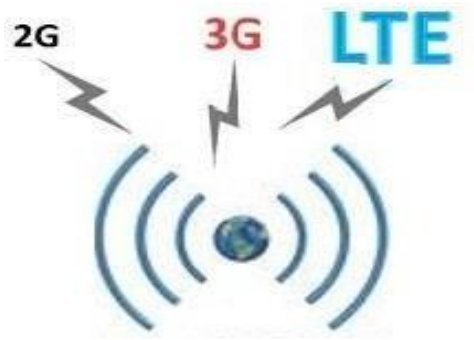
A short Analysis of Spectrum auction in India



Prepared by: V.J.Christopher,
Sr. Deputy Wireless adviser,
WPC Wing,
May 2018.

Abstract

This paper is an effort to understand the various spectrum auctions and their outcome that were held from the year 2010 to 2016 in India. This paper explores the auction generated data in the public domain to analyze the auction result with regard to some benchmarks viz: winning price, reserve price, quantum of spectrum sold, revenue generated etc. Besides, two specific auction metrics namely 'provisional winning bid' and 'provisional winning rank' at each clock round of the SMRA auction are also examined along with the benchmarks to develop a perspective about the auction and its outcome. Each auction is individually showcased with regard to the above benchmarks and the results are plotted and the inferences are tabulated. A comparison of all the auctions is also performed to give a panoramic view of all auctions. However, after completing the exercise, it is difficult to conclude an auction as success or not merely based on the information presented here on account of the fact that some attributes of auction would have been overlooked or unexploited in this paper. Further study by collecting new evidence may improve the understanding and might lead to a conclusion beyond doubt.

Executive summary:-

The purpose of this study is to analyse the various spectrum auctions conducted by Department of Telecommunications during the period from 2010 to 2016 and to do a relative comparison. On the whole, there were six auctions held during this period. Each of these auctions is conducted through an online process, called SMRA (Simultaneous Multiple Round Auction). As the name suggests, the auction for different service areas is conducted simultaneously in continuous cycles known as clock rounds. The first auction held in 2010 had two distinct sub auctions- one for 3G auction (2100 MHz band) and another for BWA auction (2300 MHz band). The BWA auction commenced immediately after ending the 3G auction. In the auctions held in subsequent years, the multiple frequency bands were auctioned simultaneously and for all intents and purposes each auction is considered a single standalone auction.

Each auction has two stages- clock round stage and frequency identification stage. In the clock stage, the price is determined for the block size in the particular band in which the bid take place for each service areas. This is a generic stage in which every slot is auctioned treating them as equivalents without frequency location information. Bidders will bid for a block (i.e. right to a single spectrum block not linked to any specific frequency).The Clock Stage will consist of a number of rounds (the "Clock Rounds"). These rounds will stop once (i) for every service area where spectrum is being auctioned, the number of Bids at the prices set in the last completed Clock Round is less than or equal to the number of blocks available; and (ii) there are no opportunities for Bidders to increase their demand in accordance with the Activity Rules. The Clock Stage will establish a common Winning Price for all blocks within a service area and who are the Winning Bidders in each service area.

The Clock Stage will be followed by a Frequency Identification Stage that will identify specific frequencies for the Winning Bidders. The frequencies identified will be announced simultaneously with the outcome of the Clock Stage. The Frequency Identification Stage will be a random identification of frequencies performed automatically by the Electronic Auction System.

The analysis angle:-

In an auction the seller does not know the real value of the spectrum, unless the band has been auctioned earlier. One way to unlock its value is to put it for auction. A reserve price of spectrum is always calculated making use of the data available to the seller. This calculation is based on many factors –previous auctions, prevailing market conditions, cross reference to equivalent goods (different bands auctioned earlier) or any other economic tools available to the seller. The reserve price which is a critical element in an auction would be arrived at only by guess based on the approach used by other countries for the band. In auction, there is an element of uncertainty for both the buyer and the seller. The buyer may not have the information on the strategy of other buyers or other information about the buying habits of others taking part in the auction. This information asymmetry is the part of the mystery factor attributed to the auction. But when a when the auction is completed the final price of the commodity (spectrum) will be optimum price at which the particular seller can get it in the prevailing circumstances. Spectrum auction also follows the same principle, but the optimum price could also be a function of reserve price, eco system of technology, licensing conditions and/or other constraints apart from demand and competition in the field.

