Valuation of 3G spectrum license in India: A real option approach

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Abstract

India is about to enter a new technological phase as far as mobile technology is concerned. After almost a decade of existence, Third Generation (3G) mobile technology will be rolled out in India. The licenses for the same were auctioned in April – May 2010 and 3G licenses were allocated to the winners in September 2010. Nine private telecom operators entered the bidding for the license and eventually seven won the licenses. The bidding was intense and eventually the aggregate fees of the license as received by the government were almost twice the expected amount. In the backdrop of experience of 3G auction winners in UK and Germany who paid huge sums to acquire the 3G licenses and later lost their market capitalization as the markets perceived that the price paid for the license was more than the actual value of the license, analysts in India were concerned if the operators had paid too much for the licenses. In this report aggregate value of the 3G licenses is calculated using both traditional discounted cash flow approach and real options approach. We find that the rollout of 3G services gives an internal rate of return of 14.2%over the life of the license. If we assume an internal rate of return of 15% for the telecom operators then the aggregate license value comes out to be INR 594 Billion which is 12% lower than what the operators have paid to acquire the license. We also found out that the value of the license as calculated from the real options methodology is INR 798 Billion which is 17.8% higher than the aggregate value paid by the operators. Hence we see that DCF valuation suggests that the licenses were overvalued while Real Options methodology suggests that the licenses were undervalued.

The report discusses the reasons for differences between real option valuation and DCF valuation of the license, the possible challenges that the 3Goperators might face in the short to long term and what are the key enablers for the growth of3G services if they want to extract the maximum mileage out of the 3G technology. The report recommends that in future while allocating telecom licenses or licenses in sectors where high and irreversible investment is required and there is a scope for the licensees to invest in phases or in modules, the government should consider real options methodology for setting the price of the license., or the base price of the licenses in case the government decides to follow an auction methodology.

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1 Introduction

India is the 2nd largest telecom market in the world and operators had bid aggressively for the 3G spectrum license primarily to shore up the fall in the ARPU and improve their profit margins. India is divided into 23 telecom circles. Though the overall Teledensity is around 60%, Teledensity in some of the Metro and Category 'A' circles is above 100%. Telecom operators in this fast growth environment are suffering from hyper competition and addition of prepaid subscribers because of which ARPU has fallen from INR 272 in Mar' 07 to 120 in Mar'10. In India ~95% of the subscribers are prepaid subscribers.

Analysts were worried if winners' curse would hit Indian 3G auction winners and whether the winners of the auction would actually end up paying more than the true value of the license. Some analysts believe that winners' curse hit the auction winners in UK and Germany. UK and Germany auction generated USD 35 Billion and USD 46 Billion[1]respectively which were much more than the amount initially expected.

The motivation to undertake this piece of research was the overwhelming 3G spectrum license fees as discovered during the 3G spectrum license auction last year. 3G license auction in India ran for almost 34 days and after 183 rounds of bidding 9 telecom operators shelled out INR 67718.95 crore. The auction started on 9th April 2010 and concluded on 20th May 2010. Out of this amount INR 50968.37 was shelled out by 7 private operators while INR 16750.58 was shelled out by the state owned operators namely BSNL & MTNL[2].The windfall received by government in the form of auction amount was almost twice the amount as expected by the government. The reserve price of the pan-India 3G spectrum as discovered during the auction (INR 16750 crore) was almost 5 times its reserve price (INR 3500 crore) as set by the government before the start of the auction[3].While many news articles claimed that price of the 3G license as paid by the operators was above its intrinsic value, there was areport in The Economic Times which claimedthat there could be a business case for some of the 3G operators despite the high license fees[4].

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[1]www.pensions-research.org/3G.pdf, accessed on 10-03-2011

[2]http://www.medianama.com/2010/05/223-3g-auction-india-ends-provisional-winners, accessed on 10-03-2011

[3]http://articles.timesofindia.indiatimes.com/2009-08-28/india-business/28196801_1_reserve-price-bwa-spectrum-pricing, accessed on 10-03-2011

[4]http://articles.timesofindia.indiatimes.com/2009-08-28/india-business/28196801_1_reserve-price-bwa-spectrum-pricing, accessed on 10-03-2011

Before discussing the intricacies of the auctions, I would now like to discuss about the relevance of 3G in Emerging Markets, 3G Auctions worldwide, 3G Auctions in India and Value of 3G from an Indian Perspective. In the 2nd chapter I would discuss about the historical evolution of the mobile technology, and the migration path of previous and futuristic wireless technologies.

1.1 3G in Emerging Markets

There is a stark difference in mobile Teledensity between developing and developed nations. The following graphic in Figure 1 represents the same,

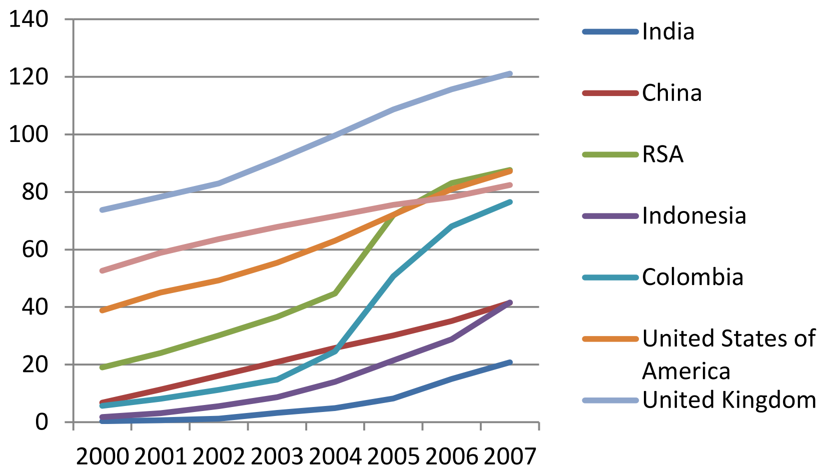

Figure 1 – Cellular Teledensity in Developed & Developing Countries

Source: Worldbank

The major factors which affect the growth of the mobile telephony are lower incomes which give rise to small tax collection and hence lower expenditure by government in providing the enabling infrastructure. As we discussed earlier there is an established correlation between growth of mobile and broadband services and the income of a nation. To provide boost to the growth of telecommunications in emerging markets, various governments establish funds to create a service infrastructure where it is really needed. Some of the measures that governments take are subsidizing the license fees, creating public sector telecom entities, reduction of duties etc. They may also adopt policies like Calling Party Pays and reduce the financial burden on lower income subscribers[5].The graphics below in Figure 2 demonstrate the 2008 values of GNI per Capita and Mobile Cellular Teledensity,

[5]http://en.wikipedia.org/wiki/4G, accessed on 10-03-2011

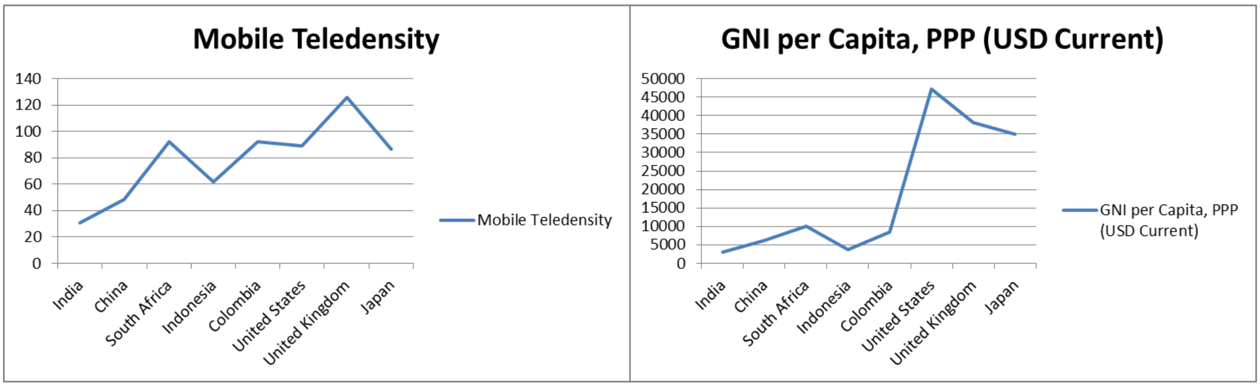

Figure 2 – Comparison of GNI & Teledensity of Developed & Developing Nations

Source: Worldbank

The figure gives a gross picture of how Mobile Teledensity affects GNI. A similar relationship is seen between Internet Penetration and GNI per Capita. Hence communications infrastructure provides an economic stimulus to a country's economy. Globally the capital cost of providing mobile coverage per subscriber is one-tenth of that of capital cost required for providing wireline coverage. Developing countries are prone to theft and vandalism of public properties because of low income levels and unstable economic and political environment. Due to this reason wireless technology is advantageous as the infrastructure is less prone to theft and vandalism as compared to wireline infrastructure. Moreover wireless infrastructure could be laid quickly as compared to wireline infrastructure and is scalable too.Till October '07 there were more than 44.2 crore CDMA2000 deployments across the globe. Majority of these deployments were in developing markets[6].

"*Popularized not only by their much greater voice/data capacities and air link, 3G wireless technologies like EV-DO Rel. 0, EV-DO Rev. A, UMTS and HSPA have also become preferred solutions given their excellent coverage, outstanding mobility attributes (the end game for most wireless WAN deployments), availability in numerous spectrum bands (such as 450 MHz, 800 MHz, 900 MHz, 1.8 GHz, 1.9 GHz, 2.1 GHz, 2.5 GHz, etc.) and interoperability with prior and future network evolutions"*(Kumar, Liu, Sengupta, & Divya, 2010).

[6]www.qualcomm.com/documents/files/3g-emerging-markets.pdf, accessed on 10-03-2011

1.2 3G Auctions Worldwide

3G spectrum is a scarce natural resource and hence countries across the world have adopted various methods to allocate this piece of resource to various utility companies. Some of the methods are,

1.2.1 Auction

In auction bidders are invited to place their bids in a competitive setting and then the spectrum is allocated to the bidder who places the highest bid. There could be multiple rounds in competitive bidding scenario.

1.2.2 Assignment

In case of Assignment mechanism government or the central agency that is in charge of allocating the spectrum assigns the spectrum to various applicants without any fees.

1.2.3 Beauty Contest

In case of beauty contest spectrum is assigned to various applicants on the basis of certain preconditions and criteria for allotment of spectrum. A spectrum fees is charged from the operators to whom spectrum is assigned.

3G services have been rolled out in more than 100 countries throughout the worlds. Table 1 – Snapshot of 3G Auctions in other nationsTable 1 gives a snapshot of some of the countries where 3G spectrum has been allotted to various operators,

Table 1 – Snapshot of 3G Auctions in other nations

Country	Date of Allocation	Method#	No. of 3G Licenses	License Fee Per Capita (US$)	License Fee/GDP
Europe					
Spain	Mar-00	BC	4	11.8	0.08%
UK	Apr-00	A	5	576.5	2.34%
Netherlands	Jul-00	A	5	156.5	0.65%
Germany	Aug-00	A	6	561.7	2.43%
Italy	Oct-00	A	5	193.6	1.01%
Austria	Nov-00	A	6	76.2	0.31%
Norway	Nov-00	BC	4	10	0.03%
Switzerland	Dec-00	A	4	16.1	0.05%
France	Jul 2001+Dec 2001	BC	3	318	1.29%
Asia					
Japan	Oct 2001-Dec 2002	Assignment	3	0	0%
Malaysia	Jul 2005-2008	BC/A	2	1	0.01%
South Korea	Oct 2000-May 2001	Assignment/BC	3	62.9	0.57%
# A: Auction; BC: Beauty Contest					

Source: ICRA(ICRA Limited, 2009)

As can be seen from the above table majority of the nations in Europe went for the auctions method of allotting spectrum while majoring of nations in Asia went with Assignment or Beauty Contest methods of allotment of spectrum. The other startling fact that comes out from this graphic is the time lag which we are seeing in case of 3G rollout in India. Most of the countries listed in the table auctioned or allotted 3G air waves in 2000 – 2002; however India auctioned 3G airwaves only in 2011.

High license cost in Germany and Europe became case studies to see if the licenses have been overvalued or not. High licenses costs coupled with low initial adoption of technology and high investment costs required to roll out the 3G services affected the financial performance of major operators in these countries.

1.3 3G Auctions in India& Industry Snapshot

India decided to go ahead with auctions methodology for allocating 3G airwaves. India is divided into 23 telecom circles. Indian government decided to auction 3G airwaves in the 2.1 GHz band in blocks of 2 x 5 MHz with a maximum of 5 blocks per circle. In some of the circles 1 more block of 2 x 1.25 MHz in the 800 MHz was auctioned to any UASL licensee who was offering CDMA services. The objectives that Government of India set for the 3G auctions were[7] (Department of Telecommunications, 2010),

- To stimulate competition in the telecom sector
- To ensure that operators don't hoard the spectrum and it is used efficiently
- To maximize proceeds from the auction
- To promote rollout of 3G & broadband services
- To provide additional spectrum to existing 2G operators so that they can overcome the problem of scarcity of spectrum and hence improving quality of service
- To obtain a market determined price for 3G spectrum

Table 2as published by ICRA in their report on 3G & Its Implications for India Operators summarizes the salient features of the auction,

[7]DOT, 3G & BWA Notice Inviting Applications for Auctions

Table 2 – Snapshot of rules of 3G auction in India

Auction Rules	Only one entity to be allowed to bid from the same Group.
Eligibility	3G spectrum – 2.1 GHz band
	o Any entity holding Unified Access Service (UAS)/Cellular Mobile Telephone Services (CMTS) License; or
	o Any entity having previous 3G experience whether directly or through a majority-owned subsidiary and undertaking to obtain a UAS license prior to commencement of operations
Frequency Bands	2 x 5 MHz in the 2.1 GHz band (maximum of 5 blocks per Circle)
	Rs. 35.0 billion for 2.1 GHz band
	Clock stage to determine the spectrum lot winners
	Assignment stage to assign specific frequency to the winners
Bid Price Increments	Negative demand: 0% increase
	Zero excess demand: 2% increase
	Demand in excess of 1 or 2 bidders: 5% increase
	Demand in excess of 3 or more bidders: 10% increase
Allocation of Spectrum	Successful bidders are required to deposit 25% of the auction amount within five days of the close of auction and the remaining 75% within the next 10 days
	On full payment, Department of Telecommunications (DoT) will issue a Letter of Intent (LoI) and would allocate spectrum within 15 days of full payment of the auction amount
	New spectrum winners would be allocated 3G spectrum after they have obtained UAS License
Rollout Obligations	At the end of 5 years from the date of spectrum allocation or grant of UAS license (if applicable) whichever is later, the service provider needs to cover 90% of the Metro areas and 50% of the District Headquarters (DHQs) or cities in the service areas, out of which 15% of the DHQs must be rural Short Distance Charging Areas
Spectrum Usage Charges	Spectrum charges for existing players to be the same as the revised spectrum charges for 2G spectrum. 3G spectrum is not to be counted to arrive at the relative slab of spectrum
	Standalone 3G carriers will be charged 3% of Adjusted Gross Revenue (AGR) after the first year of allocation of spectrum, which is equal to license fees paid by a 2G carrier with base spectrum of 4.4 MHz of GSM spectrum

Source: ICRA (ICRA Limited, 2009)

The reserve price of the pan-India 3G spectrum as discovered during the auction (INR 16750 crore) was almost 5 times its reserve price (INR 3500 crore) and that was the main motivation to do a valuation of the 3G license. Some of the qualitative reasons because of which licenses have received high valuations are,

- **Average Revenue per User**. Declining Average Revenue per user because of a hyper competitive environment and innovative pricing by prepaid operators has put immense pressure on the profitability of mobile operators.

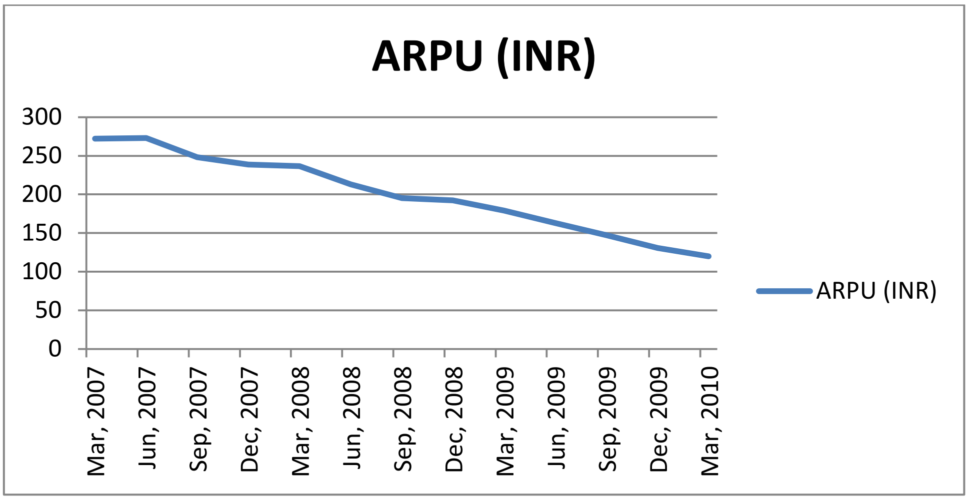

Figure 3 – ARPU trend in India

Source: CMIE Database (TRAI)

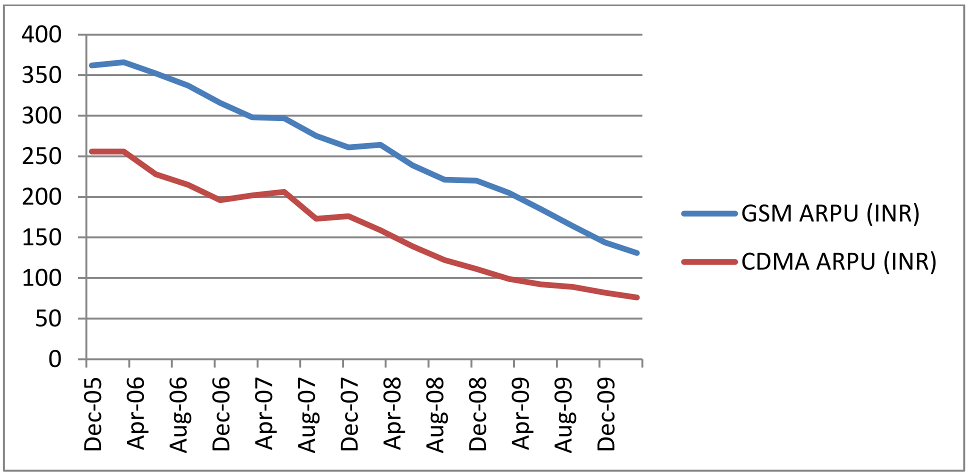

Figure 4 – Comparison of GSM & CDMA ARPU

Source: CMIE Database (TRAI)

- **Spectrum Scarcity**. Department of Telecom (DoT) has prescribed certain quality standards for providing mobile services. Operators were facing a tough time in adhering to these standards because of high subscriber and bandwidth requirement growth in face of a limited spectrum. This is especially true in case of Metros and Category A circles.
- **Mobile Number Portability**. Mobile Number Portability was to be launched in India when 3G auctions were taking place. Operators vouched to get a piece of 3G spectrum in areas where they had a stronghold to retain their premium customers by

offering them better services and transferring them to 3G spectrum to provide them better voice quality and an enhanced user experience.

- **Broadband**. 3G spectrum could be used by operators to provide broadband services. India's broadband penetration is abysmal and hence scope for growth is enormous in the future. Wireless broadband requires a low capital expenditure as compared to a wireline broadband coupled with the fact that ARPU of broadband is around INR 700 while that of Mobile Services is around INR 110.

Various operators that bid for the 3G spectrum included the incumbent operators such as Airtel, Aircel, Reliance Telecom, Idea Cellular, Vodafone Essar and TTSL. Some of the new entrants like Unitech Telenor and Sistema Shyam also bid for the 3G spectrum to compete with the incumbent operators. International operator like S-Tel also bid for the 3G spectrum. The circle wise list of operators and amount shelled by each of them is provided in appendix.

The government raised a windfall of INR 67718.95 crore from the auctions. Out of this amount almost ~39% was raised from Delhi and Mumbai circles only. If we add the other three top circles of Karnataka, Tamil Nadu, and Andhra Pradesh then it accounts for almost ~65% of the bids.

Aircel, Bharti & Reliance won 13 blocks of 2x5 MHz spectrum in 13 circles. Idea won 11, Vodafone won 9, TTSL won 9 and STel won 3 licenses. The interesting fact was that none of the operators won a pan-India license and hence we could see some collaboration between players to provide a seamless 3G access for their subscribers.

