telecommunications Commission (NBTC) have set a reserve price of THB 4.5 bn per 5 MHz slot (EUR 112m), equivalent to EUR 0.34 per MHz/pop. The following figure also show a DCF-value, which is elaborated in the following sector.

²³ Dr. Suthiphon Thaveechaiyagarn, National Broadcasting and Telecommunications Commissioner, Future of the Thai Telecommunications under the Role of the NBTC: Spectrum 2.1 GHz Auction Project, presented at the 12th APT Policy and Regulatory Forum, Bangkok, 23rd May 2012

²⁴ Telenor Capital Markets Day September 19, presentation by CEO for DTAC, see link http://telenor.com/wp-content/uploads/2012/09/07_CMD-2012-DTAC_FINAL.pdf, and <http://www.nbtc.go.th/wps/portal/Eng>

Figure 16 Comparison between auction prices, DCF-value and reserve price in EUR per MHz/pop

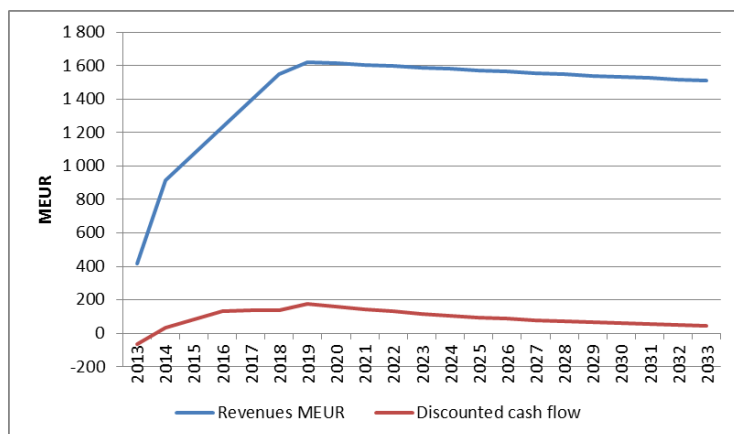


Source: NRAs, authors' calculations

In order to analyze the value of the 3G spectrum we apply a discounted cash flow analysis (DCF) for an operator covering the license period of 20 years. The DCF model is based on a number of factors with the following assumptions:

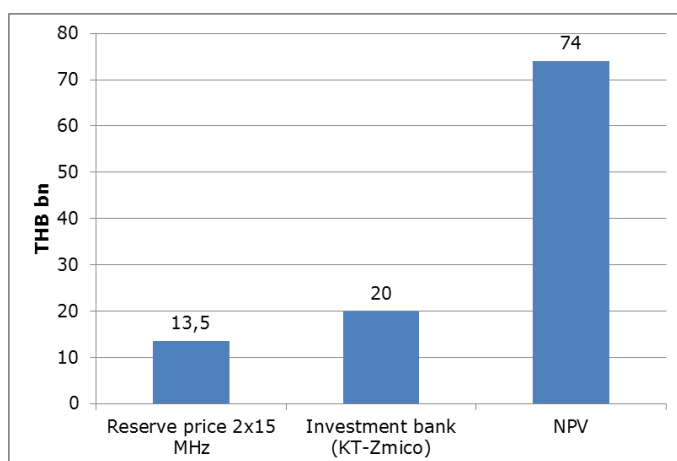
- 1) The 3G penetration is expected to increase from 50% in 2013 (facilitated by a large installed base of smartphones that is used for the 850 and 900 MHz-band) reaching 100% in 2018, and maintain at that level until 2032, which is the end of the forecast period.
- 2) The market share is expected to be 33% for the operator, and maintain at that level during the entire forecast period.
- 3) ARPU for 3G is estimated to be THB 250 (EUR 6.25) per month and subscriber 2013, and decrease by 1% per year over the forecast period.
- 4) EBITDA is estimated to be 40% and maintain stable over the forecast period, which implies that operational expenditures (excluding regulatory cost) is 60%.
- 5) Regulatory cost is set to 5.75% of gross revenues for the license regime and maintain stable during the forecast period.
- 6) Capex is estimated to be 50% of revenues in 2013, decreasing to 30% in 2014, 25% in 2015 and subsequently drop to 20% and then to 15% in 2019, which will be maintained during the remainder of the forecast period.
- 7) The discount factor is set to 10%.

Figure 17 Discounted Cash flow analysis



Altogether, this translates into a cash flow during the period with a net present value (NPV) of THB 73.9 bn (EUR 1.85 bn) compared to the reserve price for 3 slots of 2 x5 MHz which is THB 13.5 bn. As a comparison an Investment Bank estimate that the total bidding price for each operator will be around THB 20 bn.²⁵

Figure 18 Reserve price compared to estimated value of 3G spectrum



Source: NBTC, KT-Zmico, authors calculations

The wide range between the reserve price and NPV demonstrate that a 3G license represents a significant value for the operators. But given that the spectrum cap opens for three 3G licensees the final price will be determined by the financial capabilities of new entrants, however the NPV indicates that the three existing operators have value support for up to six times compared to the reserve price.

CONCLUSIONS

This paper has compared estimates of engineering value of spectrum with prices paid at a number of spectrum auctions in India and Sweden, and compared a DCF-valuation with the reserve price for 3G spectrum in Thailand. The analysis also includes a discussion of drivers that have had an impact on the willingness for the operators to pay

²⁵ KT-Zmico Securities, ICT (Mobile operators), Industry Update August 23, 2012

for spectrum. The paper makes the assumption that auction prices are an expression for what operators are prepared to pay for spectrum. But given that the engineering value of spectrum predominately is higher than prices paid at auctions it could be seen as there is a valuation gap. However, auction prices are determined by the competition on the scarce resource and how much competition is prepared to pay for spectrum. The analysis has demonstrated that the production cost is impacted by how much spectrum an operator has access to and given that HSPA is not facilitating larger carriers than 5 MHz spectrum has not yet played the key role to differentiate services that operators are marketing. This implies that the strategic importance of spectrum has not yet made a fundamental impact on the market. However, the valuation of spectrum is determined by where it is located in the spectrum band, whether it is possible to block other operators from aggregating adjacent bands. The analysis has underscored that radio spectrum is a vital asset and resource for mobile network operators and with more spectrum, i.e. wider bandwidth operators can offer higher capacity and data rates. This implies that spectrum will be instrumental in the competitive positioning when LTE will be introduced. Operators strive to have as much spectrum as its competitors as less spectrum means that it has to deploy more sites in order to provide the same capacity and that only lower data rates can be provided. The analysis has shown that the fierce competition on spectrum in India has pushed up prices, a development which will be further underscored when the diffusion of smart phones will take-off.

Concluding, the paper has shown the significant role spectrum is playing on the mobile broadband market, and its impact on the level of capital investments made by operators. The significance of spectrum will be reinforced with the introduction of LTE Advanced which will facilitate carrier aggregation making spectrum to an even more important factor for the competition and the strategic positioning of operators. Ultimately regulators have to release more spectrum in order to increase the availability for operators and making it possible for mobile communication to play a key role in achieving the broadband targets.

Acknowledgement: The research has been conducted with financial support provided by wireless@kth.

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