Each spectrum auction has certain measurable parameters associated with it. The auction results can be compared on this basis. There are some tangible and intangible outcomes in an auction. The tangible outcomes are those that are directly derivable from the auction data. The tangibles that have been compared in this study are the following.

1. Winning Price (WP)
2. The difference between the winning price and reserve price (RP) which can be used to measure the percentage change of price.
3. Quantity of spectrum sold.
4. The provisional winning bid at the end of each round (***'pwb_end'***)
5. The provisionally winning rank at the end of each round (***'pwb_rank_end'***)
6. The total rounds of auction.
7. The revenue collected in each auction.
8. The net-worth of the company participating in each auction also could be referred wherever necessary

Rationale: -

The intent is to retrieve the above characteristics from the auction data and to evaluate each of the auctions on this basis. For example the total rounds of auction are a measure of the bidding competition in a particular auction. As the number of rounds increases, so is the demand for spectrum. The activity therefore picks up with each round and finally results in a healthy competition yielding the best price for that block of spectrum. The two indicators at serial number 4 and 5 above capture the activity in an auction. Therefore these two indicators are filtered out from the auction data and plotted for each of the auction. The respective plots give a graphical view of the auction process. If there is no demand, the auction can fail resulting in unsold inventory. This also can be observed from the plots chronicling the depth of auction through these indicators. As is stated earlier, the basic economic theory and auction theory holds good for auction of spectrum.

It is also documented that there are some downside (distortions) associated with auction. They are collusion, signaling, winners curse, predation, hoarding etc which are capable of influencing the outcome of the auction. For example, the winning figure of 2100 MHz and 2300 MHz spectrum price in the auction held in the year 2010 for Mumbai and Delhi service areas are said to have a trace of 'winner's curse'. Example for another anomaly 'signaling', the 700 MHz auction in the year 2016 can be cited. After the notification of auction was issued in 2016, various agencies come out with opinions stating that the reserve price of 700 MHz is exorbitant. This kind of signaling may act as disincentive to the true bidder thereby scuttling his plan, say, to set up a pan India network by making use of the valuable 700 MHz spectrum. However, these flaws are mere hypothesis which cannot be proved through the available auction data. Therefore such things are not examined in this study.

It may be mentioned that auction is a complex process held within the rules inbuilt in the SMRA auction flow diagram, but may not have any provision to explain the distortions or externalities happening outside the auction. But these externalities might be influencing the final outcome of the auction (say for example dampening the submission of bids and to reduce the demand) which may not be perceptible in the auction data generated. The questions that may be asked, certainly outside the purview of this analysis, is whether the time for auction was conducive

or not, whether or not the reserve price is ideal to attract bidders, whether the minimum/maximum blocks set by the auctioneer is rational or not, whether the roll out demand from the bidder is unviable or not et al.

Process: -

The points that are mentioned in the analysing angle in the above paragraph are examined from the data available for each auction. The data was collected from the auction data generated and available in DoT website (http://dot.gov.in/) The corresponding CSV data dumps available in each auction (except auction 2013) are wrangled, cleaned and analysed to extricate the relevant information pertaining to each auction. After analysis, the data so arrived at are compared with reference to the various performance indicators to reach conclusion as in the ensuing para. For most of the analysis part Python* and its libraries are used.

Conclusion:-

Since each auction is an independent process, the data is analysed independently for each auction. The comparisons are later done on the derived facts and figures from data. The merit of each auction is measured in terms of the spectrum sold, how much of the spectrum has been sold above reserve price, the revenue collected, the vibrancy of activity in each auction and the ranks traced by the winning bidders.