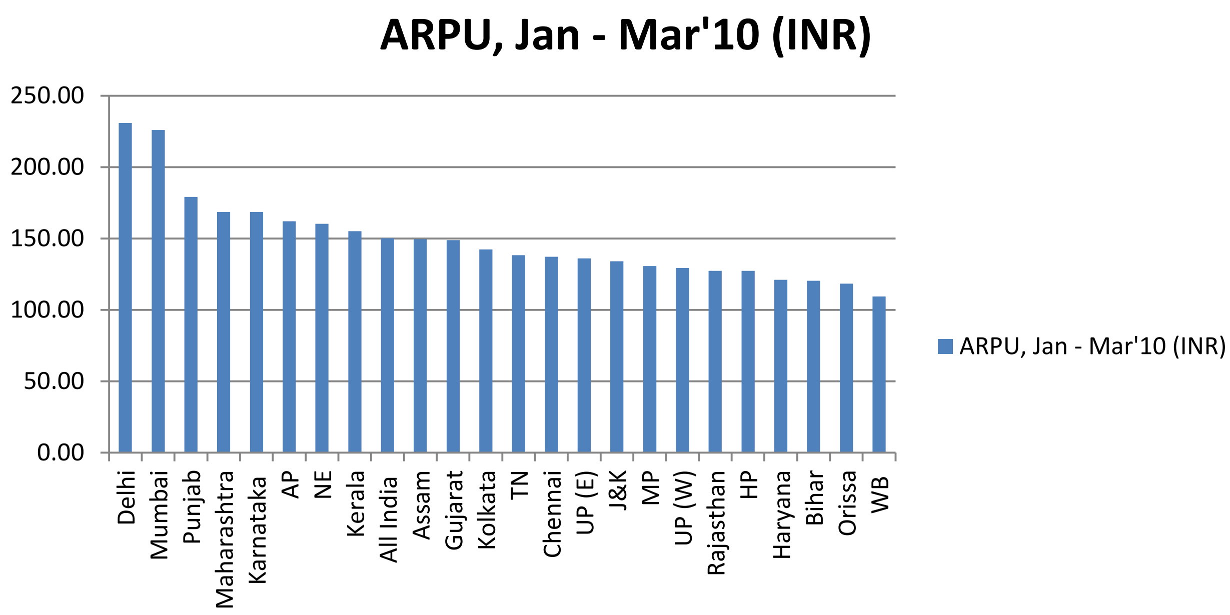

Figure 5 – Circle wise ARPU for Jan-Mar'10 Quarter

Source: Cellular Operators Association of India

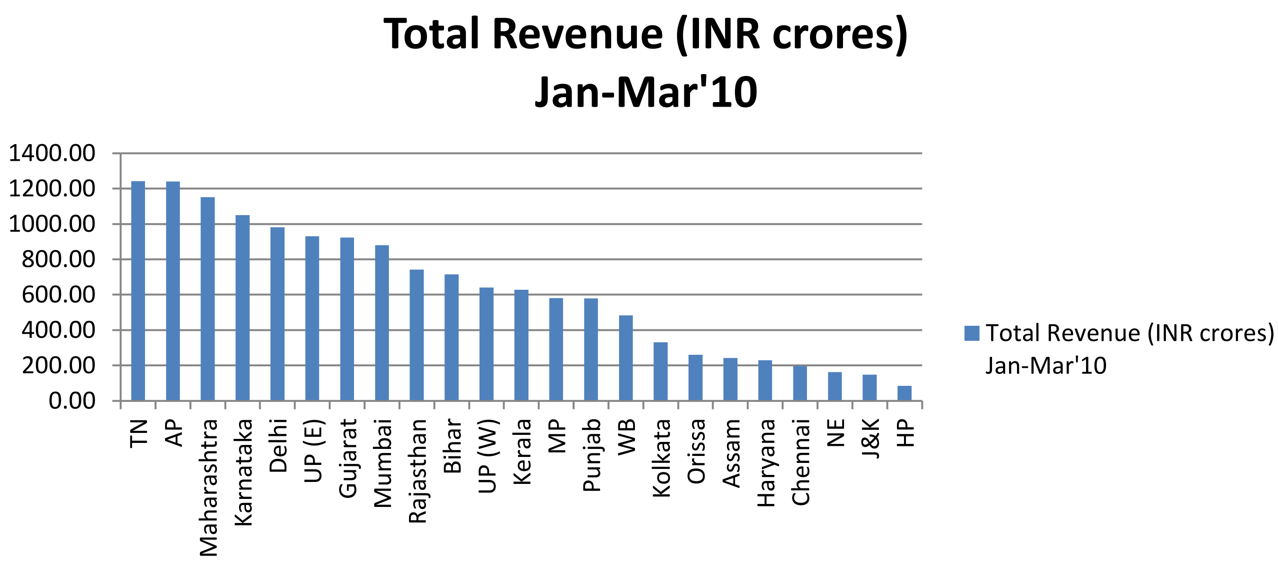

Figure 6 – Circle wise mobile revenue for Jan-Mar'10 Quarter

Source: Cellular Operators Association of India

Figure 5 and Figure 6 represent the Average Revenue per User and Total Revenue for GSM Cellular subscribers. The data has been taken from COAI (Cellular Operators Association of India). High ARPU in Delhi and Mumbai because of the demographics of the subscribers and high revenue earning circles of Tamil Nadu, Andhra Pradesh, Karnataka and Maharashtra have received the highest valuation for the license. The circle wise revenue earned from license is presented in the graph below.

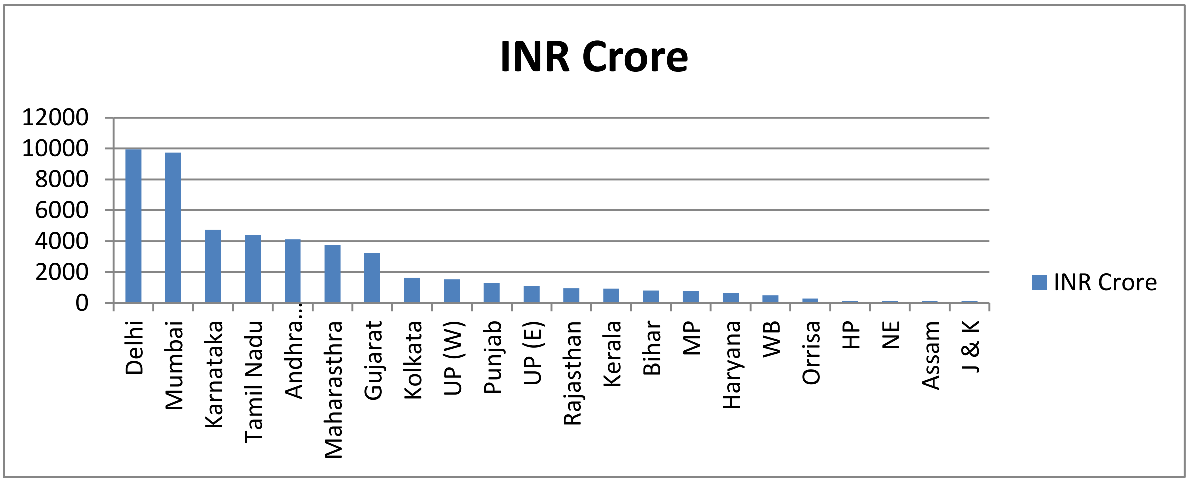

Figure 7 – Circle wise license fees paid by Operators

Source: Medianama[8]

Circle	Aircel	Bharti	Idea	Reliance	STEL	Tata	Vodafone	Total
Delhi								9950.79
Mumbai								9741.21
Maharashtra								4739.73
Gujarat								4394.82
AP								4119.42
Karnataka								3773.46
TN								3228.18
Kolkata								1632.78
Kerala								1542.12
Punjab								1288.04
Haryana								1093.71
UP (E)								963.09
UP (W)								937.44
Rajasthan								813.84
MP								775.08
WB								667.74
HP								494.52
Bihar								290.94
Orissa								148.92
Assam								126.9
NE								124.44
J&K								121.2
	1959 - 1965 MHz		1969 - 1974 MHz		1974 - 1979 MHz		1964 - 1969 MHz	

Figure 8 – Circle Wise Allotment of 3G Spectrum to Operators

Source: Medianama[9]

Though we could draw some inferences from the limited data shown above regarding the high valuations paid for licenses in some of the circles, but the underlying revenue numbers for a quarter alone are not sufficient to draw inferences regarding whether licenses in some of the circles were undervalued, overvalued or valued correctly.

There was an article in The Economic Time titled "*The Shapley Value of 3G Auction"*. As per the article in Shapley Valuation a payoff is assigned to a player based on its marginal contribution to a randomly selected coalition. Shapley value becomes important in the current context as none of the players has won a pan-India license and hence the players have to enter

[8]http://www.medianama.com/2010/09/223-3g-mobile-india-spectrum, accessed on 10-03-2011

[9]http://www.medianama.com/2010/09/223-3g-mobile-india-spectrum, accessed on 10-03-2011

into agreements with each other to provide roaming services to their subscribers. Higher the Shapley values, higher the competitive position. The table on the next page as appeared in The Economic Times reported that as per the Shapley Valuation Bharti, Vodafone and TATA underpaid for their licenses while Reliance, Aircel, Idea and STel overpaid for theirs'.

Table 3 – Shapley Valuation of Spectrum for Various Operators

Company	Shapley Value %	Total Outlay %	Value - Outlay Ratio	Decision
Bharti	24.27	24.12	1.01	Underpaid
Vodafone	23.04	22.79	1.01	Underpaid
Reliance	16.72	16.86	0.99	Overpaid
Aircel	12.6	12.75	0.99	Overpaid
Tata	11.55	11.5	1.00	Underpaid
Idea	11.27	11.32	1.00	Overpaid
STel	0.55	0.66	0.83	Overpaid
All Players	100	100	1.00	

Source: The Economic Times[10]

1.4 3G – Indian Perspective

There are over 100 countries in the world which have adopted 3G technology. As per Morgan Stanley global 3G penetration should reach almost 46% by 2014 which translates into 2776 Million 3G subscribers worldwide. 3G auctions were held in India in the timeframe of April – May 2010 and licenses were allocated to the auction winners by September 2010. The government received a windfall from the auctions. As per ICRA, the investment in 3G licenses is a good investment from a long term perspective however various telecom operators might face some cash flow issues in the short term primarily on account of high interest cost on the debt raised for paying the licenses and capital required for rolling out the 3G networks. As per an "ICRA report titled 3G Telephony Services: Implications for Indian Operators"the impacts of investment in 3G licenses will manifest both in the long and short term. Some of the impacts are discussed here (ICRA Limited, 2009),

- Telecom operators might face high interest burden in the initial years primarily on account of high debt burden because of huge investment in securing the license and the investments that would be required to roll out the 3G networks.

[10]http://economictimes.indiatimes.com/opinion/the-shapley-value-of-3g-auction/articleshow/6862694.cms, accessed on 10-03-2011

- Telecom operators would have to incur additional marketing costs to communicate about their 3G offerings. Since 3G penetration and growth is expected to be low in the initial years telecom companies might offer subsidies and bundled connection and phone in collaboration with 3G phone manufacturing company, this could suppress the margins in the early years.
- 3G technology would enable the growth of data services and Mobile broadband in India. Currently data services constitutes around 9% of the mobile ARPU, however once the 3G services will rollout this proportion is expected to go up to 25% and even more than that because of added applications, and enhanced user experience while availing data services because of better speed.
- The rate at which mobile subscribers are growing in India had made the 2G spectrum available with the existing telecom operators a constraint for adding more subscribers. With 3G spectrum available to mobile companies, their subscribes would migrate from 2G to 3G platform thus vacating the 2G bandwidth which could be used to provide mobile services to new 2G subscribers.
- With Mobile Number Portability being introduced in Indian Telecom Industry, the propensity of a premium consumer to switch from one operator to other operator has increased because the consumer can now retain his number. Offering better services and enhanced user experience can build a competitive advantage for a mobile operator which would stop its subscribers from hopping to other mobile service providers.
- In the long term as the number of 3G subscribes will increase in our country, the mobile manufacturing companies would also achieve some scale in terms of 3G mobile phone market. This would bring the costs down and simultaneously mobile companies needn't provide subsidies on handset to simulate demand.

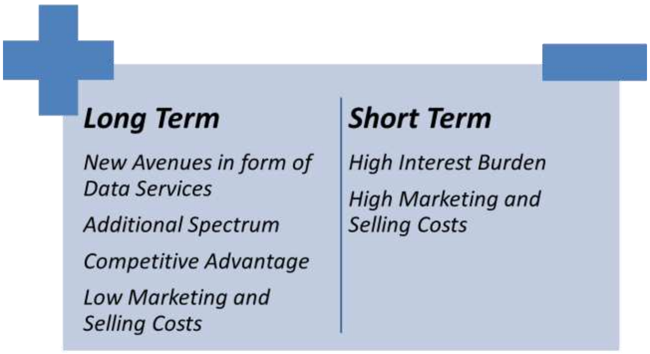

Figure 9 – Implications for 3G Operators

Source: ICRA (ICRA Limited, 2009)

1.4.1 3G Broadband

India is a country with an abysmal broadband penetration. There were only 8 Million Broadband Subscribers out of a population of around 1.2 Billion. A 10% rise in broadband penetration can boost our GDP by 1.38%[11]. While landline broadband penetration is low because of supply side constraints in terms of high per subscriber capital expenditure required in case of landline broadband, the problem with wireless broadband provided by operators like MTS, TATA, BSNL and Reliance is that of Scale. Since the scale is small, the device is expensive and since the device is expensive the demand is less. Scalability is a concern in wireline broadband, while wireless broadband is a highly scalable model.

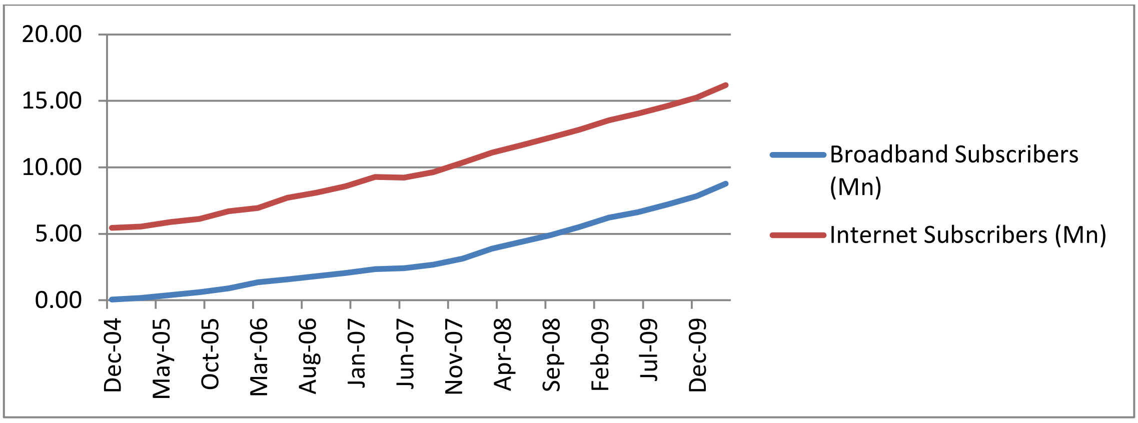

Figure 10 – Broadband & Internet Subscribers in India

Source: CMIE Database (TRAI)

[11] http://www.business-standard.com/india/news/%5C10-rise-in-broadband-penetration-will-lead-to-138-rise-in-gdp%5C/418285, accessed on 10-03-2011

Broadband penetration has been low in the country. If we look at the number of broadband connections added between the 5 years from 2004 to 2009, the number stands around 7 Million. This number is extremely low when compared to the number of mobile subscribers which are growing at a rate of 50 Million new subscribers in every quarter.

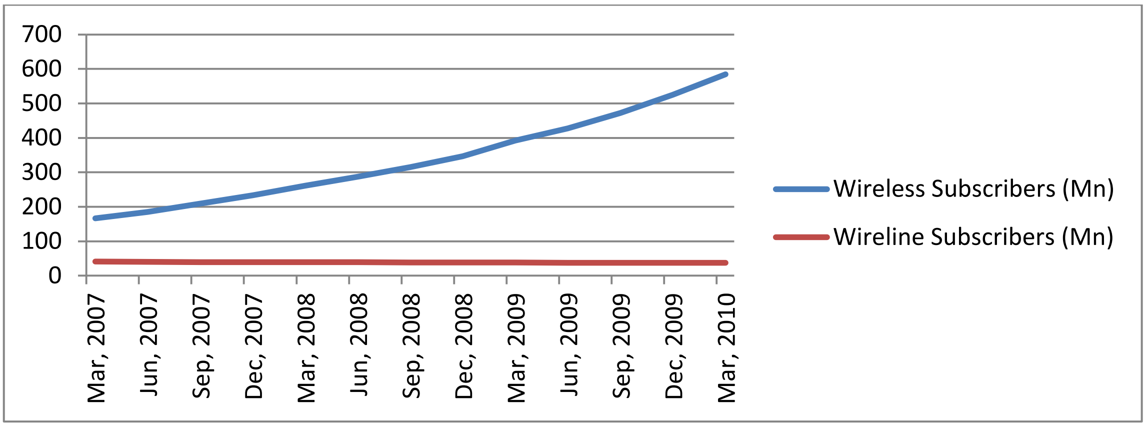

Figure 11 – Wireless & Wireline Subscribers in India

Source: CMIE Database (TRAI)

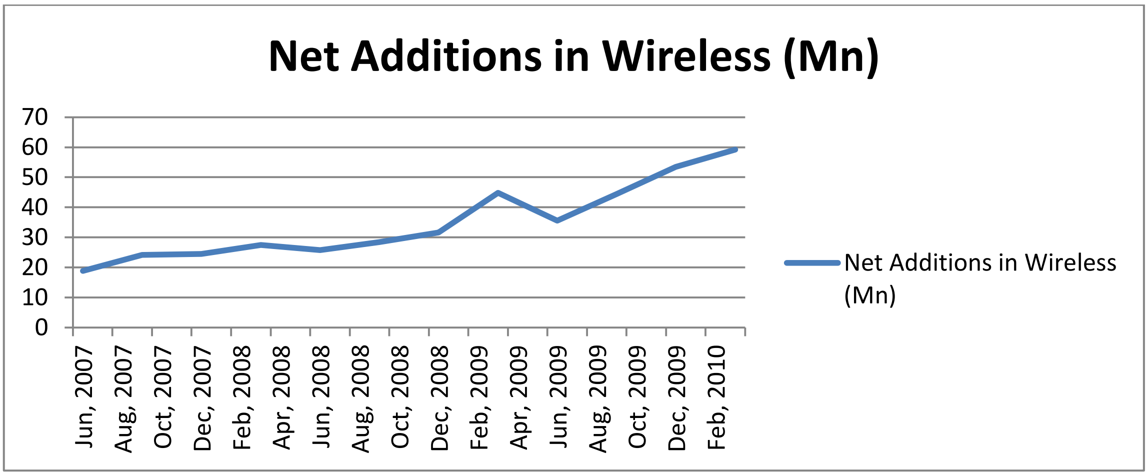

Figure 12 – Quarterly net additions in wireless subscriber base in India

Source: CMIE Database (TRAI)

The sluggish performance of broadband in our country depends on both poor demand and supply economics. As per a report by consulting firm PWC titled Mobile Broadband – Outlook 2015(PricewaterhouseCoopers India, 2010), the capital expenditure per subscriber in a wireline broadband is around INR 90000 while the capital expenditure per subscriber in a wireless broadband is as low as INR 3000. Some of the additional factors which have led to slow growth of broadband services in India are illustrated in the figure,

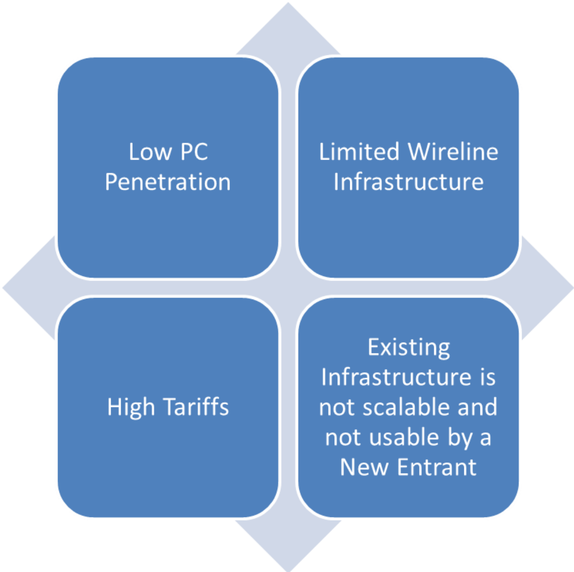

Figure 13 – Drivers of Mobile Broadband in India

Source: PWC (PricewaterhouseCoopers India, 2010)

Compare the growth of broadband subscribers with the following graphic which shows the number of users who can access data from their mobile phones.

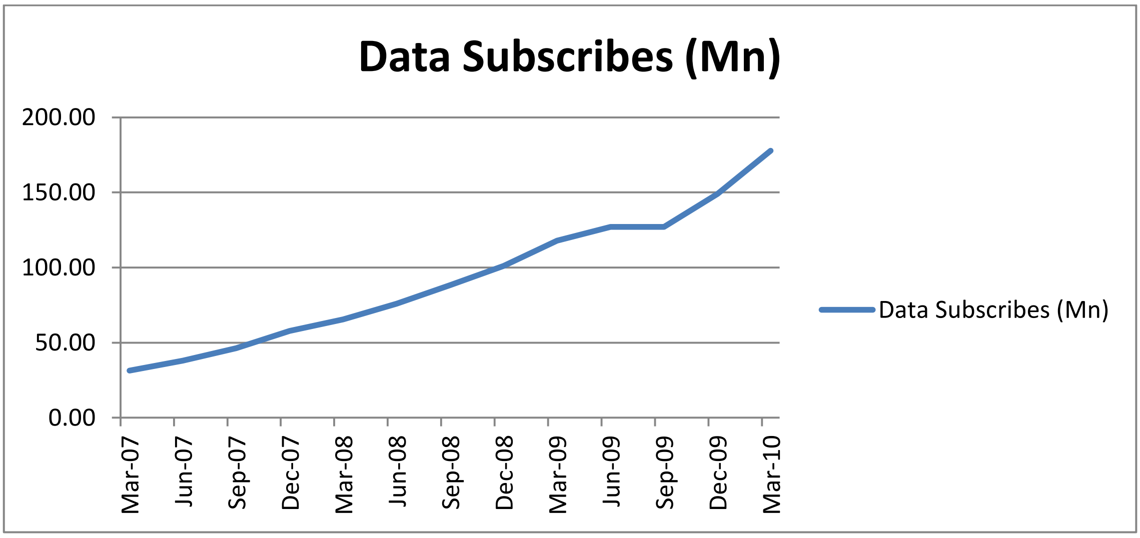

Figure 14 – Mobile Data Subscribers in India

Source: CMIE Database (TRAI)

Though people are subscribing to data from their mobile phones using technologies like EDGE, GPRS the speed and the user experience is very low. Off late some CDMA operators like Reliance, BSNL, MTS and MTNL are giving mobile broadband though data cards based on EV-DO technology. Reliance reported a figure of 2 Million EVDO subscribers[12], while MTS and MTNL reported a figure of 0.25 Million[13] and 0.815 Million subscribers[14] respectively.

Given the constraints associated with Wireline Broadband, 3G is well poised to be India's champion for providing broadband services to the masses. While the recently concluded 4G auctions are providing alternate technologies like LTE (Long Term Evolution – Time Division Duplexing) and WiMAX which are better and faster than 3G, but the restriction of voice over 4G spectrum and high investment costs would mean that operators target these services towards subscribes which have high ARPU. These subscribers typically belong to urban areas and enterprise subscribers. Till WiMAX or LTE achieve a certain scale the devices with which to connect the internet would remain expensive. On the other hand 3G handsets are available for as low as INR 4700. Nokia launched its Nokia 2730 Classic model at a price point of INR 4700[15]. The availability of 3G devices at affordable prices would mean high volume of subscribers adopting 3G technology. This coupled with the fact that the capital expenditure involved in 3G technology is less means that 3G will drive the broadband growth in India in medium to long term.

1.5 Drivers of 3G in India – Consumer & Operator Perspective

A key metric for valuing the 3G license is the prospective subscriber base of 3G license in India. In this section we would try to elaborate some of the drivers for 3G in India which could help the operators achieve the critical mass in terms of number of subscribers so that their investment in 3G license is profitable. In order to analyze the drivers of 3G in India, a bifurcation has been done in terms of factors which are associated with the consumer and the factors which are associated with the wireless operator (PricewaterhouseCoopers India, 2010).

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[12] http://convergence.in/blog/2011/01/07/reliance-netconnect-broadband-evdo-based-500-cities/, accessed on 10-03-2011

[13] http://www.medianama.com/2010/05/223-mtnl-q4-10-mobile-revenue-at-rs-1840m-348k-3g-subs-broadband-arpu-rs-592, accessed on 10-03-2011

[14] http://www.bsnlevdo.in/bsnl-evdo-news/mts-to-offer-14-7-mbps-speeds-through-cdma-dongles, accessed on 10-03-2011

[15] http://techie-buzz.com/mobile-news/nokia-launches-nokia-2730-classic-cheapest-3g-handset-in-india.html, accessed on 10-03-2011

The consumer related factors are,

- ***Quality of Service*** – Quality of service in terms of better user experience while accessing internet, streaming videos, playing online games, better applications and less frequent call drops.The quality of video calls and internet speed would depend on the coverage of network, density of Base Stations and number of subscribers per base station.
- ***Applications and Content***. The real impetus in giving an enhanced experience to the user would depend on the Applications that will be developed for the 3G technology and the quality of content that would be provided by the content providers.
- ***Access Device***. The adoption of 3G technology by a consumer would also depend on the cost of switching to 3G technology. For a subscriber, who is on a 2G technology, to switch to 3G technology would need an access device or 3G enabled phone. Since 3G has been rolled out in over 100 countries, the device manufacturers have achieved the economies of scale and the prices of 3G devices are falling. The decrease in prices of 3G devices coupled with their backward compatibility with 2G systems would be a key driver for the uptake of 3G technology in India. As previous discussed, Nokia has launched a 3G enable handset at INR 4700 and going by the trends of the device prices that we saw during the reign of 2G technology 3G device prices are surely going to come down.
- ***High Bandwidth Requirements***. High bandwidths are required by enterprises and professionals living in urban areas because of mobility requirements to enhance the productivity. 3G would surely help in catering to these requirements given that the infrastructure is already in place to roll out the services.
- ***Demographic Profile***. As per a PWC report titled *"Mobile Broadband – Outlook 2015"* India's population in the 20 – 29 age group will reach above 210 million by 2015. Direct implication of this is their propensity to try the new and enhanced services provided by 3G technology and they would be the early adopters of the technology thus driving the 3G market in India (PricewaterhouseCoopers India, 2010).

The operator related factors are,

- ***Declining ARPU***. Operators would turn to 3G to safeguard their profitability which is under pressure in a hyper competitive environment and the heavily skewed use profile towards prepaid subscribers.
- ***Better Business Case***. For operators rolling out broadband in a wireless environment makes a much better business case than rolling out broadband in a wireline environment.
- ***Low Broadband Penetration***. Operators see a huge potential in a market where broadband penetration is less than 1%.

2 Historical overview of Mobile Technology

Current GSM and CDMA based mobile communication systems are basically 2G or 2nd Generation Mobile communication technology. Before 2G and 3G there was 1G or the 1st generation mobile communication technology. 1G technology was based on analog signals as compared to the present day technology which is digital. First commercial launch of a 3G systems was in the year 1979 by NTT in Japan. NMT (Nordic Mobile Telephone), AMPS (Advanced Mobile Phone System) and TACS (Total Access Communication System) are some of the example of the 1G telecommunication systems[16].

After almost a decade of 1G technology 2G technology was rolled out on GSM (Global System for Mobile Communications) standard in the year 1991 in Finland. The main advantage of 2G systems over 1G systems was that the technology was made digital. The inherent advantage of digital systems is that the data is encrypted and compressed thus allowing a more efficient use of the available bandwidth which translates into higher penetration for the same amount of available bandwidth. 2G systems also allowed data services which weren't there in the 1G technology[17]. 2G systems were primarily based on two technologies,

- CDMA (Code Division Multiple Access) – CDMAone
- TDMA (Time Division Multiple Access) – GSM

CDMA and TDMA are channel access methods while CDMAone and GSM are standards of mobile technology. Channel Access Methods are explained in a further section. GSM technology is by far the most adopted technology across the world with a worldwide penetration of 80% among all the wireless subscribers. 2G systems were built primarily for voice communication and limited amount of data communication (SMSs etc.). The spectrum used by 2G services is in the range of 800 MHz, 900 MHz, 1800 MHz and 1900 MHz with a limited speed of around 14 Kbps. By the end of the century 20th century voice services no longer remained the focus area for the mobile communications engineers and the demand for a faster way to access the internet from mobile device started picking momentum[18]. This led to the development of new standards like GPRS (2.5G) and EDGE (2.75G). Though the

[16] http://en.wikipedia.org/wiki/2G, accessed on 10-03-2011

[17] http://en.wikipedia.org/wiki/2G, accessed on 10-03-2011

[18] http://en.wikipedia.org/wiki/3G, accessed on 10-03-2011

speeds were limited on these standards, however they were much better than the speed of a 2G network. GPRA could support up to 115 Kbps while EDGE could support up to 236.8 Kbps of data speeds. These standards were used to provide Media Messaging Services, Pocket Internet and Wireless Application Protocols. We will now discuss about the two most prominent 2G technologies which are prevalent across the world,

2.1 GSM

Global System for Mobile Communication (GSM) is most widely adopted mobile technology standard. As per GSM association almost 80% of the mobile subscribers are on GSM networks. There were over 3.45 Billion GSM subscribers in Q2 2009[19]. GSM is a 2G technology with both the voice signal which is encoded and the signal over which voice is encoded are digital. The main advantage over GSM over any other technology is that you can use your phone anywhere because of high penetration of GSM technology. GSM is based on cellular technology which means that when the phone connects to the operator's network by searching for the nearby cells. The service areas are divided into cells of various sizes. The size of the cell depends upon the signal strength and the number of subscribers in a given service area. The more the number of subscribers the smaller the cell size as a base station required by GSM technology can serve only a limited number of subscribers. Radius of the cell could vary from a few hundred meters to few kilometers. The largest possible radius supported by GSM specification is 35 KM.

2.2 CDMAone

CDMAone is a front name for IS-95 standard. This standard is also based on cellular technology. CDMA is actually the channel access method used by IS-95 standard. In CDMA channel is such that several clients can use the same frequency. In case of GSM channel access method is TDMA which means only one client can access the channel at a single time and access is granted to various clients in a sequential manner. The advantage of CDMAone vis-à-vis GSM is that in CDMAone all clients can access the channel anytime and hence there is no direct relation between channel capacity and a limit on the number of active subscribers. In case of GSM if an operator wants to add subscribers to an existing cell which is already running full capacity the operator might need to split the cell into smaller cells, while in case of CDMA the number of cells required would be lesser than that of GSM with

[19] http://en.wikipedia.org/wiki/GSM, accessed on 10-03-2011

same number of subscribers and hence CDMA channel access method provides a huge economical advantage to mobile operators[20].

2.3 Channel Access Method/Air Technology

Channel Access Method in the simplest possible language could be described as a permission mechanism by which the signal which we wish to send is given a permit to transmit over a channel. When there are multiple users who are attached to the same channel there arise a problem of who will access the channel and in what sequence the access would be granted. In case of mobile technology, there are two kinds of signals,

- Carrier Signal – Carrier signal is the mother signal over which the signal which we wish to send is piggybacked. There are various technologies to piggyback the voice/data signal over the carrier signal. The discussion of those technologies is not relevant in the scope of this research.
- Modulating Signal – This is the user generated or received signal.

The two kinds of channel methods which are more prevalent in wireless telecommunications industry are TDMA and CDMA.

2.3.1 TDMA

TDMA is the channel access method in which each user shares the same frequency and the access to channel is given on a sequential basis. Most of the 2G systems except CDMAone are based on TDMA[21].

2.3.2 CDMA

CDMA is based on a spread spectrum technology in which the bandwidth of the modulated carrier signal is much more than the bandwidth of the modulating signal. This form of channel access method is much more economically favorable than TDMA[22].

2.4 Cellular Technology

A Cellular network is a radio network whose use is widespread in mobile communications. The name cellular network comes from the word ***"Cell"***. In this kind of network the coverage area is divided into number of territories known as cells. Each cell has a Base station with

[20]http://en.wikipedia.org/wiki/IS-95, accessed on 10-03-2011

[21]http://en.wikipedia.org/wiki/Time_division_multiple_access, accessed on 10-03-2011

[22]http://en.wikipedia.org/wiki/Code_division_multiple_access, accessed on 10-03-2011

which a number of mobile from that cell interacts. These Base Stations are connected to each other on a backbone network. Each and every connection which is established between a mobile phone and other mobile phone or an internet server is routed through the base station. The advantage of having a Cellular Network is[23],

- Reduced Power Requirements
- Increased Coverage
- Increased Capacity
- Reduced Interference from other signals

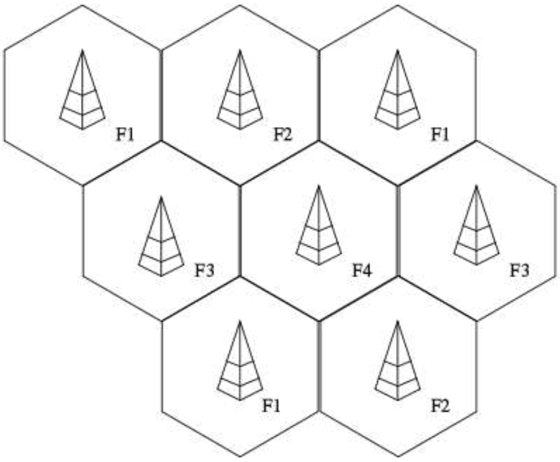

Figure 15 – Cellular Network

Source: http://en.wikipedia.org/wiki/Cellular_network, accessed on 10-03-2011

2.5 What is 3G?

"*International Mobile Telecommunications – 2000 (IMT – 2000), popularly known as 3G or 3rd generation, is a mobile communication standard fulfilling the requirements as specified by the International Telecommunication Union*"[24]. The advantage over 3G over the present day mobile communication systems is the wide range of applications that can be run over it because of the higher bandwidth available in the 3G technology. As per the IMT – 2000 specification 3G systems should support at least 200 Kbps of peak data speed. HSPA technology which is an evolution of 3G technology can theoretically support up to 56 Mbps downlink speed.Applications that a 3G network could possibly support are wide area wireless telephony, video calls, mobile internet access and mobile TV.

[23] http://en.wikipedia.org/wiki/Cellular_network, accessed on 10-03-2011

[24] http://en.wikipedia.org/wiki/3G, accessed on 10-03-2011

The following major standards come under the umbrella of 3G technologies. These are also the technologies which could be used in India.

2.5.1 UMTS

Universal Mobile Telecommunication Systems (UMTS) is technology which has been standardized by 3GPP (3rd Generation Partnership Project) and is primarily adopted by countries where GSM was prevalent. Some of the counties which have adopted UMTS are Europe, Japan and China. UMTS technology can be implemented using different multiplexing technologies. The signal is based on a direct sequence WCDMA which has a radio frequency bandwidth of 5 MHz, which could be operated in two different modes (Tanguturi & Harmantzisa, 2006),

- Time Division Duplexing (Multiple Access) – In this signals are spread over time and the access of the spectrum is sequential. In this mode uplink and downlink frequencies are transmitted in the same carrier band.
- Frequency Division Duplexing (Multiple Access) – In this mode signals are spread over the same spectrum and are spread over frequency and the access of the spectrum is not sequential as in the case of TDD. In this mode uplink and downlink frequencies are transmitted in two different bands of frequencies.

In India FDD will be implemented and the spectrum allocated clearly demarcates the spectrum boundaries for various carriers for both uplink and downlink frequencies[23]. 3G phones based on UMTS technology are generally hybrid to support GSM technology as well so as to provide a seamless connectivity while moving from one geographic region to other where mobile signals are based on a backward technology. WCDMA systems are notorious for their heavy bandwidth requirements[25]. The competing technology cdma2000 which is discussed in the next section is more efficient in terms of usage of bandwidth. The frequency bands as defined under UMTS standards are 1885 – 2025 MHz for uplink channel and 2110 – 2200 MHz for downlink channel[24].

2.5.2 CDMA2000

CDMA2000 is another 3G standard which is a direct evolution from CDMA[26]. The various standards which come under the umbrella of CDMA2000 are CDMA2000 1X, CDMA2000

[25] http://en.wikipedia.org/wiki/Universal_Mobile_Telecommunications_System, accessed on 10-03-2011

[26] http://en.wikipedia.org/wiki/CDMA2000, accessed on 10-03-2011

EV-DO Rev. 0, CDMA2000 EV-DO Rev. A, and CDMA2000 EV-DO Rev. B[25]. The advantage of CDMA2000 is that it could be deployed in the same band of spectrum as its predecessor technology IS-95 (CDMAone).

"The world's first 3G commercial system was launched by SK Telecom (South Korea) in October 2000, using CDMA2000 1X. CDMA2000 can support mobile data communications at speeds ranging from 144 Kbps to 2 Mbps."[27]

Bandwidth required by CDMA2000 systems is 1.25MHz times (1, 3, 6, 9 or 12). In India 3G spectrum for CDMA2000 standard have been offered in blocks of 1.25 MHz. Companies like Reliance, TATA, MTS and BSNL were offering 3G mobile broadband services on EV-DO (Evolutionary Data Optimized) platform much before the auction of 3G spectrum as they could do that on their existing 2G CDMA spectrum.

2.6 Technology Evolution Path & Future Technologies

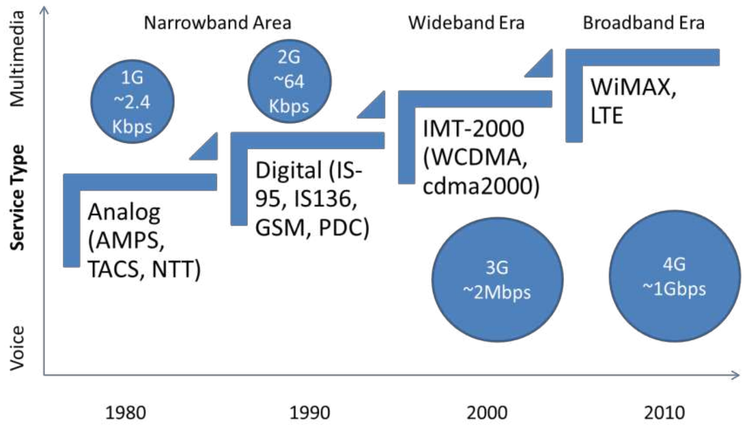

Figure 16 – Evolution of Wireless Technology

The figure above describes the evolution of mobile technology since the inception of wireless communication around 1980. India is lagging by almost a decade as far as adoption and rollout of 3G technology is concerned. As far as 4G is concerned the licenses were auctioned last year along with the licenses of 3G spectrum. However there has been no clarity as to when the operators would be launching 4G services and which technology platform would they use. The restriction of voice over 4G and expensive access devices are the major impediments hampering the business case of 4G in India in the near future. India is currently using 2G technology for mobile wireless communications.

[27]http://articles.timesofindia.indiatimes.com/2008-04-07/tech-jargon/27762820_1_cdma2000-imt-2000-cdma-development-group, accessed on 10-03-2011

2.6.1 Evolution of 3G

The speed that 2G offers is very less as compared to 3G. There have been few improvements and new releases of 2G GSM standard like GPRS and EDGE which have improved the data throughput speeds. EDGE has been considered a pre 3G technology and is part of ITU's 3G definition[28]. Though the speeds on offer by EDGE could be compared to 256 Kbps DSL broadband, however the circuit switch technology which it uses leads to a loss in efficiency of the network and a diminished user experience. The other problem with EDGE was that the standards which were being followed to develop the networks were different for different part of the world where the technology was deployed.

It was because of the non-standardization of the technology that The International Telecommunication Union stepped up its effort to create a network whose services are independent of the technology platform whose network design standards are same globally and thus began the 3GPP (3rd Generation Partnership Project)[29]. The official standard set by ITU for 3G networks is IMT-2000. In Europe the standard was christened as UMTS (Universal Terrestrial Mobile System). IMT2000 is the ITU-T name for the third generationsystem, while cdma2000 is the name of the American 3Gvariant[27]. WCDMA is the technology platform in UMTS with base station or nod B, RNC (Radio Network Controller), apart from WMSC (Wideband CDMA Mobile Switching Centre) and SGSN/GGSN[27]. 3G standard gives a total mobile experience with wide area voice and video telephony with broadband and data services at a high speed. New releases and advancements of 3G technology has led to the evolution of HSPA technology (High Speed Packet Access) which can offer speeds up to 14.4 Mbps on Downlink and 5.8 Mbps Uplink.

2.6.2 Evolution of 4G (AII – IP)

The 4G standard is the successor to 2G and 3G technology standards. The two competing technologies which are vying to be the major 4G technology are LTE (Long Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access).4G set the peak speed requirements of 100 Mbps for high mobility communication and 1 Gbps for low mobility communication[30]. The main principles behind the initiation of the 4G project are represented in the graphic below.