The following table give the comparative outcome of the various auctions:-

Auction	Total spectrum sold (MHz)	Percentage of spectrum sold	Percent. spectrum sold above R.P.	Total Revenue collection (Rs crores)	Revenue collection per MHz (Rs crores)	Clock rounds held in auction	No of operators who got spectrum	Remarks
2010-3G	465	100	100	50968.37	109.61	183	7	Revenue from BSNL/MTNL not taken into a/c
2010-BWA	1320	100	100	25695.54	19.47	117	7	
2012	127.5	32.69	10.7	9642.11	75.62	14	5	
2013	30	15.38	0	4113.65	137.12	3	1	
2014	353.2	81.91	53	61162.22	173.17	68	7	
2015	418.25	88.85	78.7	113932.2	272.40	115	7	
2016	964.8	40.97	21	64809.12	67.17	31	7	

From the above table it may be observed that the in 2010 BWA auction all spectrum was sold above the reserve price but the revenue per MHz gives a figure of 19 Crores. However in the auction held 2013, the spectrum whatever was sold, it was so at the reserve price. But the revenue collected per MHz spectrum in 2013 auction is substantially higher among the different auctions. If the number of clock rounds in an auction is a criterion for competition, 2013 auction can be considered ended prematurely with no competition at all. Therefore it may be wrong to conclude

the outcome whether success or failure of auction based only on the revenue collected from the auction. It may be reasonable to look at the figures for 2014 and 2015 auction where a balanced picture can be seen. In auctions, revenue collection as well as the spectrum sold above reserve price is giving a healthy figure.

When the different auctions are compared, it would be easy to jump to such conclusion as based on the quantum of spectrum sold that a particular auction was productive than other auction. When more and more spectrum is sold at a higher price than set by the auctioneer, then that auction is generally considered successful. The Government get revenue; the bidder is keen to deploy the spectrum to introduce the latest technology and thereby attracting more and more customers. This whole chain ultimately contributes to the economic progress. However, if for some reasons, the network is not deployed within a certain time frame, then the final outcome may not be as desired to be. In the short term, it would look glossy, but in the longer term it would be realised that the bidder might not have utilized the spectrum efficiently. For example various bidders won spectrum in 2300 MHz in the year 2010 with the objective of improving broad band penetration .In the short term Government received revenue from the auction. But it was after long gap the network took shape and the spectrum was efficiently deployed to realise the objectives. Therefore there is a time period to mature the technology and derive the full benefit to society through the sale of spectrum.

With reference to the tangible benchmarks mentioned above, each auction can be compared. A comparison on the basis of these tangibles is tabulated below:

Sl.no	**Parameters for judgement**	**2010 -3G**	**2010 - BWA**	**2012**	**2013**	**2014**	**2015**	**2016**
1	Winning Price (WP)	High price	High price	Low price	Lowest price	High price	High price	Low price
2	Maximum percentage of change (%) w.r.t. RP	936	1333	9	0	415	348	64
3	Percentage of quantity of spectrum sold. (%)	100	100	32.69	15.38	81.91	88.85	40.97
4	The provisional winning bid at the end of each round (***'pwb_end' movement***)	Brisk	Brisk	Slow	Slow	Moderate	Moderate	Slow
5	The provisionally winning rank at the end of each round (***'pwb_rank_end' movement***)	Brisk	Brisk	Slow	Slow	Moderate	Moderate	Slow
6	The total rounds of auction.	183	117	14	3	68	115	31
7	Bands put up for auction	2100	2300	800, 1800	800, 900, 1800	900, 1800	800, 900, 1800, 2100	700,800, 900,1800, 2100,2300, 2500
8	The revenue collected (Rs Crores)	50968.37	25695.54	9642.11	4113.65	61162.22	113932.2	64809.12

From the aforesaid facts and figures, it would be reasonable to conclude that the auction held in 2010 was the most successful auction followed by 2015 and 2014 auctions in that order. These three auctions produce healthy figures in all comparison indices and charts. The auction held in 2016 does not warrant attention as much as these auctions. It will be however remembered for reaching another milestone in the auction journey in as much as it is for the first time that such diverse bands and quantity of spectrum ('Mega auction') was offered to the eligible bidders. In fact, the quantum of spectrum sold is equivalent to the spectrum sold in the previous 4 auctions put together.

What are the intangibles that can be ascribed to the outcome of an auction? The auction can fail if it does not generate adequate interest and competition. The major factors that could influence are the availability of an ecosystem in the band considered for auction, technological upgrade path in future i.e. the availability of spectrum in future, lower reserve price, rationalised spectrum usage charges, availability of backhaul spectrum etc can influence the outcome of an auction.