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[28]http://en.wikipedia.org/wiki/Enhanced_Data_Rates_for_GSM_Evolution, accessed on 10-03-2011

[29]www.iject.org/pdf/amit.pdf, accessed on 10-03-2011

[30]http://en.wikipedia.org/wiki/4G, accessed on 10-03-2011

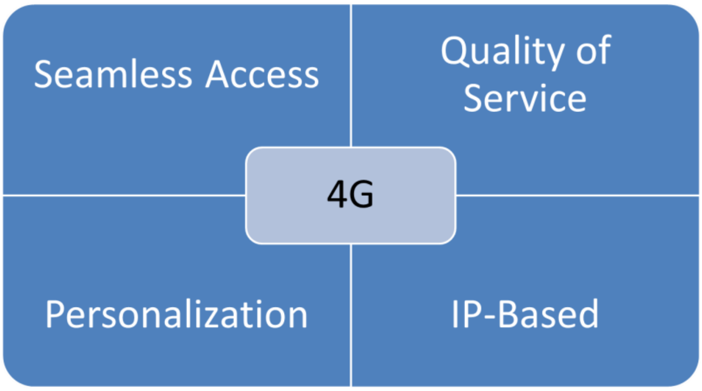

Figure 17 – Guiding Principles for 4G Technology

Source: Wikipedia[31]

4G system is expected to provide ultra-broadband Internet access on a fully mobile platform and is expected to provide services like IP telephony, Gaming, and Live Video Streaming. WiMAX and LTE are the pre-4G technologies; however they are branded as the 4G technology for marketing purpose. Nonetheless ITU has said that these technologies could be considered as 4G technologies provided they are in the consideration to reach the standard set by ITU for 4G mobile wireless. Following table has been taken from the page on 4G on Wikipedia. It gives a data rate comparison for various wireless technologies[29],

Table 4 – Comparison of Wireless Technologies

Standard	Family	Primary Use	Radio Tech	Downlink (Mbit/s)	Uplink (Mbit/s)
LTE	UMTS/4GSM	General 4G	OFDMA/MIMO/SC-FDMA	100 (in 20MHz bandwidth)	50 (in 20 MHz bandwidth)
UMTS-TDD	UMTS/3GSM	Mobile Internet	CDMA/TDD	16	
UMTS W-CDMA	UMTS/3GSM	General 3G	CDMA/FDD	0.384	0.384
HSDPA+HSUPA				14.4	5.76
HSPA+			CDMA/FDD/MIMO	56	22
HIPERMAN	HIPERMAN	Mobile Internet	OFDM	56.9	
EDGE Evolution	GSM	Mobile Internet	TDMA/FDD	1.6	0.5
Flash-OFDM	Flash-OFDM	Mobile Internet mobility up to 200mph (350km/h)	Flash-OFDM	5.3 10.6 15.9	1.8 3.6 5.4
EV-DO 1x Rev. 0	CDMA2000	Mobile Internet	CDMA/FDD	2.45	0.15
EV-DO 1x Rev.A.	CDMA2000			3.1	1.8

[31]http://en.wikipedia.org/wiki/4G, accessed on 10-03-2011

EV-DO Rev.B.	CDMA2000			4.9xN	1.8Xn
1xRTT	CDMA2000	Mobile phone	CDMA	0.144	
iBurst	802.2	Mobile Internet	HC-SDMA/TDD/MIMO	95	36
WiMAX	802.16	Mobile Internet	MIMO-SOFDMA	128 (in 20MHz bandwidth)	56 (in 20MHz bandwidth)
Wi-Fi	802.11	Mobile Internet	OFDM/MIMO	300 (using 4x4 configuration in 20MHz bandwidth) or 600 (using 4x4 configuration in 40MHz bandwidth)	

Source: http://en.wikipedia.org/wiki/4G accessed on 10-03-2011

2.7 Migration Path to 3G

Migration path to 3G depends on the technology platforms on which the operators are offering 2G services. If they are offering 2G services on a GSM platform then the likely platform for them to migrate is WDCMA. While CDMA players are expected to migrate to CDMA2000 platform. Migration to CDMA2000 platform though requires less Upgradation costs however handset subsidy costs would be higher and hence dual technology platform operators should weigh the pros and cons of both the technology platform before deciding on the migration path (ICRA Limited, 2009).

3 Literature Review

Discounted Cash Flow (DCF) valuation is the most common method to value real assets whose future cash flows can be forecasted with certain degree of predictability. The net present value of a project can be calculated by discounting the cash flows which are expected from the project at a certain discount rate which represents the risk of the project. This discount rate is weighted average cost of capital for a project whose risk matches the average risk of the projects of the firm. However if a project's risk differs considerably from the firm's average risk then the WACC is adjusted upwards or downwards to arrive at the new discount rate for the project depending on whether the project is more risky or less risky respectively (Brandao, Dyer, & Hahn, 2005).

DCF method criticized for one of its inherent and structural weakness which is that the project's value will remain same and unaffected despite any future decisions by the management of the firm or the project (Brandao, Dyer, & Hahn, 2005). As a project runs through its useful life a manager might want to bring about some changes and depart from the original plan of action. Such departure from the initially conceived plan of action is not represented adequately by the DCF model which assumes that the investments are made at predetermined time intervals. We can incorporate Monte-Carlo analysis to vary the shape of the probability distribution of the actual investment; however we can't change the time at which that investment will be made.

Consider an investment where a pharmaceutical company invests in the trial of a new drug, if the trial is successful the company will launch the new drug in the market if it is not then the company would stop further research and development in this new drug. Though this is a pretty straight forward scenario where the financial manager can incorporate decision tree analysis to evaluate the scenario, however actual problems in real life can be very different and in such cases instead of investing all capital upfront a more strategic investment plan might be the need.

Some of the examples of project flexibilities are (Brandao, Dyer, & Hahn, 2005),

- Expanding operations in response to affirmative response from the market
- Deferring a particular investment or abandoning it completely if it underperforms
- Scaling down the project in case the project has reached a maturity state and the returns have hit the cap.

As the uncertainty in various facets of long term and strategic investments increases Real options will find broad application as a strategic tool. Leslie and Michaels (Leslie & Michaels, 1997) discuss some of the fundamental differences that exist between the traditional discounted cash flow valuation (DCF) and the Real option valuation using Black Scholes & Merton options theory.

They argue that traditional methods like DCF ignore the value of flexibility and strategic decision making and hence they tend to ignore the additional value embedded in investment opportunities where the investment is irreversible and constitutes a huge cost to the company (Leslie & Michaels, 1997). Real option methodology empowers the management to capture the value of this flexibility (Alleman, 2002).

They discuss the case of a hypothetical oil company and take some hypothetical values of present value of cash flows and present value of investment required in an oil well to be made by the company such that the NPV is negative. Now in such a case ordinarily a project would get rejected, however they claim that while doing the DCF NPV analysis we ignore the value of the uncertainty in the project which would accrue to the project from uncertain future oil prices and uncertainty vis-à-vis the level of production of oil. Though we can incorporate a certain degree of variability in DCF methodology using Monte-Carlo and sensitivity analysis, however the timing of the investment decisions can't be controlled strategically in case of a DCF analysis. They argue that DCF valuation ignores the value of learning from the project which a Real option methodology would take into account. They also suggest that the value hidden in the form of learning and flexibility in terms of project execution would be of much more importance to financial and project managers working in capital intensive sectors. DCF methodology assumes that the capital investment decision is a one-time decision, however when a high amount of capital is involved such huge investment decisions are rarely taken in one go and rather they are strategic decisions and receive a continuous feedback from the limited execution of the project and market forces (Leslie & Michaels, 1997).

They also put forward a completely new and interesting facet to real options methodology by suggesting that apart from being a better methodology for strategic investment projects real options methodology also refines the management's thinking. They say that when a manager begins to think about a decision from an options perspective his thinking changes as the process of analyzing the options hidden in an investment is a very systematic one and instead of viewing uncertainty negatively a manager could look at the possible ways in which he could maximize his gains from the same.

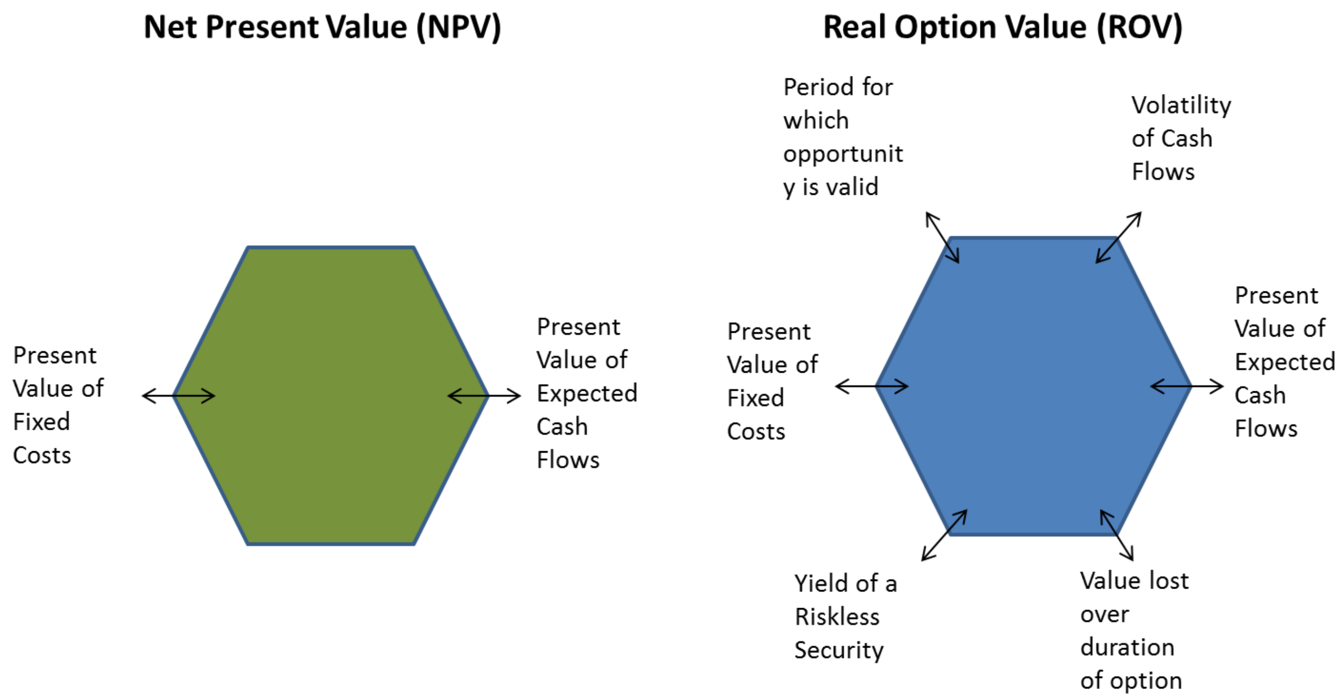

Figure 18 -- Differences between Net Present Value & Real Options Valuation Approach

(Leslie & Michaels, 1997)

Another literature (Kemma, 1993) attempts to gain insights into the Real Option valuation methodology by means of applying the theory to various practical case applications which were developed by the author (Angelien G.Z. Kemma) in collaboration with an Oil MNC. The major insights gained from the author's experience while working with the management and planning team of the Oil MNC are,

- Before applying the real option valuation methodology it is important for the management to realize that certain strategic financial decisions are better evaluated using Real Options theory rather that the traditional discount rate valuation. The management should not complicate the decision making by creating too many options as that would lead to complexity and more importantly options should not be thought of as investment alternatives. Before actually going ahead with the analysis it is important to realize the sources of volatility in the future cash flows and how to quantify it. Lastly competition and cash flows which could have been availed by early exercise should be factored in to calculate the value of the embedded options (Kemma, 1993).

- Discounted cash flow valuations and Real option valuation are not competitive and substitute techniques, rather both are complementary techniques as the inputs to the real option theory comes from the output of DCF valuation. DCF technique is more suited when the investment decision is under passive management and risk associated with different projects could be appropriately quantified using different discount rates (Kemma, 1993).
- The benefit of the real options technique to management could be bifurcated into two parts. First is that it leads to a better and more structured approach while the second is the ease with which flexibilities in the decision making could be modeled (Kemma, 1993).
- Though real options methodology has many advantages, the major disadvantage that this technique suffers from is that of quantifying the underlying volatility which is an important input to the model. For this very reason real options methodology has find its application mainly in fields where the accrued cash flow is a function of the price of a natural resource (Kemma, 1993). Prices of natural resources are quoted and their volatility could be found with much more ease.

Though it is comparatively easier to apply real options methodology to problems where cash flows are related to the prices of the natural resources, it doesn’t diminish the capacity of the Real Options methodology to be applied to different areas under different circumstances. Real Options methodology has find its way in projects related to irreversible decisions under uncertainty in the field of IT (Benaroch & Kauffman, 1999).

Michael Benaroch and Robert J. Kauffman (Benaroch & Kauffman, 1999) posits that the literature on the application of real options pricing models like Black-Scholes option pricing model and Binomial pricing model though provide useful insights from a strategic point of view in irreversible decisions under uncertainty, they are often based on cases which are hypothetical. In this paper the important contribution to the field of real option pricing are that it provides a theoretical background and explanation for the rationality of BS and Binomial model in the subject of Information Technology Investments.

Secondly, they argue that much like the traditional DCF techniques, the real option technique by virtue of its assumptions place a limit to the spectrum of problems of IT investments that could be analyzed using real options and lastly the paper demonstrates the application of real option techniques to a real life problem. The investment decision that they analyze is the timing decision of the deployment of Point of Sale Debit Services by a company (Benaroch & Kauffman, 1999).

Though real options do provide some very useful insights into an irreversible decision under uncertainty in an Information Technology setting, the professionals who evaluate these decisions are typically ill equipped to use real option pricing techniques. They are acquainted to DCF NPV techniques or simple cost benefit analysis. However, the underlying logic of using option pricing where one can time the decision regarding scaling of the project, deferring the project or even abandoning it depending on the learning from the project could of immense relevance to these professionals (Benaroch & Kauffman, 1999).

A particular relevance of this paper was that it showed how real options pricing technique could be used in evaluating capital decisions involving non traded information technology assets. This is particularly important as capital budgeting decisions analyze the assets as though they were being traded, which makes sense also, as any organization is assigned a value by the market by way of market capitalization (Benaroch & Kauffman, 1999).

Another paper posits that the decisions in Information Technology are often characterized by high uncertainty and irreversible capital decisions. The uncertainty increases when there is a high degree of innovation in that particular sector. Some of the sources of uncertainties could be the emergence of an alternate and superior technology and the rate of adoption of the new technology thus affecting the timing of the payoffs (Fichman, 2004).

The value of the option increases the motivation of the early adopters of the technology and financial experts in the field of real options see Information Technology as a likely sector where Real options methodology could be used to exploit the strategic value of IT investments (Fichman, 2004).

The problem which is attempted to solve with the help of the theory of real options is the timing decision of when a firm should innovate with an emerging technology and what could be its possible implications. Useful insights into managing, launching and valuing an innovative Information Technology platform are also provided. The real options that could be created in an IT investment are Pilot Projects, which if successful can lead to full-fledged development and deployment of a new technology (Fichman, 2004).

The theory of real option pricing has also found its application in the technology investments in the Automobile sector. Neely III and Neufville in their paper combine the decision making under the DCF analysis and real option analysis to evaluate a portfolio of technological improvements (Neely III & Neufville, 2001).

They posit that planners are risk managers and professionals who are in planning division should realize the potential of real options and exploit it to get better at their job of managing risk. The professionals who are in the planning division or the controllers in financial parlance should recognize the value of management control and the exercise of selections at critical junctures. For these professional real options is an effective tool to quantify this value (Neely III & Neufville, 2001).

The scope for the applications of real options theory is very wide. Till now we have seen how real options theory has been exploited by various researchers in multitude of areas ranging from oil exploration to information technology.

We will now discuss some of the really diverse applications. Real options theory has also been used to actively manage risk in research and development setting. (Herath & Bremser, 2005)

Research and Development investments resemble financial option properties in many ways. The initial investment in an R&D project is high and capital intensive with no immediate cash flows, long time to maturity (longer time horizon projects), multiple sources of uncertainty and hence the volatility which affects the option value (Herath & Bremser, 2005).

In their paper Chang, Hung & Tsai provide a new approach to valuate Intellectual property. (Chang, Hung, & Tsai, 2005). They incorporate a sensitivity variable so that they can account for the volatility in the rate of return. So in addition to the scenario where the rate of return is kept constant they add a scenario where it can go up with certain volatility. The value addition that they provide in addition to the previous research on the similar topic is that they show that the volatility of the future cash flows motivate the firms to invest now than later.

Till this point most the literature that has been discussed is relevant from the point of view of methodology and usefulness of real options technique. We haven't so far discussed the application of real options technique in the domain of telecommunications in general and more specifically we haven't discussed the application of real options in valuing a 3G license.

Mkhize & Moja in their research discuss the application of real options valuation technique in the cellular telecommunications industry in South Africa (Mkhize & Moja, 2009). They discuss about the evaluation of investment that managers in the telecommunication industry of South Africa might have to make in the next generation technologies.

Investment in the next generation technology incorporates a fair degree of uncertainty and real options theory using Black Scholes method and Binomial models have been found effective while making capital budgeting decisions (Mkhize & Moja, 2009).

Cellular operators are often required to take complex decisions regarding whether to deploy a new technology or keep using the existing one. The sources of volatility while doing capital budgeting decision analysis are the volatile demand of the customer, high initial expenditure and a threat of a new and a better technology.

They calculate the total investment value of the new project as the sum of the passive Net present value (which is the base case discounted cash flow analysis) plus the option value which arises from various strategic opportunities that managers might encounter during the course of the project. They conclude that the value of the project is much more than that calculated using a traditional DCF as a premium was added to it in the form of option value.

Another application of real options valuation technique is explained by Basili & Fontini in their valuation of the 3G license in the United Kingdom(Basili & Fontini, 2003). They calculated the aggregate option value of the 3G licenses which were auctioned in UK in the year 2000.

Telecommunications industry is considered to be one of the central bones of the economy and the application of auction to allocate 3G airwaves to various bidders is considered to be one of the most effective economic paradigms of a real life problem (Basili & Fontini, 2003).

The revenues which were generated in the auction exceeded the government's initial estimate by a far greater amount. Though the government received a windfall in the auction process the operators were tied down under huge debt burden and within 2 years after the auctions European telecommunication firms started doubting the ability of an auction to maximize the total surplus and not just the government's surplus. The stocks of the firms which had bid for the license performed badly after the auctions which led analysts to believe that the market is discounting the future earnings of these firms at a higher discount rate because of the perceived risk because of heavy debt burden (Basili & Fontini, 2003).

The option value of the license is calculated in the article and it has been shown that the value of the project roughly corresponds to the value of the fees extracted from the bidders (Basili & Fontini, 2003).

It is widely believed that the telecommunication firms in the Europe lost a lot market value because of the perceived high price paid for the 3G spectrum, nonetheless, a real option valuation shows that the value extracted from the project is approximately equal to the value paid for the licenses.

The loss in value of the telecom firms could not be explained on the basis of the high prices paid for the license, instead the authors brings in the discussion of a very crucial aspect of the 3G technology which is the killer applicationthat is required to get the users hooked to your network and hence resulting in a higher ARPU. In the absence of such applications and difficulties regarding the handset (Access Device) and the general downward trend in the Economic scenario were given as the probably reasons for the loss in value. They also mentioned that over a long term such as 20 years which is also the term of the license such effects might not remain that relevant and eventually the technology might take off (Basili & Fontini, 2003). Logically too, these possibilities are taken care of by the real options methodology inherently because of the incorporation of the volatility of the future cash flows as an input in the valuation model and hence the added value.

Another recent literature in this field tries to evaluate the value of the transferability value of the telecommunication license. The driver behind such kind of research is the fact that in most of the nation when government allots a telecommunication license it also stipulates that the license could not be transferred to another telecom operators. Stipulation like the one mentioned above might cause inconvenience to the customers and hence removal of the option is the best solution in such cases. When removal is considered there is an added value to the original license and hence an option is embedded in the original license which should be valued to arrive at the final price of the license (Mastroeni & Naldi, 2010).

In most of the countries when the government assigns the telecommunication licenses to various firm, they also set out certain time bound conditions like rollout etc. In case a company is not able to achieve its target within the stipulated time, the government might reassign the spectrum but that would take a lot of time and resources. If the government allows reselling of the spectrum the bidders would look at this as an embedded option in the license which gives them an option to exit the project in case it doesn't suit their operations.This also will increase the value of the license at the time of the auction (Mastroeni & Naldi, 2010).

In their paper Stille, Limme and Brandao analyze the real option methodology in the Decision making process in the Telecommunication Industry. They study the 3G license auctions which allocated 3G spectrums to various operators who wish to operate 3G mobile services in Brazil (Stille, Lemme, & Brandao, 2010). They had calculated 64% premium on the license when the value of the license was calculated using Real options methodology as compared to discounted cash flow methodology. Their results show that real options methodology can be used by telecom operators in other countries to find the worth of the investment in 3G license before actually investing in it.

The degree of similarity that they brought forward between a license and auction so as to justify their methodology of following real options valuation is (Stille, Lemme, & Brandao, 2010),

- There are a large number of factors which make the investment in the rollout of the mobile services a strategic investment which needs to be managed actively as against a passive investment. This gives rise to a volatility which is adequately taken into consideration in a Real options methodology.
- The acquisition of the license gives the operator the right and not the obligation to invest in the rollout of 3G services. The operator can decide to invest at a small scale and then based on the market expectations and expected future demand it may decide to scale up its investment. In short timing of the decision to undertake an irreversible financial decision is very important.
- The third characteristic of the license that increases its option value and thus justifying the use of real options methodology is that the license represents a strong barrier to entry from the competition and hence increases the value of the option.

The methodology that they follow is a pretty straightforward one. The follow the following sequence (Stille, Lemme, & Brandao, 2010),

- Calculate the static NPV of the asset which in this case is license. NPV is calculated using expected level of cash flows generated from the license and the WACC.
- In the next step they calculated the volatility of the returns of the project.
- Once they had the volatility they proceeded to the option valuation step.

So far we have discussed the advantages of real option valuation methodology versus the discounted cash flow valuation methodology; we then discussed some of the relevant literature exploiting the importance of real option valuation methodology.

Though real options have wide applications across various Capital investment decision situations practitioners do get bogged down by the higher mathematics involved in the real options valuation theory. A simple framework which could be applied to various practical situations and is backward compatible with the Discounted Cash Flow valuation method and valuation sheets is provided by Luehrman in an article in *Harvard Business Review*(Luehrman, 1998).

Though the framework is not that effective when the analysis requires absolute precision however it gives a good starting point to analyze strategic decision making under uncertainty. On top of giving a good head start the valuation and insights that the framework provides are definitely better than the base case DCF analysis. Luehrman draws an analogy between an investment opportunity before a company to a call option as the organization has a right to invest but is not under the obligation to do so. Luehrman considers the case of a European Call Option and then he tries to map the parameters of the investment opportunity over the parameters of the European Call Option (Luehrman, 1998). The mapping is displayed in the graphic below.

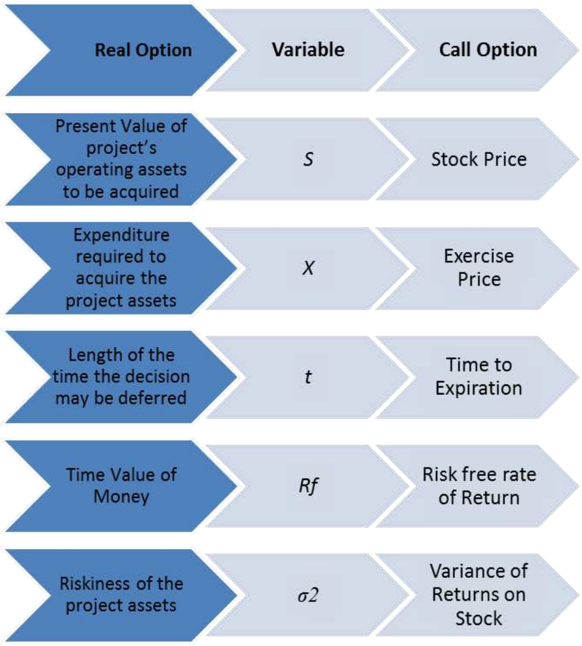

Figure 19 – Analogies between a Real Option and a Financial Call Option

(Luehrman, 1998)

4 Methodology

This research attempts to find the aggregate value of the 3G spectrum licenses which were auctioned last year. To calculate the value of the 3G license it has been considered as a project and then we have tried to calculate the aggregate value of the project for which the methodology has been explained below,

- A discounted cash flow analysis has been done on the expected earnings (cash-flows) which would result from the deployment of the 3G technology. The DCF analysis serves as the base case for our real option valuation purpose and some of the outputs which would be generated in the process of doing DCF would be used to calculate the option value of the project. The projections and assumptions used for estimating the future earnings/cash-flows are explained in the chapter.
- Sensitivity analysis done on the NPV obtained from the DCF model to see the risk associated with the project.
- Real option valuation is the last step in the valuation process to calculate the value of the option. Options associated with the project are identified and then Real Option valuation model is used to find the value of the option. The model which is used is explained in a further section.

4.1 Discounted Cash Flow Valuation

Under the purview of discounted cash flow valuation following two methods are used,

- *Net Present Value Method*. Under NPV method net present value of the company is calculated by discounting the cash flows from a project at a risk adjusted rate of return. NPV is the difference of the present value of cash inflows from the project and the present value of the investment overlay that will go into the project.

$$NPV = \sum_{n=0}^{n=T} \frac{C_n}{(1+R)^n}$$

Where,

T – Useful life of the project

R – Risk adjusted discount rate of the project

C_n – Net Cash flow in period 'n' inclusive of investment outlays

The above equation could be re-written as,

$$NPV = S - K$$

Where,

S – Net present value of the cash inflows from the project

K – Net present value of the investment overlay for the project

The decision criterion for NPV method is,

$$NPV > 0$$

- *Internal Rate of Return*. Internal rate of return is the discount rate at which NPV of the project becomes zero. It is the rate of return generated by the project. Though there are some loopholes associated with the IRR method, we would restrict ourselves to the basics of IRR. The equation for IRR is,

$$\sum_{n=0}^{n=T} \frac{C_n}{(1+I)^n} = 0$$

Where,

T – Useful life of the project

C_n – Net Cash flow in period 'n' inclusive of investment outlays

I – Discount Rate (Internal Rate of Return)

The decision criterion for Internal Rate of Return rule is,

$$I > R$$

Where,

I – IRR

R – Risk adjusted rate of return required from the project

Though we discussed the disadvantages of the DCF valuation in the previous section, just to reiterate, the main disadvantage of using NPV method is aptly highlighted by (Brandao, Dyer, & Hahn, 2005) contending that NPV method doesn't take into consideration managerial flexibility and hence strategies like "wait and see" and "pilot project" can't be taken into account while valuing the project.

Since DCF valuation will serve as a base case scenario we will first try to calculate the NPV and IRR of the project before doing a real option valuation.

4.2 Real Option Valuation

We will now discuss the model that we will use to calculate the value of the real option. For calculating the value we will use the Black-Scholes model (Damodaran, 2000),

$$ROV = S.e^{-qt}.N(d_1) - K.e^{-r_f t}.N(d_2)$$

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

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

Where,

Parameter	In context of Real Option	In context of Financial Option

S	Present Value of cash flows expected from the project	Stock Price
Q	Oppurtunity Cost of not Expanding (Explained Below)	Dividend Yield
T	Expected Competitive Advantage Period/Rights for Expansion	Time to Expiration
$\mathbf{r_f}$	Risk free rate of return on 10 year GOI bond	Risk free rate of return
K	Present Value of Capital Costs	Strike Price
σ	Volatility of Project Value	Volatility of Return on Stock

$N(d_1)$ & $N(d_2)$ are normal cumulative distributions which gives us the range of the likelihood of the real option being viable before expiration date.

In the context of current project the real option is the option to expand and upgrade their 2G systems for the incumbent operators or to expand in a new project for standalone 3G players. Basili & Fontini (Basili & Fontini, 2003) mentioned in their paper on the real option valuation of 3G license that implementation of technologies like 3G /UMTS are considered as segmental process where in the operator has the flexibility to launch new services in a sequential and discrete manner. Operator also has the flexibility to start off the rollout by a pilot project and then scale up the project according to the need and market response.

The inputs used in the above model are explained below,

1. S – Present value of cash flows is calculated from the assumptions explained in the previous section and the output from DCF model is used as input in this model.
2. K – Present value of capital expenditure required to rollout 3G services. This value is also explained in the previous section.
3. q – Oppurtunity cost of waiting and not rolling out 3G services. Though we have calculated the cash flows for each year, however it is difficult to predict the exact pattern of cash flows which would be lost by waiting to roll out 3G services. To overcome this problem we have assumed a dividend yield of 5%. Since useful life of the project is 20 years, 5% of the value of the present value of cash flows could be considered as the dividend payments which we would not receive in case we don't rollout 3G services immediately. The other cost of waiting is the loss of market to competition which once lost is difficult to recapture.

4. t – This is the time period over which the option should be exercised lest the telecom operators will lose competitive edge. On top of that TRAI has set certain rollout obligations which involve covering 90% of the metro areas and 50% of DHQs within 5 years of allotment of 3G license which effectively translates the expansion of 3G services by a company as a series of call options. However we are taking an approximation here that the telecom operators need to rollout the 3G services within 5 years.

5. r_f – Risk free rate on 10 year GOI. The yield on 10 year GOI bond is 7.94% in March[32].

6. σ – Volatility of project is difficult to estimate and theoretically a Monte-Carlo analysis needs to be done with all relevant probability distributions of the input variables. Since we don't have the relevant probability distribution we have used annualized standard deviation of returns of Bombay Stock Exchange Technology, Media and Telecom Index (BSE TECK) as a proxy which is equal to ~27.5%.

5 Data & Assumptions

The data for the purpose of valuation has been taken from public sources and sector reports.Data has also been estimated for some of the years by taking assumptions. We will now discuss various data points and assumptions.

5.1 Population& Population Growth Rate

India's population was 1.15 Bn in 2009[33] and population growth has been declining from 1.7% in 2000 to 1.3% in 2009[34]. We have safely assumed a population growth rate of 1.5% for the next 20 years over the base of 2009 population. The growth rate assumption is also justified by the planning commission's working paper which projects India's population growth from 1.51% to 1.39%[35].

[32]http://www.tradingeconomics.com/Economics/Government-Bond-Yield.aspx?Symbol=INR, accessed on 10-03-2011

[33]http://www.google.com/publicdata, accessed, on 10-03-2011

[34]http://www.google.com/publicdata, accessed on 10-03-2011

[35]planningcommission.nic.in/reports/wrkpapers/wp_hwpaper.pdf, accessed on 10-03-2011

5.2 Wireless Subscribers & Wireless Teledensity

Gartner projects India's mobile subscribers to cross 993 Million by the end of 2014[36]. According to TRAI, India's current subscriber base was 584 Million in 2010. Based on these two numbers a constant cumulative growth rate was assumed till end of 2014. India's Teledensity would reach 78% by the end of 2014.Since Teledensity can't go on increasing indefinitely as penetration in metros is Category "A" circles have reached above 100% or sub 100% level. Penetration in rural areas has increased at a rather slow pace because of unprofitable business case. Hence an assumption of 90% Teledensity has been taken by the end of 2020 which has been kept constant thereafter. Since as per Gartner's projections growth of wireless subscribers will be around ~11% in the next 4-5 years. A growth of 4%, which will take India's Teledensity to 90% by the end of 2020, thereafter is not a very optimistic assumption. Moreover this assumption doesn't hurt our calculations and has been shown to give a perspective on wireless growth.

5.3 3G penetration

The projections for 3G penetration till the end of 2015 are taken from PWC's report titled "Mobile Broadband: Outlook 2015". Though India is a favorable market as far as wireless services are concerned, India's 3G penetration has been projected to remain low during the initial years. Only the early adopters will be adopting it. Issues like availability of handsets, 3G coverage and rollout needs to be sorted out before a growth can be realized. As per PWC, India's 3G Teledensity has been assumed to be (PricewaterhouseCoopers India, 2010),

2010	2011	2012	2013	2014	2015
0.01%	0.1%	0.8%	2.1%	4.7%	8.3%

Figures are as of year end

Post 2015, India's 3G penetrations is expected to rise rapidly as network and rollout issues would be sorted out and more affordable handsets would be available. A growth rate of 50% has been assumed from 2016 to 2021 such that the 3G Teledensity should reach 60% in 10 years. The This growth rate doesn't look unreasonable given a worldwide developed markets 3G subscribers' growth rate of 41% year on year (Morgan Stanley, 2010). A comparative study on the penetration of 3G in other countries is presented in the following two graphics. The graphics further adds credence to the assumed growth rate of 3G subscribes.

[36]http://www.businessworld.in/bw/2010_07_15_Gartner_Sees_Mobile_Users_At_993_Mn_In_2014.html, accessed on 10-03-2011

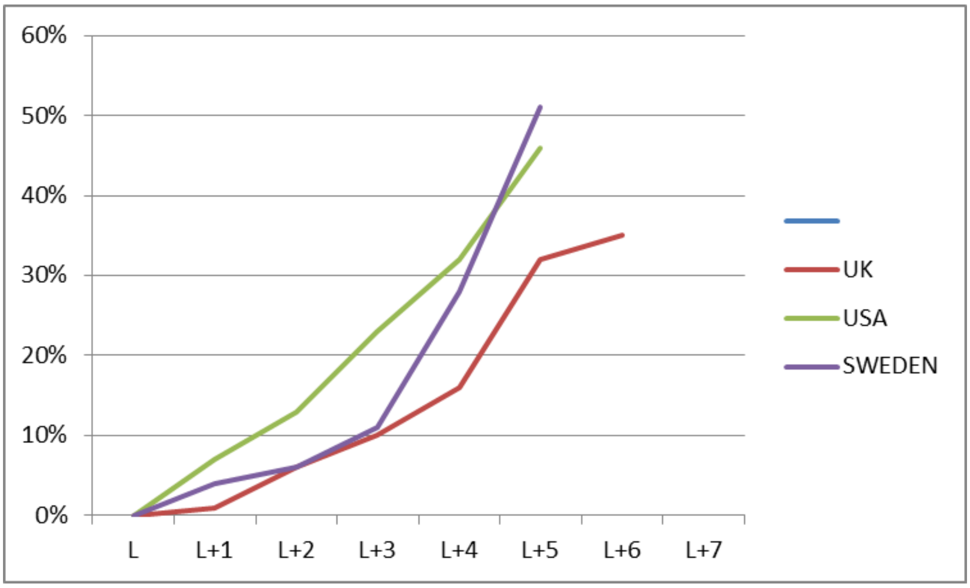

Figure 20 – Rise in 3G Penetration in Developed Countries

L represents the year of launch

Source: ICRA(ICRA Limited, 2009)

3G Penetration in Developed Markets								
	2007	2008	2009E	2010E	2011E	2012E	2013E	2014E
Western Europe	79,617	126,724	205,962	299,220	381,422	448,691	499,686	549,615
3G Penetration	*17%*	*25%*	*39%*	*54%*	*67%*	*77%*	*85%*	*92%*
Japan	72,690	88,434	101,320	110,823	116,581	120,463	123,217	124,770
3G Penetration	*72%*	*84%*	*91%*	*96%*	*98%*	*99%*	*99%*	*100%*
Asia / Pacific (ex. Japan)	50,163	83,514	151,192	295,230	482,981	693,995	918,063	1,135,626
3G Penetration	*4%*	*5%*	*7%*	*13%*	*19%*	*25%*	*31%*	*37%*
North America	53,307	83,460	116,575	145,683	177,451	204,835	231,271	260,575
3G Penetration	*20%*	*29%*	*38%*	*46%*	*54%*	*61%*	*67%*	*74%*
Eastern Europe	8,785	19,918	40,944	72,321	120,291	139,960	166,288	199,977
3G Penetration	*2%*	*5%*	*9%*	*16%*	*26%*	*29%*	*34%*	*40%*
Middle East & Africa	5,781	18,424	50,409	91,085	165,564	239,805	309,251	383,238
3G Penetration	*1%*	*3%*	*7%*	*12%*	*19%*	*25%*	*30%*	*35%*
South & Central America	3,126	9,265	21,875	40,448	59,107	80,087	100,027	122,258
3G Penetration	*1%*	*2%*	*4%*	*7%*	*10%*	*12%*	*15%*	*17%*
Total	273,469	429,739	688,278	1,054,810	1,503,397	1,927,837	2,347,804	2,776,058
3G Penetration	*8%*	*11%*	*15%*	*21%*	*27%*	*33%*	*38%*	*43%*

Figure 21 – 3G Penetration in Developed Markets

Morgan Stanley(Morgan Stanley, 2010)

From the beginning of 2021 and till the end of 2030 we have assumed a zero growth of 3G subscribers. This assumption is a bit naïve; however it is difficult to predict about the technology after 10 years from now and moreover assumption is much more plausible than assuming a continued growth in the second decade of the 3G license. Parallels could be drawn between the growth path assumed for 3G and the growth that we have seen in the 2G technology. The graphic below displays the growth path of India's Urban and Rural Teledensity over the last decade.

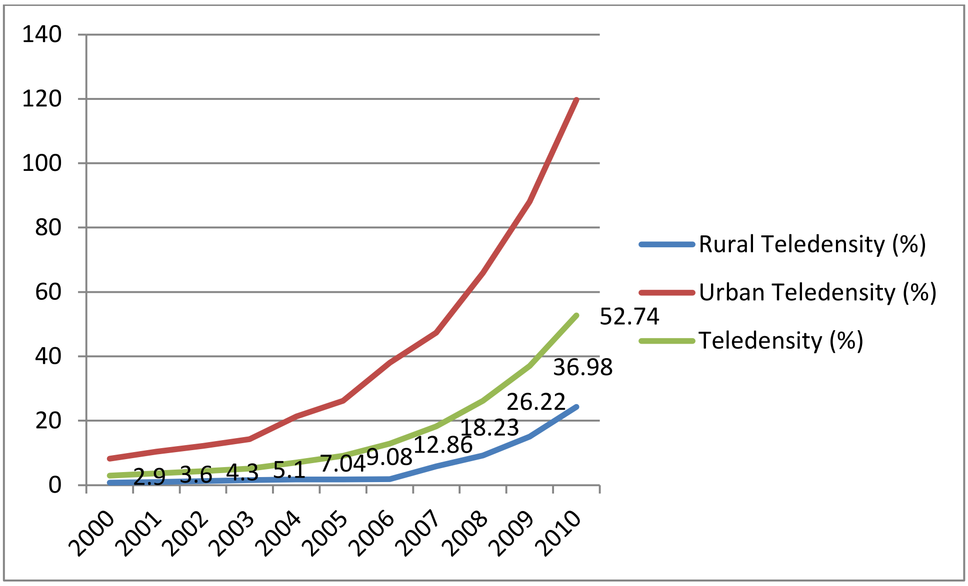

Figure 22 – Teledensity in India (Urban Vs. Rural)

Source: TRAI

Growth in the urban areas really picked up in 2003 when Reliance entered the industry and with it came down the ownership price of the mobile. A series of factors including policy changes by government and entry of new players, innovative pricing schemes and handset subsidies propelled India's Teledensity to around ~60% by the end of 2010 from 4.3% in 2003.

5.4 Revenue Projections

To calculate future revenues and cash-flows it becomes important for us to look at the drivers of the revenue. In telecommunication industry the important metrics which are looked at are the number of subscribers and the average revenue per user (***ARPU***).

$$Revenue = ARPU \times Number\ of\ Subscribers$$

If we further bifurcate this formula into number of mobile subscribers and number of broadband subscribers and then further bifurcate the number of mobile subscribers into number of prepaid subscribers and number of postpaid subscribers then we get the following equation,

$$Revenue = ARPU_{Broadband} \times Subs_{Broadband} + ARPU_{Prepaid} \times Subs_{Prepaid} + ARPU_{Postpaid} \times Subs_{Postpaid}$$

Now we have six variables to forecast on the basis of above equation. We will look into them one by one.

5.5 3G Mobile-Broadband Subscribers Ratio

To project the ratio of the number of mobile[37] and broadband subscribers'[38] two main inputs have been taken which are as follows,

1. **Technological Constraint** –Voice and Data Capacity of a 3G site shall play a key role in determining the capacity of a Base site and hence the number of subscribers for broadband and mobile services. 3G deployment is anticipated to be voice focused because of reasons like shortage of spectrum for voice subscribers and limited data availability even if a bandwidth of 256 Kbps is considered per subscriber with an assumed contention ratio of 1:10. There has been a crunch of spectrum in some of the circles where the operators are using the spectrum for 2.5 G technologies to be used for voice subscribers and hence voice centric deployment could be the focus of the telecom companies in the initial years. Operators might transfer their premium subscribers to 3G networks with better capacity in order to deliver an enhanced user experience and acknowledge the loyalty of their premium subscribers especially with Mobile Number Portability in the offing for the subscribers. Following graphic compares 2G and 3G base sites. The data has been taken from a report by a joint report prepared by FICCI and consulting firm BDA (BDA Connect & FICCI, 2009).

[37] Mobile Subscriber has been considered as a subscriber who will be using a Mobile Phone to access 3G network.

[38] Broadband Subscribers has been considered as a subscriber who will be using a data card or a USB modem to access 3G network

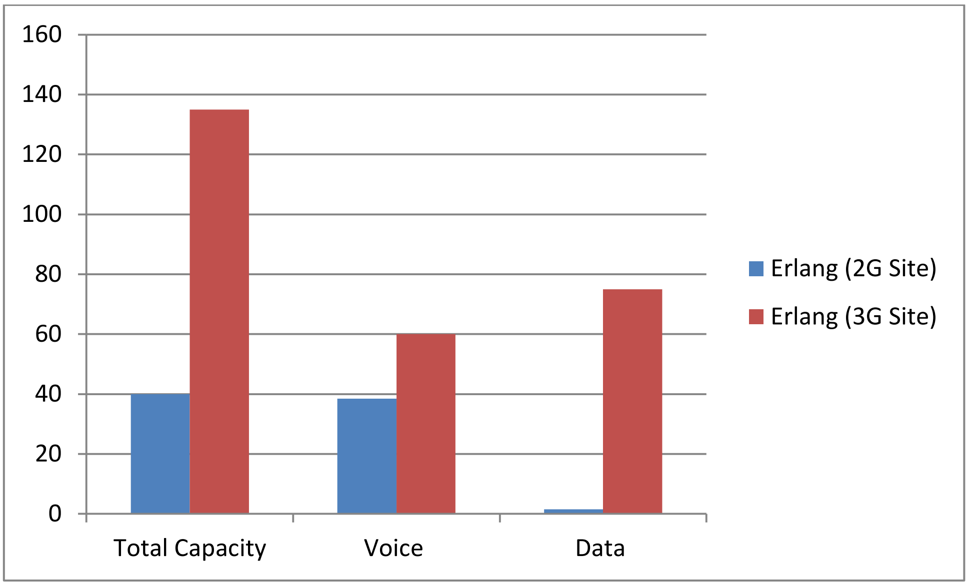

Figure 23 – Comparison of Capacity of 3G Vs. 2G Base Sites

Source: BDA (BDA Connect & FICCI, 2009)

Total 2G Site Capacity - 40 Erlang
Voice usage for 1100 Subscribers @ 0.035 Erlang per Subscriber

Total 3G Site Capacity - 135 Erlang[39]
Voice usage for 1100 Subscribers @ 0.055 Erlang per Subscriber
250 Data Users @ 256 Kbps (Assumed Contention Ratio 1:10)

Figure 24 – Capacity of 2G & 3G Base Sites

Source: BDA(BDA Connect & FICCI, 2009)

250 users for data and 1100 subscribers for voice give us an approximate base case ratio of broadband and total 3G subscribers to be around ~18.5%.