Recommendations:-

It is often mentioned that the average spectrum held per operator in India is much below the global average of 50 MHz. After the consolidation of industry, the chances are this magic figure will be achieved by the remaining players. But with the 5G services appearing on the horizon, it may not be far when the companies may feel the dire need for more spectrum than ever. The Government therefore should open up more spectrum in tune with the global spread of technological advancements. The second issue which is often quoted is the high reserve price which can become an entry barrier for small firms to enter the field. When the participation is limited, then the chances of an auction becoming successful is remote. The trick is to find the right price at which the reserve price can be fixed as it can depend on various factors related to the health of industry apart from the last auction price. When revenue maximisation is given emphasis with higher reserve price, the competition would come down. In effect the policies from the Government that foster innovation and competition in the telecom field can also help government earns revenue from auction which eventually would help towards the welfare of the society.

As far as the type of auction that could be used, the SMRA auction has been successfully used by FCC, OFCOM and other regulatory authorities across the world. In the technology neutral world multiple bands have been effectively used for seamless implementation of mobile services. Technique like bandwidth aggregation has also enhanced the flawless acceptance of different frequency bands in 4G networks like LTE. Therefore there is a synergy factor existing in such similar bands for which Combinatorial auction (CCA) is found to be more suitable than SMRA. These days, CCA or its variations are also being tried successfully in other countries. A hypothetical example can be cited to demonstrate this synergy. Assume a new company wants to set up mobile service pan India. In the normal SMRA auction, as a new entrant he has to compete with big corporations in all service areas separately. The existing operators may not require spectrum in all bands. If he is not successful in getting the spectrum in all service areas, he may not show interest and may withdraw. Suppose if it is possible that a block from, say, 700 MHz auction, can be sold as a separate single unit pan India, at a different reserve price, then it may be possible to generate interest and therefore competition. In such case separate pan India license also required. In another example, suppose 5 G can be implemented using spectrum aggregation of different bands, then spectrum in different

bands can be bundled together as a single entity (say 20 MHz in 700 MHz, 40 MHz in 3300 MHz, 40 MHz in 3400 MHz band combined) to create the 'synergy factor'. The CCA auction can help us in auctioning such combinations as per need. Therefore it is called Combinational auction. This fine tuning may not be possible in the SMRA. Such variations can be tried to improve the output and outcome of auction.

A final suggestion is regarding the massive data that are generated through these auctions which can be harnessed to develop a better strategy and to develop a model for future auctions. The 'Machine Learning' techniques can be effectively utilized to come out with an 'auction model for India' while taking note of the telecom growth from the legacy periods to modern wireless world. Such tweaked model would help in meeting the objective of keeping the dual objective of efficient allocation of limited spectrum resources and to maximise the revenues.

Reference: - http://dot.gov.in/spectrum

Feedback: - Comments, suggestions and errata may please be mailed at: **christ.wpc@gmail.com**

Disclaimer: - The views expressed are personal and contextual and the same does not necessarily reflect the views of DoT or WPC Wing.

The analysis of the spectrum auction data for the auctions conducted by Department of Telecom during the period 2010 to 2016

1. Auction theory:-

There are mainly two popular spectrum auction adopted by different countries.

1. Simultaneous Multiple Round Auction (SMRA)
2. Combinational Clock Auction (CCA).

CCA is used when different band of spectrum is offered as a package. The synergy factor in the CCA is effectively used so that the winner will take the package rather than winning only individual item in which case his business can be hindered for not winning its complementary item to start his business. In India we have used SMRA in all of the auctions held so far. It is not plain vanilla SMRA, but an extended version of it -SMRA with clock auction. The e-auction indicates that the auction is held electronically and the word clock refers to the number of clock rounds (timed) an auction can last as long as the demand is maintained positive.

SMRA will have two stages, one is a generic stage in which every slot is auctioned treating them as equivalents without frequency location information and the second stage is frequency identification stage. Multiple rounds of auctions are held and in each round every bidder was allowed to make only one bid for each item by accepting or rejecting the price determined by the auction software. In case of a 'Yes' response, the bidder was also required to mention the quantity sought for the item. Since bidders were not quoting any price and were only accepting or rejecting the price determined by the auction software designed by the ranking rules decide the winner and the quantity allotted. Ranking rules were prudentially designed to determine allocation when demand exceeded supply and vice-versa. Conducting multiple rounds gave bidders the option to switch at any time between any of the offerings if the price became unaffordable. Since the DoT has been conducting the above auction from 2010 onwards, the auction software has been optimally tweaked to cater to the demand of the industry. (Source: 'm-junction'-auctioneer)

Advantages of auction: A carefully designed auction allocates the resources to those who value it most by extracting information which otherwise is not available. Further, auction can generate large sum of money that can be utilised for social purposes. Economic theory has shown that ascending auctions are particularly likely to allocate the prizes to the bidders who value them the most, as the bidder with higher value can always bid again to top a lower-value bidder that might have bid higher initially. There are also particularly suited in the case of complementaries between the auctioned objects. Conducting multiple rounds gave bidders the option to switch at any time between any of the offerings if the price became unaffordable.