2. **Projections made by BDA & FICCI** – The projections made by BDA & FICCI (BDA Connect & FICCI, 2009) are represented in the graphic below. While preparing the report BDA had assumed that the license shall be allocated to operators by mid of 2009, however licenses were allocated to operators only by Sep'2010. Hence we can shift the projections given in the graph below by 1 year. If we look at the number of modem broadband subscribers as percentage to total 3G subscribers it comes around to be an average value of 24%.

[39] Erlang is a unit which measures the capacity of a wireless channel and is used commonly in Wireless industry parlance

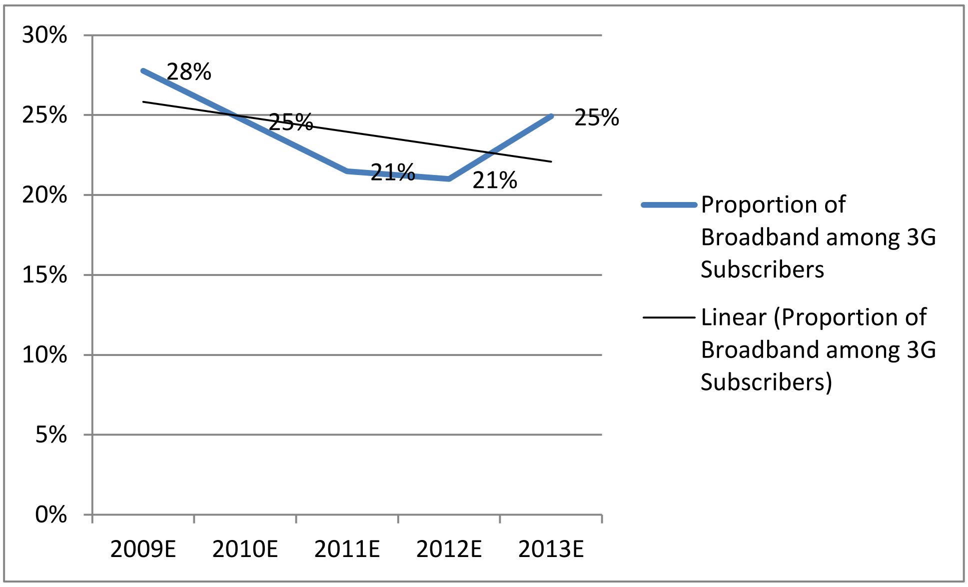

Figure 25 – Proportion of Broadband among 3G Subscribers (Projections)

Source: BDA(BDA Connect & FICCI, 2009)

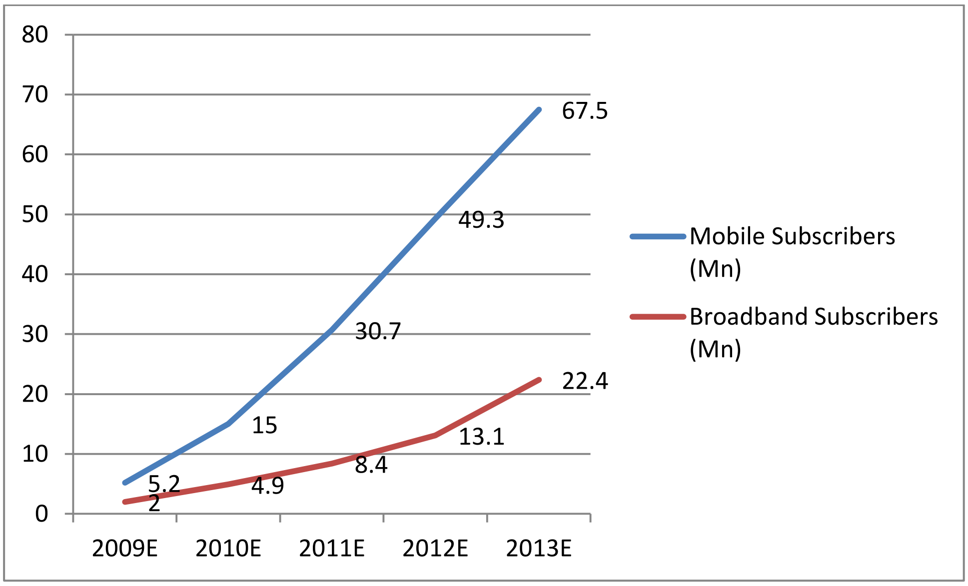

Figure 26 – Split of 3G Subscribers

Source: BDA (BDA Connect & FICCI, 2009)

As a base case an assumed penetration of 20% for broadband subscribers among the total 3G subscribers is taken and which has been kept constant throughout. The percentage is not optimistic by any means as ARPU of broadband subscriber would be higher than the ARPU of mobile subscriber and is also in line with the technological constraint.A sensitivity analysis has been done on this value after the DCF valuation to show its effect on the DCF.

5.6 3G Prepaid-Postpaid Split (Mobile Services)

As far 2G is concerned India is a heavily skewed telecom market as far as prepaid and postpaid mobile subscribers are concerned. The graphic below shows the postpaid and prepaid subscriber growth and proportion of Postpaid Subscribers in the total wireless subscribers.

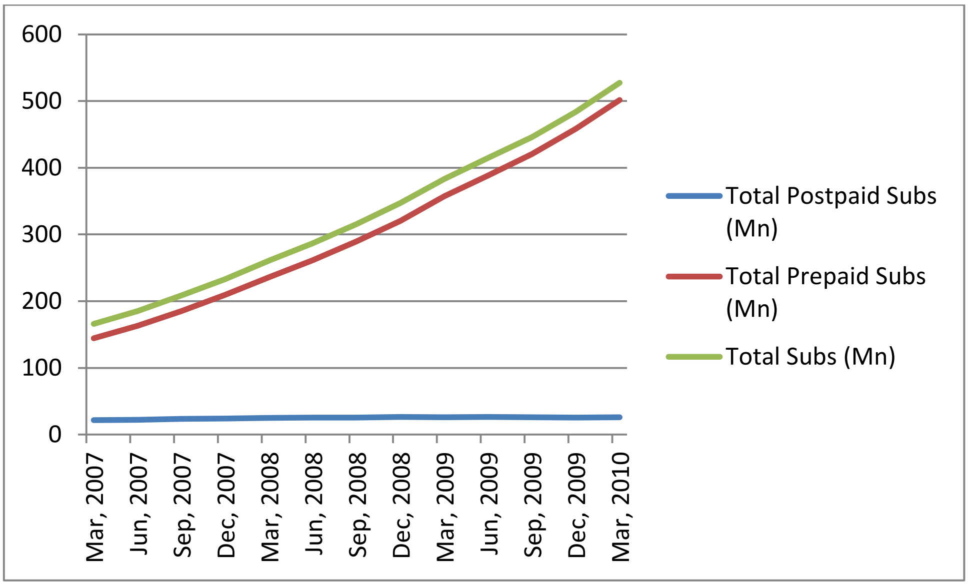

Figure 27 – Number of Postpaid & Prepaid Subscribers in India

Source: CMIE Database (TRAI)

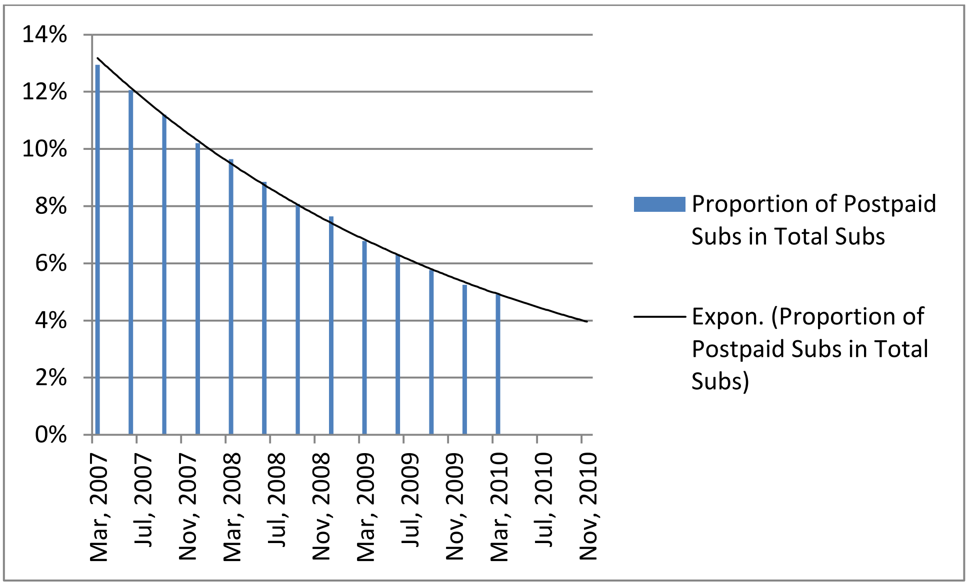

Figure 28 – Proportion of Postpaid Subscribers among Total Mobile Subscribers in India

Source: CMIA Database (TRAI)

Proportion of postpaid subscribers has been around 5% since the last couple years and as can be seen from the exponential trend line it will go down but should stabilize around 4% to 5%. PWC projects the following split between prepaid and postpaid subscribers,

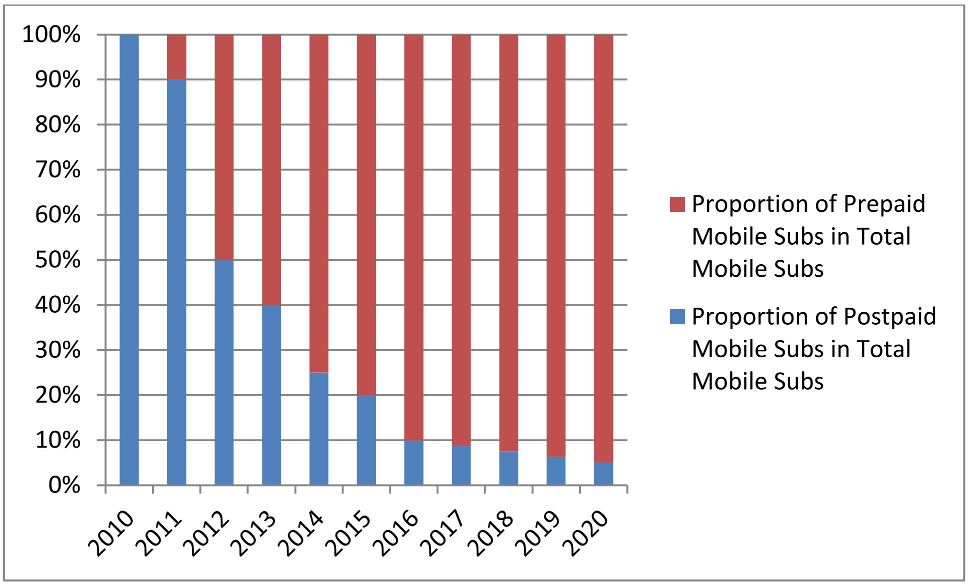

Figure 29 – Projections for proportion of prepaid and postpaid subscribers among total mobile subscribers

Source: PWC (PricewaterhouseCoopers India, 2010)

PWC in its report has provided the projections from the end of 2011 to end of 2015 (PricewaterhouseCoopers India, 2010). We have extrapolated those projections on both sides to assume that at the end of 2010 100% of 3G mobile subscribers would postpaid subscribers and by the end of 2016 only 10% of the 3G subscribers would be postpaid and by the end of 2020 only 5% of the 3G mobile subscribers are assumed to be postpaid. The assumptions are in line with the trend observed in the 2G technology. The propensity of the telecom operators to switch their premium mobile subscribers (Postpaid Subscribers) to 3G technology and start the rollout of the 3G technology in the Metro and Category 'A' circles adds credence to the above assumption.

5.7 2G ARPU Projections

2G ARPU in India has fallen at a rate of -24% CAGR in the last 3 years since 2007. Since we have bifurcated ARPU into prepaid ARPU and postpaid ARPU we will consider them independently. In the same period of 3 years prepaid ARPU has fallen by ~-23.7% CAGR and postpaid ARPU has fallen by ~-5.5%. A graphical representation of the fall in the ARPUs is given in the following figure.

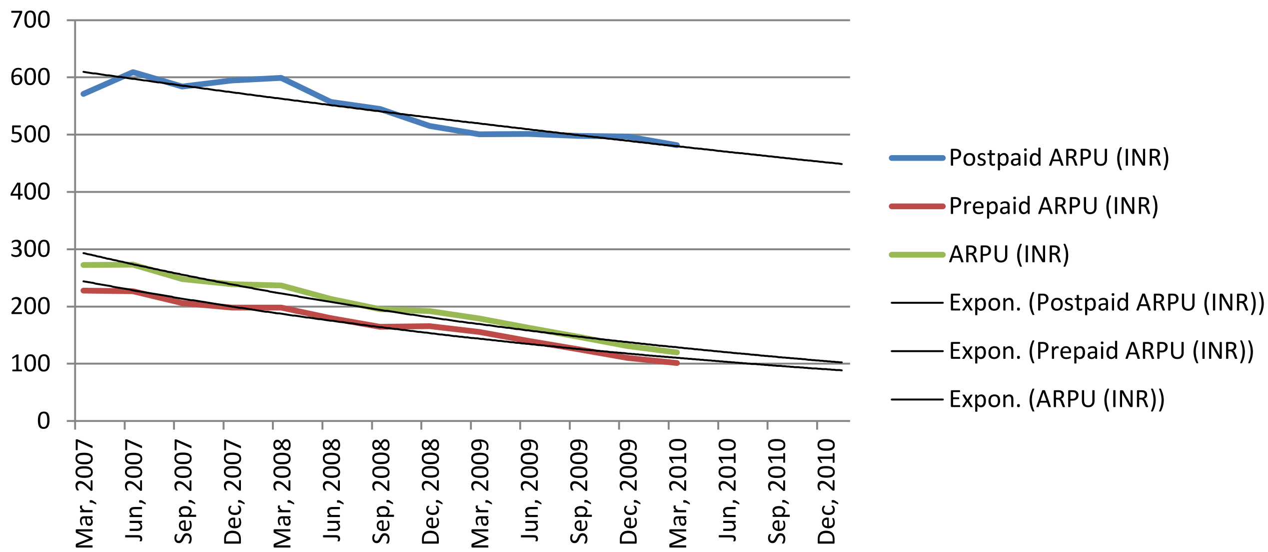

Figure 30 – 2G Prepaid & Postpaid ARPU in India

Source: CMIE Database (TRAI)

In the figure above the trend lines for ARPUs indicate that ARPU will go down further. A similar assumption with some modification has been used here such that Postpaid ARPU will decrease by -5% during the year 2010 based on the historical CAGR and Prepaid ARPU will decrease by -20% during the year 2010 based on the historical CAGR. The rate of decline of ARPU is going to decrease in future as the industry is facing hyper competition and there will be some consolidation in the near future thus stabilizing the fall in the 2G ARPU. The shape that has been assumed for the 2G ARPU in future is as follows,

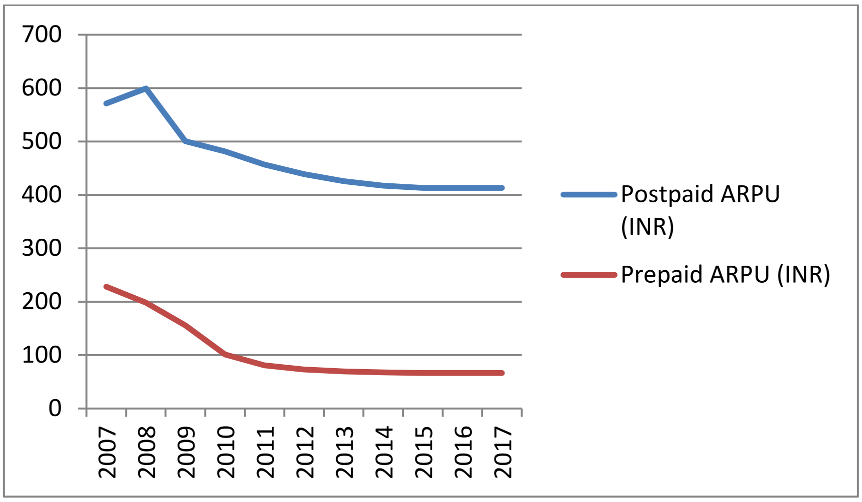

Figure 31 – Projections for 2G Prepaid & Postpaid ARPU in India

The assumption here is that 2G ARPUs will continue to fall till end of 2015 and after that ARPUs will stabilize. The argument of consolidation because of hyper-competition gains credence from the view of industry experts[40]. India's tariff is among the lowest in the world and on top of that operators entered into price war in the last few years and in the process dragged India's tariffs into an abyss. In order to win customers new operators cut their prices thus forcing the incumbent operators to cut their prices too in order to remain competitive[41]. For incumbent operators this becomes more important as their Quality of Service levels are expected to be low than the incumbent operators because their bandwidths are already running to full capacity and there is a spectrum shortage especially in Metro and Category 'A' circles. Nonetheless an assumption has been taken regarding the future shape of the 2G ARPU. A sensitivity analysis could be done later to see how NPV will be affected by a deviation of the expected 2G ARPU.

5.8 3G Mobile Handset ARPU

According to PWC a premium of 15-35% is expected on the 2G ARPU(PricewaterhouseCoopers India, 2010). Globally 3G ARPUs are more than 2G ARPUs because of increased use of VAS and other applications. In the telecom parlance a term "Killer Application" is used to describe an application which gets the user hooked on to the network and thus increase the revenues for the mobile operator. In Japan NTT DoCoMo

[40]http://articles.economictimes.indiatimes.com/2010-04-15/news/27619761_1_new-customers-sims-tariffs, accessed on 10-03-2011

[41]http://www.business-standard.com/india/news/indian-telecom-space-to-witness-consolidation-macquarie/13/55/75375 on, accessed on 10-03-2011

enjoyed a 58% premium on 2G ARPU from its 3G subscribers (ICRA Limited, 2009). As a base case we have taken 25% premium on 2G ARPU. We have kept it constant throughout the duration of the project as it is difficult to estimate the premium. Instead we will later do a sensitivity analysis to see how a variation from our base case assumption shall affect the NPV of the project.

5.9 Modem-Broadband ARPU

ARPU for mobile broadband ARPU is around INR 700[42]. Penetration of broadband is very low in India and so far the industry hasn't seen a price war in this segment and hence Mobile broadband ARPU is not expected to decrease in the near future. The report by BDA & FICC also considers a minor decline in 3G modem ARPU from 14.1 USD in 2009 to 13.3 USD by the end of 2013 which gives us a rate of -1.45% CAGR. They consider a 2009 rollout. We have used a -1.5% drop annually till the end of 2020 and then the ARPU is kept constant in the next decade.

5.10 Blended 3G ARPU

The blended ARPU as calculated from the above projections declines from INR 600 at the end of 2010 to INR 273 at the end of 2015 which is in line with the ARPU projections given by PWC. The decline in 3G ARPU will be because of two reasons,

a. Competitive Pressure will result in decline in tariffs.
b. Addition of low ARPU prepaid subscribers.

In environment of declining ARPU it becomes important for telecom operators to partner with application developers, content providers and device manufactures to give an enhanced user experience to customer to charge a premium on the 3G services.

5.11 Revenue Composition of 3G Mobile ARPU

In India data constitutes only ~9-10% of the mobile ARPU. The primary reason is lack of available bandwidth and devices which reduces customer satisfaction from these services. With the rollout of 3G the share of data in mobile ARPU should go up from the current ~11-12% to 25%(PricewaterhouseCoopers India, 2010). Though this doesn't harm our valuation but it is the base assumption by which public sources have predicted a 25% premium for 3G on 2G ARPU. A liner increase is considered between 2010 and 2015 such that data revenues

[42] http://www.bsnlevdo.in/bsnl-evdo-news/mts-to-offer-14-7-mbps-speeds-through-cdma-dongles, accessed on 10-03-2011

from mobile services shall reach 24% by the end of 2015 and it has been kept at 25% for the rest of the life of the license/project. The assumption seems consistent when compared with the trend that proportion of data revenue of the total service revenue has seen by other operators in other countries.