SMRA: In a simultaneous multiple-round (SMR) auction, all spectrum slots are available for bidding throughout the entire auction, thus the term "simultaneous." Unlike most auctions in which bidding is continuous, SMR auctions have discrete, successive rounds, with the length of each round announced in advance by the auctioneer. After each round closes, round results are processed and made public. Only then bidders learn about the bids placed by other bidders. This provides information about the value of the spectrum to all bidders and increases the likelihood that the spectrum will be assigned to the bidders who value them the most. The period between

auction rounds also allows bidders to adjust their bidding strategies. In an SMR auction, there is no preset number of rounds and the auction closes with around in which all bidder activity ceases.

2. Objective of study: - The objective of this study is to analyse the spectrum auction conducted by Department of Telecommunications since the year 2010 onwards. DoT had conducted 6 auctions till date. The details are as follows:

Sl. no	Year of auction	Bands auctioned	Outcome
1	2010	2100 MHz and 2300 MHz	Both bands were completely sold.
2	2012	1800 MHz and 800 MHz	Only 1800 MHz was (partially)sold.
3	2013	800 MHz,900 MHz and 1800 MHz	Only 800 MHz was (partially)sold.
4	2014	900 MHz and 1800 MHz	Both bands were (moderately)sold
5	2015	800 MHz, 900 MHz, 1800 MHz and 2100 MHz	All bands were (moderately) sold.
6	2016	700 MHz,800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz	All bands, except 700 MHz and 900 MHz, were (partially)sold.

Before conducting an auction, there are various stages and processes involved, some of which are highlighted here.

1. The availability of spectrum has to be ascertained. The band intended for auction has to be clean spectrum. This means that the block of spectrum among the lot should be wide enough to support the prevailing technology. If the spectrum is already in use for other purposes, it has to be re-farmed to vacate the spectrum.
2. Once the spectrum is identified, TRAI would be requested to give recommendations on the reserve price and other relevant recommendations as appropriate.
3. After the recommendations are received, they are examined by a high level committee (HLC) to ensure that the auction would be feasible within the set objectives of auction and does not deviates from the broad policy guidelines of the Department.
4. The report of the committee is further discussed by the Telecom Commission (TC). The TC may suggest changes if required in which case the differences with TRAI shall be referred back to the latter for their comments. After the feedback is received from TRAI, the HLC discuss it again and subsequently place its report again to the TC.
5. After the TC approves the proposal, a comprehensive Cabinet Note is prepared and submits for its approval.
6. After the Cabinet ratifies the proposal for auction, the required follow-up action will be taken by the Department to conduct auction through an electronic auction (e-auction). First the auctioneer with technical competence and experience is selected. The next major step is the release of the Notice Inviting Applications (NIA). NIA is the document that provides complete information about the auction including the reserve price of various bands. The

terms and conditions will be binding to all parties and serve as a contract document. The interested parties have to submit the applications and pay the EMD as appropriate.

7. The auction is concluded as stipulated by the activity rules as defined in the NIA. The winners are declared after all clock rounds (the timed periods) are completed. The winners have to make the payment after which the frequency slots (spectrum) won by them will be assigned. The exclusive right of use of the spectrum will be reserved to all winners for twenty years (license period).

If we look at the table above, the various auctions have produced mixed results. Each auction has its primary objective of determining the market price which is generally considered interplay of demand and supply. However it may not be possible always to find the holy grail of equilibrium price in an auction thanks to other externalities. There could be external factors outside the auction enterprise contributing to the skewed outcome of a particular auction. For example two examples can be cited. In such cases where a licensee is on the verge of expiry, the demand will shoot up to a desperate level forcing the bidder to buy at a high price than a market determined value. The second instance is when the reserve price lies outside of certain threshold value the result will be different from what could be achieved through a market determined process. If the base price is too low, the bid price may not attain the market price in an auction and if it is too high the outcome will be no participation. Both outcomes are inefficient and not desirable in an auction, but they are part of the external factors influencing the outcome of the auction.