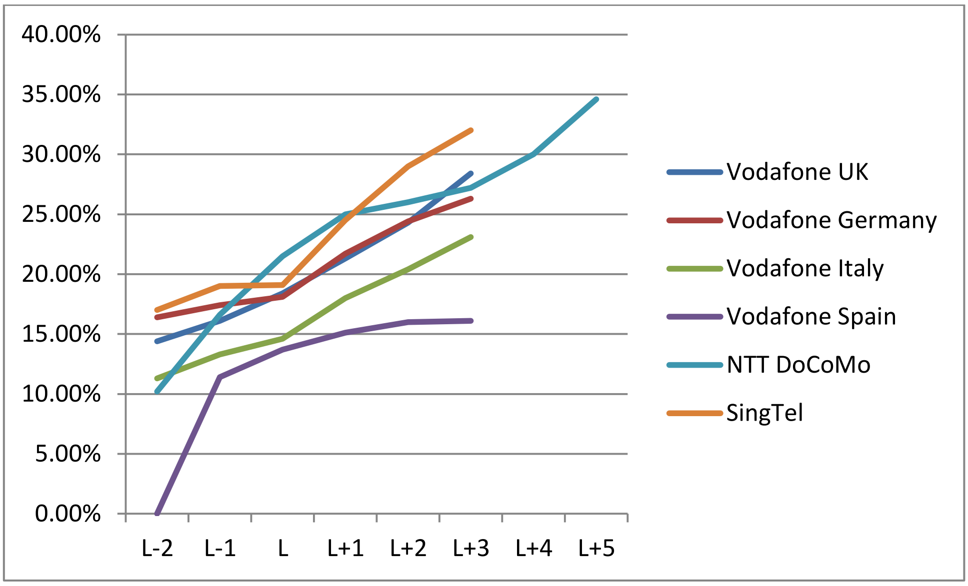

Figure 32 – Premium of 3G over 2G for some of the operators in Developed Nations

Source: ICRA (ICRA Limited, 2009)

5.12 Operator's share in Data ARPU

The value chain of broadband and data which is provided over mobile handset typically has 4 players,

1. Device Provider – This is the manufacturer of the mobile phone and other access devices.
2. Application Provider – These are the software vendors, game and application developers.
3. Content Provider – They provide the content which the application uses.
4. Channel Provider – This is the telecom operator which facilitates and provides channel or bandwidth.

To put this into context we'll take the example of XYZ mobile company which is giving a "Bloomberg Live Market Update Software" bundled with its phone. In this case,

1. Device provider is the XYZ mobile company.
2. Bloomberg is the content provider.

3. Application developer is the software vendor which has given license to XYZ mobile company to bundle the software with its phone.
4. Channel Provider is the telecom operator which provides the required bandwidth.

Currently the share of data revenue is heavily skewed towards the telecom operators because of the limited uptake of data services in India for reasons mentioned before. Operator's share of the total data service revenue is expected to go down from the current 70-75% to 63-67% by the end of 2015 (PricewaterhouseCoopers India, 2010). This is bound to happen as when data services will uptake in the country supported by 3G rollout. We have considered a decline from 72.5% to 65% from end of 2010 to end of 2015 respectively and from 2016 to 2030 we have kept it constant at 65%.

5.13 Capital Expenditure

Capital expenditure is Indian telecom industry can be broadly divided into two segments,

1. Investment in Passive Infrastructure – Investment in passive infrastructure is not done by telecom companies instead there are separate companies like Reliance Infratel and Indus Towers who create passive infrastructure and then rent it out to various telecom companies.
2. Investment in Active Infrastructure – Telecom companies have to install their Base Transceiver Stations (BTS) to rollout 3G services. The number of BTS installed during the rollout phase shall determine our Capital Expenditure.

For estimating the capital expenditure following methodology has been used,

a. As per our projections which are shown in the appendix 3G users should reach 815 million by the end of 2020.
b. We have assumed that each BTS can support up to 1350 Subscribers (1100 Voice and 250 Broadband @256 Kbps) as discussed before.
c. The above two assumptions gives us a figure of around 6 Lakh BTS which needs to be installed throughout the country in order to rollout 3G services.
d. The capital cost per BTS is USD 10000-12000 equivalent to INR 495000.
e. Points 4 & 5 give us an investment of INR 300 Billion in BTS.
f. We have taken an upfront investment of INR 400 Billion for rollout of 3G services. Since an exact schedule of capital expenditure is difficult to approximate we have assumed that this investment will be made upfront. This will give us a pessimistic

valuation however it is better than splitting the investment in equal installments or as per the growth of the subscribers.

The assumption taken is line with PWC analysis which projects a cumulative investment of INR 380 Billion by 2015 for the rollout of 3G services (PricewaterhouseCoopers India, 2010).

5.14 Operating Expenditure

The projections for operating expenditure have been taken from a report prepared by FICCI-BDA in which they had given the industry wide cost structure with various heads (BDA Connect & FICCI, 2009). We have taken the values as they are except for few changes which are discussed below. The assumptions that we have taken for operating expenditure along with their cost drivers are given in Table 5,

Table 5 – Operating Cost Structure in Telecommunications Industry in India

Net Interconnection Charges as % of Gross Revenues	20%
Expenses as % of Net Revenue	
Network Operating Expenses	15%
Sales & Distribution Expenses	7%
IT Expenses	2%
Service Expenses	3%
Billing, Collection and Bad Debt	2%
Marketing Expenses	3%
Personnel Administration	5%
Total Operating Expenses	37%
Spectrum Usage Charge as % of AGR	3%
EBITDA as % of Net Revenue	58%
EBITDA as % of Gross Revenue	46%

Source: BDA(BDA Connect & FICCI, 2009)

The only change made is that in spectrum usage charge which has been set as 4% as per Department of Technology, GOI guidelines (DOT, GOI, 2010).

5.15 Financing of Capital Expenditure and License Fees

License Fees is the aggregate fees paid by all the operators for acquiring 3G licenses which is equal to INR 677190 Million (INR 677.2 Billion) and capital expenditure has been assumed to be upfront and equal to INR 400 Billion as per our calculations and on the basis of reports. For financing we have assumed a debt equity ratio of 1. A Sensitivity analysis has been done on this assumption to see its effect on NPV. For the purpose of valuation we have kept financing separate from the project and have assumed that the industry will tend to maintain the debt and equity in the same ratio. The debt equity ratio is taken as the average debt equity ratio of 3 telecom operators for the last 5 years as shown inTable 6

Table 6 – Average Debt Equity Ratio of Telecom Operators

			Debt Equity Ratio			
Company	2006	2007	2008	2009	2010	Average
Bharti Airtel	0.65	0.47	0.33	0.28	0.14	0.374
Idea Cellular	4.96	1.95	1.84	0.67	0.57	1.998
Reliance Communications	NA	0.71	0.82	0.6	0.48	0.6525
Average						1.00

Source: Moneycontrol[43]

5.16 Depreciation & Amortization

For depreciation of capital expenditure and amortization of license fees a period of 15 years has been considered and straight line method has been assumed.

5.17 Cost of Capital

Weighted average cost of capital is calculated using the following formula,

$$WACC = K_e \times W_e + K_d \times W_d \times (1 - t)$$

Where,

K_e – Cost of Equity (Calculated from CAPM)

K_d – Cost of Debt (Assumed to be 9%)[44]

W_e – Weight of Equity in Capital Structure

W_d – Weight of Debt in Capital Structure

T – Tax Rate (Assumed to be 30%)

[43]http://www.moneycontrol.com, accessed on 10-03-2011

[44]http://articles.economictimes.indiatimes.com/2010-05-25/news/27573892_1_bharti-airtel-3g-third-generation-mobile-spectrum, accessed on 10-03-2011

For calculating Cost of Equity, Market Return on Nifty is calculated in 2010 CY. Risk free rate of return is considered as yield on 10 Year GOI bonds which is 7.94% in March. These values have then been substituted in Capital Asset Pricing Model (CAPM),

$$K_e = R_f + \beta \times (R_m - R_f)$$

Where,

β – This is measure of systematic risk of the project.

R_f – Risk free rate of return

R_m – Rate of return on market

For calculating β two methods have been considered,

1. Median beta of telecom companies has been taken.
2. Beta of a portfolio of stocks of telecom companies have been taken with weights of each stock being equal to their weight in the combined market capitalization.

The two methods are illustrated in Table 7,

Table 7 – Calculation of Beta

Company (Stock)	Beta	Market Capitalization (Crore)	Weight in Portfolio
Bharti Airtel	0.73	122489	72%
Idea Cellular	1.06	20031	12%
Reliance Communications	1.52	18976	11%
MTNL	1.17	2753	2%
TATA Communications	0.53	6022	4%
Median Beta	**1.06**		
Portfolio Beta	**0.86**		
Sector Beta	**0.54**		

The highest value of 1.06 has been taken for the base case valuation. A sensitivity analysis has been done on NPV by changing the WACC to see how much NPV is affected by variations in the assumption of WACC. WACC calculations are shown in Table 8,

Table 8 – Cost of Capital Calculations

Debt-Equity Ratio		1
Weight of Debt		0.50
Weight of Equity		0.50
Cost of Debt		9%
Tax Rate		30%
Effective Cost of Debt		6%
Return on Nifty		
	Monday, January 04, 2010	5232.2
	Friday, December 31, 2010	6134.5
	Return	17.25%
Cost of Equity Calculations		
Risk Free Rate on 10 Year GOI Bond		7.94%
Market Return on Nifty in 2010 CY		17%
Beta		1.06
Cost of Equity		17.80%
Cost of Capital		12.05%

6 Results& Findings

In this chapter first the base case DCF valuation results are presented along with the sensitivity analysis of key variables on the basis of Chapter 4 & 5. After the DCF valuation we have given the projections for revenue from 3G Data & Voice Services. An incremental revenue analysis has also been given for the 3G operators. Following that real option value of the license has been given which is calculated on the basis of Chapter 4 & 5.

6.1 NPV & IRR

The NPV of the project after deducting the license and capital expenditure comes out to be 291 Billion and IRR comes out to be 14.24%. The DCF model is presented inFigure 36 in Appendix.

Table 9 – Base Case NPV & IRR

NPV (Bn)	**291**
IRR	**14.24%**

Since these are the base case values we would now try to vary some of the key input variables in the DCF model to see their effect on NPV. The variables that we would vary and their effect on NPV is presented in the following sections,

1. Beta and Premium of 3G Services over 2G Services – Since we calculated a range of beta values in the previous section we would vary beta from 0.54 which is the sector beta to 1.2 which is more than the highest value of beta which we calculated. As far as the premium is considered we would vary it from the 15% which is the pessimistic scenario to 50% which operators could charge based on the international experience of operators in other countries.

Table 10 – Sensitivity Analysis of NPV vs. Beta & Premium of 3G over 2G

Sensitivity Analysis NPV (Bn)		*Beta*				
		0.5	0.7	0.9	1.0	1.2
Premium of 3G over 2G	20%	695	548	423	309	173
	25%	727	577	450	334	196
	30%	759	607	477	360	218
	35%	791	636	505	385	241
	40%	823	666	532	410	264
	45%	856	695	559	435	287
	50%	888	725	586	460	309

As far as Premium of 3G over 2G and Beta is concerned NPV is pretty robust with the variation in these assumptions and is greater than zero. The results are presented in Table 10.

2. **Proportion of Broadband Subscribers in Total 3G Subscribers and Cost of Capital** – Proportion of 3G subscribers sis varied from 18% which was calculated from the technological constraints by 3GPP simulations to 30%,an extreme case considering the capacity of a 3G site and the current bandwidth crunch in the 2G technology. We see that with our base case assumption of 22% proportion of broadband subscribers in total 3G subscribers NPV becomes zero between 14% and 15% Cost of Capital which is consistent with our IRR. On the other hand a 30% proportion of broadband subscribers increase our NPV tremendously which is logically consistent with the fact that ARPU of Broadband is around 700 which is much higher than the ARPU of mobile services.This suggests that 3G broadband will play a critical role in the future as far as operators' returns are concerned. The results are presented in Table 11,

Table 11 – Sensitivity Analysis of NPV vs. Proportion of Broadband Subs in Total 3G Subs & Cost of Capital

Sensitivity Analysis NPV (Bn)		Proportion of Broadband Subs in Total 3G Subs			
		18%	22%	26%	30%
Cost of Capital	10%	540	651	762	874
	11%	365	463	562	661
	12%	211	299	387	474
	13%	77	155	233	311
	14%	-41	28	98	168
	15%	-145	-83	-20	42
	16%	-237	-181	-125	-69

3. **EBITDA Margin** – EBITDA Margin has been taken as 46.4% in the base case. While doing sensitivity analysis it has been varied from 40% to 52% and the results are presented in Table 12. From the results we see that NPV is pretty robust vis-à-vis the EBITDA margin. Though our base case suggests that EBITDA should be around 46.4% however considering that the technology is new, there would be added promotional and advertising expenditure in the short term coupled with the subsidies that the operators are expected to provide on wireless broadband devices to push the adoption of 3G technologies. These issues are adequately taken care of by the sensitivity analysis on EBITDA margin.

Table 12 Sensitivity Analysis of NPV vs. EBITDA Margin

Sensitivity Analysis NPV (Bn)	***EBITDA Margin (As % of Gross Revenue)***						
	40%	42%	44%	46%	48%	50%	52%
NPV (Bn)	116	171	226	280	334	389	443

6.2 Revenue Projections

3G Services are expected to generate INR 273 Billion in revenues by the end of year 2015. Out of this INR 100 Billion will come from voice revenue and INR 173 Billion from data services including broadband services. 3G Broadband Revenue is expected to touch INR 90 Billion by the end of 2015.

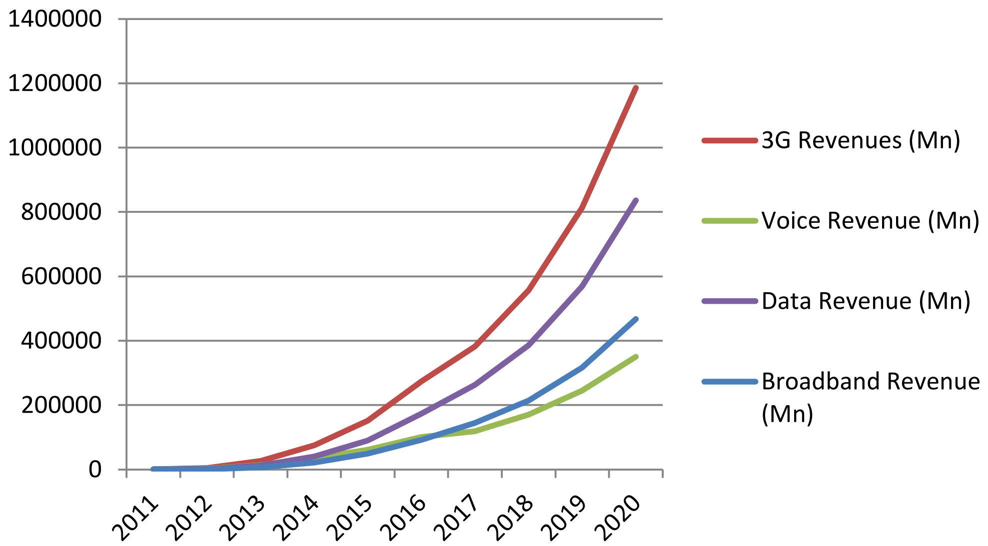

Figure 33 – Revenues from 3G Services

6.3 Incremental Revenues for 3G Operators

Though rollout of 3G technology would cannibalize the 2G technology for the incumbent operators the incremental revenues would be positive which would be equal to the premium that the operators would charge on 3G on account of the increased data usage driven by high speed applications, better network performance and enhanced user experience. The incremental data and voice revenues for 3G operators are presented in Figure 34,

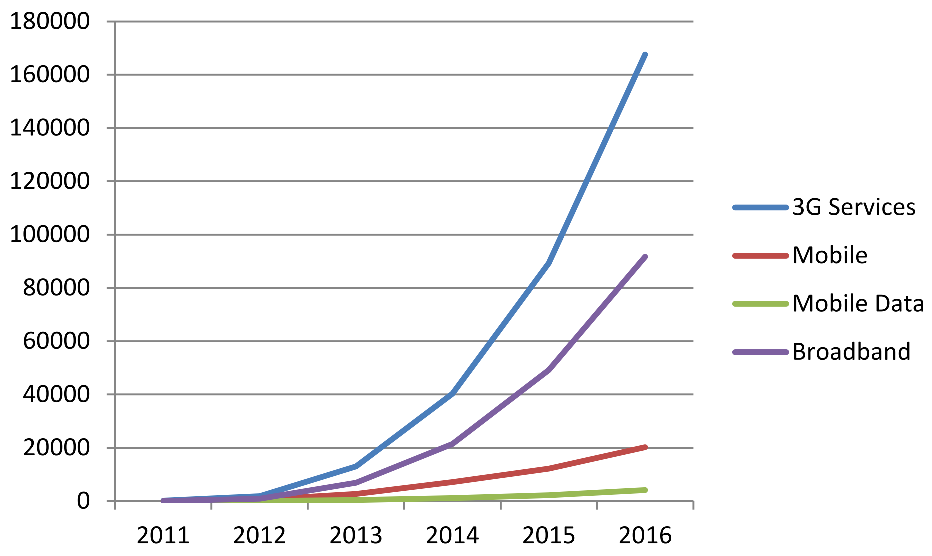

Figure 34 – Incremental Revenues from 3G Services for 3G Operators

6.4 Real Option Valuation of 3G License

As per the methodology described in Chapter 4, the key variables which are required as an input were calculated and shown in Table 13,

Table 13 – Inputs Required for Black Scholes Model

S (Bn)	136
K (Bn)	400
r_f	7.94%
Q	5%
t (years)	5
σ	27.5%

Table 14 – Output from Black Scholes Model

D1	2.546349886
D2	1.931431192
N(D1)	99.46%
N(D2)	97.33%
License Value (Bn)	**798**

The value of the license calculated using Black Scholes Model is analogous to the value of a European Call. However, the telecom operators to a certain extent are free to exercise their option of rolling out the services whenever they deem fit, which is analogous to an American Call Option whose value will be always be greater than European Call. Hence value obtained here is the lower bound of the license value. The value of the aggregate 3G license calculated using Real Options Methodology is INR 798 Billion which is within 17.8% more than what the operators have paid to the government to acquire the rights to rollout 3G services. The operators have paid INR 677 Billion to the government for acquiring rights for 3G services. In Table 15 sensitivity analysis of License value is presented by varying the Capital Expenditure which would be required for rolling out the 3G services and the time to expiration. The analysis is,

1. As the capital expenditure increases the value of the license decreases for the telecom operators and as we increase the time to expiration we observe that loss of value due to waiting is greater than the value which is added by the option.
2. The license loses its value as time to expiration increases because if we look at the 3G telecom scenario in India there are around 4-5 telecom operators vouching to offer 3G services in every circle.
3. Now as an operator decides to wait competitors will enter the market and the operator will lose its competitive edge.
4. If we compare this scenario to a financial stock option then by waiting to exercise the option we lose the dividend payments from the stock and before each dividend payment date the option holder should check if the cost of losing the dividend is greater than the benefit of benefit of waiting to exercise the option.
5. Similarly an operator should weigh its cost of waiting by not availing the cash flows from subscribers who are willing to adopt the new technology with the benefits of waiting to expand and scale up its operations.

Table 15 – Sensitivity Analysis of License Value vs. Time to Expiration & Present Value of Capex

Sensitivity Analysis of License Value (Bn)		*Time to Expiration (Years)*				
		5	6	7	8	9
Capex (Bn)	360	824	791	760	729	699
	400	798	767	738	709	681
	440	772	744	716	689	663
	480	746	720	695	670	646
	520	721	697	674	651	629
	560	696	675	654	633	612

On the whole it looks like as if the firms evaluated the project carefully before entering the auctions and placing their bids.This observation looks credential when looked at in combination with TRAI's rollout obligations. In Figure 35 – Option Value with Change in Volatilitya sensitivity analysis of the option value is presented vis-à-vis volatility of assets.

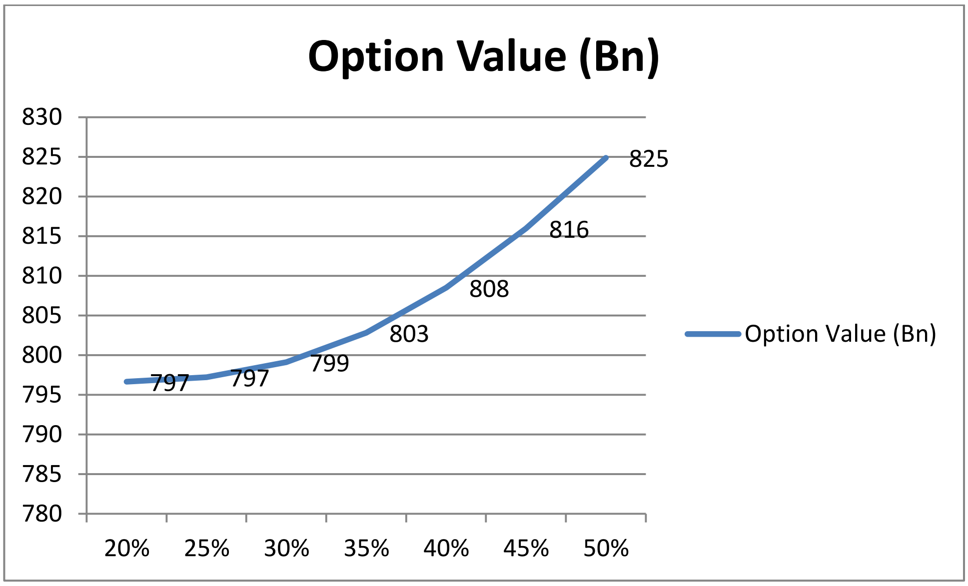

Figure 35 – Option Value with Change in Volatility

Increase in volatility adds value to the license as increase in volatility increases the value of managerial flexibility, thus increasing the value of the option.