If we observe the objectives of the first auction (3G and BWA auction) which are stated below:

- Obtain a market determined price of 3G/ BWA spectrum through a transparent process;
- Ensure efficient use of spectrum and avoid hoarding;
- Stimulate competition in the sector;
- Promote rollout of 3G and Broadband services;
- Maximise revenue proceeds from the Auctions;
- Resolve congestion issues related to second generation (“2G”) mobile services.

From looking at the objectives and the outcome of the auction, it can be stated that the 3G-BWA auction achieved the objectives. The important thing to note is to ensure efficient use of spectrum while maximising the revenue proceeds from the auctions. A bidder who pays highest is likely to use it more efficiently than others who receive it, say, at a lesser market price. The bidder who pays highest is also more likely to have the wherewithal (meaning having high net-worth) to make the spectrum use it more optimally by deploying the relevant technology at the earliest. This in turn will bring economic benefits to the society as a whole and contribute maximum revenue to the Government. The auction process by design will be transparent as it is conducted through a transparent electronic process. It is difficult to achieve this dual objective in a non-market based distribution of spectrum.

The subsequent auctions were different from the first auction held in 2010. Next auction was held in the year 2012. This was held after the Supreme Court cancelled 122 licenses in the 2G

case in Feb.2012. There was a compulsion on DoT to organise the auction within a limited time frame. Therefore it is considered as a 'duress auction' that might have happened without a well planned action plan. In this auction both 1800 MHz and 800 MHz spectrum were offered, but only 1800 MHz was sold. It may be understood that this was the first time the 2G spectrum was put on auction amidst the legacy issues as well as the legal issues prevailing at that time. The low reception was probably due to the fact that the service providers who were providing service were having adequate 2G spectrum, but the new players who would like to provide the service was at a disadvantage vis-a-vis existing operators since the cost of acquiring the spectrum and establishing infrastructure was very high. There was a muted response overall and 800 MHz spectrum was not sold at all. In 15 service areas where the 1800 MHz spectrum was sold, it was sold at Reserve price only.

The unsold spectrum in 800 MHz and 1800 MHz and additional spectrum in 900 MHz was again put to auction in the year 2013. The response to this auction was also lukewarm. The spectrum in 800 MHz was partly sold whereas spectrum offered in 900 MHz and 1800 MHz was not sold at all.

In the 2014 auction 900 MHz and 1800 MHz were again put to auction and the outcome was more positive, with DoT able to auction major chunk of the spectrum. However there was a downside that in 11 service areas, 1800 MHz was sold at Reserve price out of the 14 service areas where the spectrum was on sale. Another interesting thing to note is that 900 MHz spectrum witnessed heavy bidding, in the 4 service areas where the licenses were to be renewed.

In the 2015 auction, the bands 800 MHz, 1800 MHz and 2100 MHz bands had moderate bidding and 900 MHz witnessed highest bidding, again due to the expiry of spectrum in some circles.

In 2016auction, response was tepid, as may be seen that 700 MHz and 900 MHz were not sold at all and in the 1800MHz, 2100MHz, 2300 MHz and 2500 MHz only part of the spectrum offered was sold. It may also be noted that this is the first auction after the spectrum sharing and trading guidelines were released by the Department. Therefore some urgent need of the service providers could have met through the sharing/trading route.

3. <u>Analysis part</u>:

The decision to purchase spectrum by an existing operator or new operator is determined by various factors- technological, regulatory as well as economic factors. It can be influenced by the prevailing policy conditions, advances in the technology, the conditions associated with auction and the price of the spectrum. The auction therefore can be graded successful or failure due to many attributes. When an auction is declared success, it should create awin-win situation for both the licensor and the licensee. However by only referring to the revenue collected as the yardstick, it may not be credible to grade an auction as success. The success is only when the spectrum is deployed and efficiently utilized, which in turn can contribute to the reach of technology to the user level and thereby achieving economic progress. Therefore this is required to be assessed in a long term perspective. It may be recalled that the BWA auction in 2010 has contributed to the kitty of the Government. However the benefits of the spectrum to the society were reaped after the progress of technology (VoLTE in 2300 MHz) and its deployment few years later only. A good eco system would get created in the long term and the auction then becomes a benchmark of success in the long term.