7 Conclusions & Recommendations

The motivation behind this research was to find the intrinsic and option value of the licenses which many believed were overvalued. There is often debate on the topic that auctions don't maximize the overall surplus. Overall surplus is maximized when the transaction price is determined by the market on the basis of the perceived worth of the underlying which in turn is governed by the demand and supply forces. In this research it was found that the real option value of the license in the base case is 798 Billion and is ~17.28% higher than the aggregate value paid by the winners of the auction. Hence according to base case real option analysis the auctions didn't overvalue the license.

If we assume an Internal rate of return of 15% for the telecom operators then the aggregate license value comes out to be ~INR 594 Billion which is ~12% lower than what the operators have paid to acquire the license. Hence we see that DCF valuation suggests that the licenses were overvalued while Real Options methodology suggests that the licenses were undervalued. In other words we can say that Real option analysis has allowed us to look at the option value embedded in the 3G spectrum licenses.

The higher value using the real option methodology could be explained due to the nature of the technology itself. Rollout of 3G technology could be considered as a modular process where in the modularity could be present in the following aspects,

1. Operators could implement and "wait and see" strategy wherein they could learn from the mistakes of the other operators or they could wait for the time when the prices of the 3G devices are low enough so that it is affordable for a wide stratum of the society or they could wait till the time when users are more willing to adopt data services or wait for application developers to develop the killer application for making the subscribers hooked on to their network.
2. Operators could rollout 3G services as a pilot project in some areas and then on the basis of the success of these rollouts it might decide to rollout in other areas as well.
3. Operators could implement modularity in terms of the types of applications and services that operators might want to launch. For ex – Operators might start with the launch of entertainment services like Games and then they might decide to launch email and other corporate services.

This flexibility in the hands of the managers is not adequately represented with a DCF analysis where in the timing of the investment should be known/predicted beforehand. However such kind of information and knowledge is rarely available at the time of planning and moreover in projects with high degree of uncertainty and with irreversible investments. Real options analysis adequately captures this flexibility and hence it results in higher valuation for the aggregate 3G licenses.

However the operators should weigh the positive and negative aspects of the flexibility to wait to launch 3G services as by not rolling the operator would lose the market to the competition and will also have to bear to oppurtunity costs of the lost cash flows. The license loses its value as time to expiration increases because if we look at the 3G telecom scenario in India there are around 4-5 telecom operators vouching to offer 3G services in every circle. Now as an operator decides to wait competitors will enter the market and the operator will lose its competitive edge. The discussion is intuitive and could be easily put in perspective by taking the analogy of a financial stock option where the holder of the option bears the oppurtunity cost of the lost dividends.

The other motivation of valuing aggregate 3G licenses was to look at the attractiveness of the investment in 3G licenses. On the face of it and as per the financial and sensitivity analysis, investment in 3G licenses looks a good investment however operators could face certain challenges.

The attractiveness of the investment depends on the uptake of 3G broadband services as seen from the sensitivity analysis wherein we vary the proportion of broadband subscribers in the total 3G subscribers. However for the uptake of 3G broadband services there are certain impediments and preconditions which are as follows,

1. Availability of utility and content in vernacular language (PricewaterhouseCoopers India, 2010). 3G broadband has huge positives for business user as it provides them mobility but the real impetus to 3G growth can come from rural India where it is needed most in the form of applications like telemedicine, m-banking, m-governance, m-education etc. However for 3G broadband to flouring in rural India content and applications should be developed in local vernacular languages for early adoption.
2. Bandwidth offered in India is 2X5 MHz which is less when compared to bandwidth offered in other countries for 3G spectrum. This restricts the speed of the network and might

affect the takeoff of data intensive applications like video streaming and mobile television. In order to provide these services the operators need to incur additional capital expenditure to reduce the cell size which again leaves us the operators with a question of cost vs. benefit.

3. Last but not the least handset and access devices' affordability will play a key role in determining the growth of 3G services.

The other challenge that the operators might face in the short run is that of reduced EBITDA margin because of subsidies on handsets and heavy promotional and advertising costs. Operators will also have to bear high interest payments with low payoffs from the project in the short term and hence their ability to raise additional debt might get affected.

Given the current crunch of bandwidth in the 2G spectrum and with the introduction of Mobile Number Portability operators might transfer their premium subscribers onto 3G spectrum, however operators should not divert their focus from pushing the 3G broadband services as that is where the growth lies. With an abysmal broadband penetration the scope for growth is humongous. Though there is a risk of 4G technology offering better speed and bandwidth we believe that there is enough space for both the technologies to grow and co-exist in a symbiotic manner. Since the access devices for 3G technology are relatively cheap as compared to 4G because of their economies of scale advantage (3G technology has been around since a decade) they could be used to provide mobile broadband solutions to business users, home users and in villages. 4G technology on the other hand is relatively new and the access devices are expensive they could be used to target the enterprise broadband solutions.

All said and done we believe that 3G is a good investment however operators have to act in a strategic manner to realize its potential.

We also recommend that in future while allocating telecom licenses or licenses in sectors where high and irreversible investment is required and there is a scope for the licensees to invest in phases or in modules, the government should consider real options methodology for setting the price of the license, or the base price of the licenses in case the government decides to follow an auction methodology to allocate the licenses to determine a more accurate price of the license which takes into account the managerial flexibility.

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9 Appendix

9.1 DCF Model

DCF Model 3G License Valuation							
Year (Start of the Year)	2010 (A)	2011	2012	2013	2014	2015	2016
Population (Bn)		1.2	1.22	1.24	1.25	1.27	1.29
Wireless Subscribers							
Total Wireless Subscribers (Mn)	584	649	722	803	893	993	1032
Wireless Teledensity		54%	59%	65%	71%	78%	80%
Net Additions (Mn)			73	81	90	100	39
3G Subscribers							
3G Penetration		0.01%	0.10%	1%	2%	5%	8%
Total 3G Subscribers (Mn)		0.12	1.22	10	26	60	107
3G Mobile Subs (Mn)		0.09	0.95	8	21	47	84
3G Postpaid Subs (Mn)		0.09	0.86	4	8	12	17
3G Prepaid Subs (Mn)		0.00	0.10	4	12	35	67
3G Modem Subs (Mn)		0.03	0.27	2	6	13	24
ARPU Projections (Handsets)							
2G Postpaid ARPU	481	457	439	426	417	413	413
2G Prepaid ARPU	101	81	73	69	67	67	67
3G ARPU		571	503	309	259	191	170
ARPU Projections (Broadband)							
3G Broadband ARPU	700	690	679	669	659	649	639
ARPU Projections (Blended)							
3G Blended ARPU (Handsets + Modems)		597	541	388	347	292	273
Revenue from 3G (Mn)							
Total Revenue 3G		430	4347	25879	75454	151073	273839
Revenue Split (Mobile Service Provider)							
Voice Revenue (Mn)		285	2719	13467	35673	60688	100909
Mobile Data Revenue (Mn)		26	304	1809	5616	10988	20713
Broadband Revenue (Mn)		79	852	6817	21435	49118	91692
Total Data Revenue (Mn)		105	1156	8627	27052	60106	112405
Gross Revenue (Mn)		390	3875	22093	62724	120794	213313
Net Interconnection Charges		78	775	4,419	12,545	24,159	42,663
Net Revenue		312	3100	17675	50179	96636	170651
EBITDA (Mn)		181	1798	10251	29104	56049	98977
Interest		48474	48474	48474	48474	48474	48474
Depreciation + Amortization		71813	71813	71813	71813	71813	71813
EBIT (Mn)		-120105	-118488	-110035	-91182	-64238	-21309
Tax @ 30%		0	0	0	0	0	0
Net Income (Mn)		-120105	-118488	-110035	-91182	-64238	-21309
Add							
Interest		48474	48474	48474	48474	48474	48474
Depreciation + Amortization		71813	71813	71813	71813	71813	71813
Free Cash Flow (Mn)	-1077189.5	181	1798	10251	29104	56049	98977
NPV (Bn)	**291**						
IRR	**14.24%**						
Debt Schedule							
Debt Remaining	538595	538595	538595	538595	538595	538595	538595
Interest		48474	48474	48474	48474	48474	48474
Depreciation + Amortization Schedule							
Years	15						
Asset Remaining	1077189.5	1005377	933564	861752	789939	718126	646314
Depreciaiton		71813	71813	71813	71813	71813	71813

Figure 36 – DCF Model (2010 – 2016)

DCF Model 3G License Valuation							
Year (Start of the Year)	2017	2018	2019	2020	2021	2022	2023
Population (Bn)	1.31	1.33	1.35	1.37	1.39	1.41	1.43
Wireless Subscribers							
Total Wireless Subscribers (Mn)	1073	1116	1160	1206	1253	1272	1291
Wireless Teledensity	82%	84%	86%	88%	90%	90%	90%
Net Additions (Mn)	41	42	44	46	48	19	19
3G Subscribers							
3G Penetration	12%	18%	27%	40%	59%	58%	57%
Total 3G Subscribers (Mn)	161	241	362	543	815	815	815
3G Mobile Subs (Mn)	126	188	282	424	636	636	636
3G Postpaid Subs (Mn)	13	16	21	26	32	32	32
3G Prepaid Subs (Mn)	113	172	261	397	604	604	604
3G Modem Subs (Mn)	35	53	80	120	179	179	179
ARPU Projections (Handsets)							
2G Postpaid ARPU	413	413	413	413	413	413	413
2G Prepaid ARPU	67	67	67	67	67	67	67
3G ARPU	126	121	116	110	105	105	105
ARPU Projections (Broadband)							
3G Broadband ARPU	630	620	611	602	593	593	593
ARPU Projections (Blended)							
3G Blended ARPU (Handsets + Modems)	237	231	225	218	212	212	212
Revenue from 3G (Mn)							
Total Revenue 3G	381696	557338	813310	1186086	1728557	2074269	2074269
Revenue Split (Mobile Service Provider)							
Voice Revenue (Mn)	119041	170920	244916	350179	499477	599372	599372
Mobile Data Revenue (Mn)	25792	37033	53065	75872	108220	129864	129864
Broadband Revenue (Mn)	144933	214139	316391	467467	690683	828819	828819
Total Data Revenue (Mn)	170726	251172	369456	543339	798902	958683	958683
Gross Revenue (Mn)	289767	422092	614372	893519	1298379	1558055	1558055
Net Interconnection Charges	57,953	84,418	122,874	178,704	259,676	311,611	311,611
Net Revenue	231814	337673	491498	714815	1038703	1246444	1246444
EBITDA (Mn)	134452	195850	285069	414593	602448	722937	722937
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization	71813	71813	71813	71813	71813	71813	71813
EBIT (Mn)	14166	75564	164783	294307	482162	602651	602651
Tax @ 30%	4250	22669	49435	88292	144649	180795	180795
Net Income (Mn)	9916	52895	115348	206015	337513	421856	421856
Add							
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization	71813	71813	71813	71813	71813	71813	71813
Free Cash Flow (Mn)	130202	173181	235634	326301	457799	542142	542142
NPV (Bn)							
IRR							
Debt Schedule							
Debt Remaining	538595	538595	538595	538595	538595	538595	538595
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization Schedule							
Years							
Asset Remaining	574501	502688	430876	359063	287251	215438	143625
Depreciaiton	71813	71813	71813	71813	71813	71813	71813

Figure 37 – DCF Model (2017 – 2023)

DCF Model 3G License Valuation							
Year (Start of the Year)	2024	2025	2026	2027	2028	2029	2030
Population (Bn)	1.46	1.48	1.50	1.52	1.55	1.57	1.59
Wireless Subscribers							
Total Wireless Subscribers (Mn)	1311	1330	1350	1371	1391	1412	1433
Wireless Teledensity	90%	90%	90%	90%	90%	90%	90%
Net Additions (Mn)	19	20	20	20	21	21	21
3G Subscribers							
3G Penetration	56%	55%	54%	54%	53%	52%	51%
Total 3G Subscribers (Mn)	815	815	815	815	815	815	815
3G Mobile Subs (Mn)	636	636	636	636	636	636	636
3G Postpaid Subs (Mn)	32	32	32	32	32	32	32
3G Prepaid Subs (Mn)	604	604	604	604	604	604	604
3G Modem Subs (Mn)	179	179	179	179	179	179	179
ARPU Projections (Handsets)							
2G Postpaid ARPU	413	413	413	413	413	413	413
2G Prepaid ARPU	67	67	67	67	67	67	67
3G ARPU	105	105	105	105	105	105	105
ARPU Projections (Broadband)							
3G Broadband ARPU	593	593	593	593	593	593	593
ARPU Projections (Blended)							
3G Blended ARPU (Handsets + Modems)	212	212	212	212	212	212	212
Revenue from 3G (Mn)							
Total Revenue 3G	2074269	2074269	2074269	2074269	2074269	2074269	2074269
Revenue Split (Mobile Service Provider)							
Voice Revenue (Mn)	599372	599372	599372	599372	599372	599372	599372
Mobile Data Revenue (Mn)	129864	129864	129864	129864	129864	129864	129864
Broadband Revenue (Mn)	828819	828819	828819	828819	828819	828819	828819
Total Data Revenue (Mn)	958683	958683	958683	958683	958683	958683	958683
Gross Revenue (Mn)	1558055	1558055	1558055	1558055	1558055	1558055	1558055
Net Interconnection Charges	311,611	311,611	311,611	311,611	311,611	311,611	311,611
Net Revenue	1246444	1246444	1246444	1246444	1246444	1246444	1246444
EBITDA (Mn)	722937	722937	722937	722937	722937	722937	722937
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization	71813	71813	0	0	0	0	0
EBIT (Mn)	602651	602651	674464	674464	674464	674464	674464
Tax @ 30%	180795	180795	202339	202339	202339	202339	202339
Net Income (Mn)	421856	421856	472125	472125	472125	472125	472125
Add							
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization	71813	71813	0	0	0	0	0
Free Cash Flow (Mn)	542142	542142	520598	520598	520598	520598	520598
NPV (Bn)							
IRR							
Debt Schedule							
Debt Remaining	538595	538595	538595	538595	538595	538595	538595
Interest	48474	48474	48474	48474	48474	48474	48474
Depreciation + Amortization Schedule							
Years							
Asset Remaining	71813	0	0	0	0	0	0
Depreciaiton	71813	71813	0	0	0	0	0

Figure 38 – DCF Model (2024 – 2030)

9.2 DCF Assumptions

Assumptions						
Year	2011	2012	2013	2014	2015	2016
Population Gowth Rate	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Wireless Subscribers Growth Rate	11.20%	11.20%	11.20%	11.20%	11.20%	4.0%
3G Penetration	0.01%	0.1%	0.8%	2.1%	4.7%	8.3%
Growth of 3G Subscribers	NA	915%	712%	166%	127%	79%
Proportion of 3G Mobile Services out of Total 3G Subs	78%	78%	78%	78%	78%	78%
Proportion of 3G Modems out of Total 3G Subs	22%	22%	22%	22%	22%	22%
Proportion of Postpaid in 3G Mobile	100%	90%	50%	40%	25%	20%
Proportion of Prepaid in 3G Mobile	0.00%	10.0%	50.0%	60.0%	75.00%	80.0%
Growth of 2G ARPU (Postpaid)	-5.00%	-4.00%	-3%	-2%	-1%	0
Growth of 2G ARPU (Prepaid)	-20.00%	-10.00%	-5%	-2.50%	-1%	0
Premium of 3G over 2G (15 - 35%)	25%	25%	25%	25%	25%	25%
Delcine in 3G Broadband ARPU	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%
Share of VAS in 3G Mobile ARPU	11%	14%	16%	19%	21%	24%
Share of Operator ARPU in 3G Mobile Data ARPU	72.50%	71.00%	69.50%	68.00%	66.50%	65.00%
Net Interconnection Charges as % of Gross Revenues	20%	20%	20%	20%	20%	20%
Expenses as % of Net Revenue						
Network Operating Expenses	15%	15%	15%	15%	15%	15%
Sales & Distribution Expenses	7%	7%	7%	7%	7%	7%
IT Expenses	2%	2%	2%	2%	2%	2%
Service Expenses	3%	3%	3%	3%	3%	3%
Billing, Collection and Bad Debt	2%	2%	2%	2%	2%	2%
Marketing Expenses	3%	3%	3%	3%	3%	3%
Personnel Administration	5%	5%	5%	5%	5%	5%
Total Operating Expenses	37%	37%	37%	37%	37%	37%
Spectrum Usage Charge as % of AGR	4%	4%	4%	4%	4%	4%
EBITDA as % of Net Revenue	58%	58%	58%	58%	58%	58%
EBITDA as % of Gross Revenue	46%	46%	46%	46%	46%	46%

Figure 39 – DCF Assumptions (2011 – 2016)

Assumptions							
Year	2017	2018	2019	2020	2021	2022	2023
Population Gowth Rate	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Wireless Subscribers Growth Rate	4.0%	4.0%	4.0%	4.0%	4.0%	1.50%	1.50%
3G Penetration	12.3%	18%	27%	40%	59%	58%	57%
Growth of 3G Subscribers	50%	50%	50%	50%	50%	0.00%	0.00%
Proportion of 3G Mobile Services out of Total 3G Subs	78%	78%	78%	78%	78%	78%	78%
Proportion of 3G Modems out of Total 3G Subs	22%	22%	22%	22%	22%	22%	22%
Proportion of Postpaid in 3G Mobile	10%	8.75%	7.50%	6.25%	5%	5%	5%
Proportion of Prepaid in 3G Mobile	90%	91%	93%	94%	95%	95%	95%
Growth of 2G ARPU (Postpaid)	0	0	0	0	0	0	0
Growth of 2G ARPU (Prepaid)	0	0	0	0	0	0	0
Premium of 3G over 2G (15 - 35%)	25%	25%	25%	25%	25%	25%	25%
Delcine in 3G Broadband ARPU	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%	0%	0%
Share of VAS in 3G Mobile ARPU	25%	25%	25%	25%	25%	25%	25%
Share of Operator ARPU in 3G Mobile Data ARPU	65%	65%	65%	65%	65%	65%	65%
Net Interconnection Charges as % of Gross Revenues	20%	20%	20%	20%	20%	20%	20%
Expenses as % of Net Revenue							
Network Operating Expenses	15%	15%	15%	15%	15%	15%	15%
Sales & Distribution Expenses	7%	7%	7%	7%	7%	7%	7%
IT Expenses	2%	2%	2%	2%	2%	2%	2%
Service Expenses	3%	3%	3%	3%	3%	3%	3%
Billing, Collection and Bad Debt	2%	2%	2%	2%	2%	2%	2%
Marketing Expenses	3%	3%	3%	3%	3%	3%	3%
Personnel Administration	5%	5%	5%	5%	5%	5%	5%
Total Operating Expenses	37%	37%	37%	37%	37%	37%	37%
Spectrum Usage Charge as % of AGR	4%	4%	4%	4%	4%	4%	4%
EBITDA as % of Net Revenue	58%	58%	58%	58%	58%	58%	58%
EBITDA as % of Gross Revenue	46%	46%	46%	46%	46%	46%	46%

Figure 40 – DCF Assumptions (2017 – 2023)

Assumptions							
Year	2024	2025	2026	2027	2028	2029	2030
Population Gowth Rate	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Wireless Subscribers Growth Rate	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
3G Penetration	56%	55%	54%	54%	53%	52%	51%
Growth of 3G Subscribers	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Proportion of 3G Mobile Services out of Total 3G Subs	78%	78%	78%	78%	78%	78%	78%
Proportion of 3G Modems out of Total 3G Subs	22%	22%	22%	22%	22%	22%	22%
Proportion of Postpaid in 3G Mobile	5%	5%	5%	5%	5%	5%	5%
Proportion of Prepaid in 3G Mobile	95%	95%	95%	95%	95%	95%	95%
Growth of 2G ARPU (Postpaid)	0	0	0	0	0	0	0
Growth of 2G ARPU (Prepaid)	0	0	0	0	0	0	0
Premium of 3G over 2G (15 - 35%)	25%	25%	25%	25%	25%	25%	25%
Delcine in 3G Broadband ARPU	0%	0%	0%	0%	0%	0%	0%
Share of VAS in 3G Mobile ARPU	25%	25%	25%	25%	25%	25%	25%
Share of Operator ARPU in 3G Mobile Data ARPU	65%	65%	65%	65%	65%	65%	65%
Net Interconnection Charges as % of Gross Revenues	20%	20%	20%	20%	20%	20%	20%
Expenses as % of Net Revenue							
Network Operating Expenses	15%	15%	15%	15%	15%	15%	15%
Sales & Distribution Expenses	7%	7%	7%	7%	7%	7%	7%
IT Expenses	2%	2%	2%	2%	2%	2%	2%
Service Expenses	3%	3%	3%	3%	3%	3%	3%
Billing, Collection and Bad Debt	2%	2%	2%	2%	2%	2%	2%
Marketing Expenses	3%	3%	3%	3%	3%	3%	3%
Personnel Administration	5%	5%	5%	5%	5%	5%	5%
Total Operating Expenses	37%	37%	37%	37%	37%	37%	37%
Spectrum Usage Charge as % of AGR	4%	4%	4%	4%	4%	4%	4%
EBITDA as % of Net Revenue	58%	58%	58%	58%	58%	58%	58%
EBITDA as % of Gross Revenue	46%	46%	46%	46%	46%	46%	46%

Figure 41 – DCF Assumptions (2024 – 2030)