A number of auctions have been conducted in the last 7 years and the Government could become a lot wiser.

For the short term evaluation of the spectrum auction the following input inter-alia could be considered vital:

1. The selling price and reserve price of the spectrum and the percentage change in the price.
2. The circles where the RP and SP are the same. That is the percentage change is zero.
3. The number of rounds depends on the competition and in turn on demand of the spectrum.
4. The change in the provisional ranking of the bidder in each round.
5. The total quantity of spectrum sold.
6. Is it contiguous spectrum.
7. The total bid amount received in each auction.

4. <u>Methodology</u>:

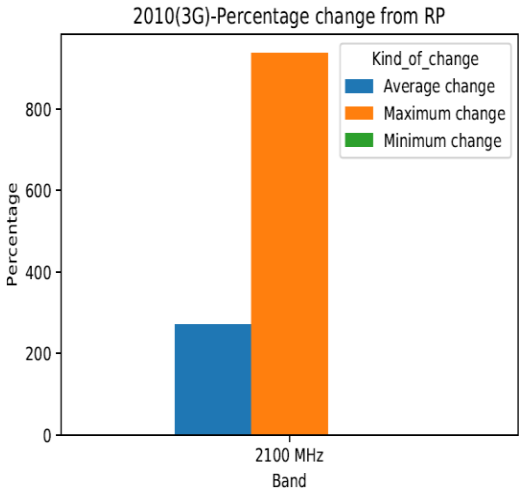
In order to bring some objectivity in the analysis, the following key indicators are captured from the auction data for analysing with regard to the input mentioned above.

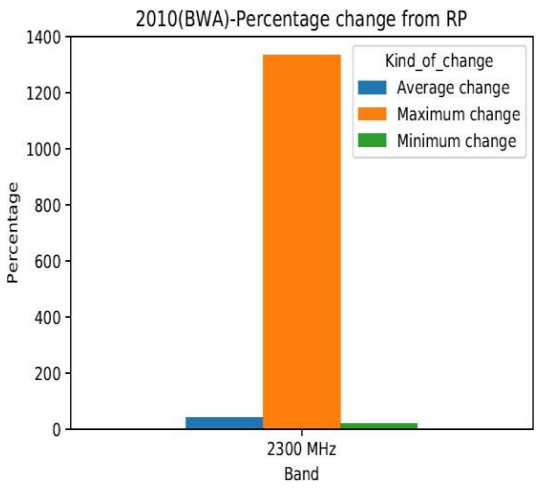
I. Winning Price (WP)
II. The difference between the winning price and RP to show the percentage change of price.
III. Quantity of spectrum sold for the percentage sold.
IV. The provisional winning bid at the end of each round (***'pwb_end'***)
V. The provisionally winning rank at the end of each round (***'pwb_rank_end'***)
VI. The total rounds of auction.

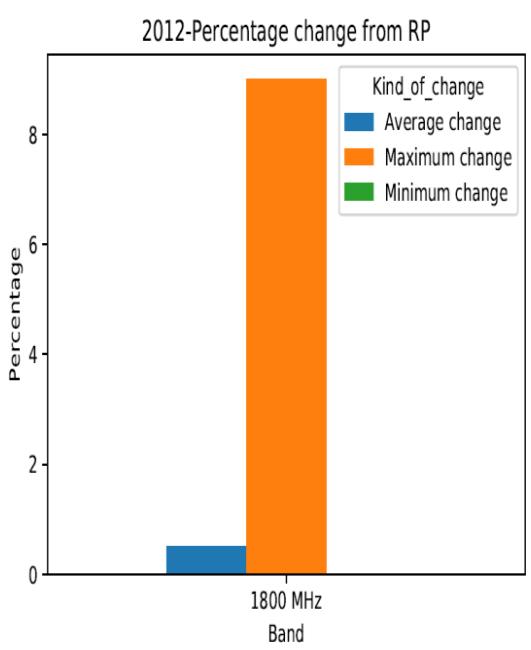
I. Calculation of maximum and minimum percentage change in an auction in any service area. The percent change is tabulated in the following table, followed by graphical plot.

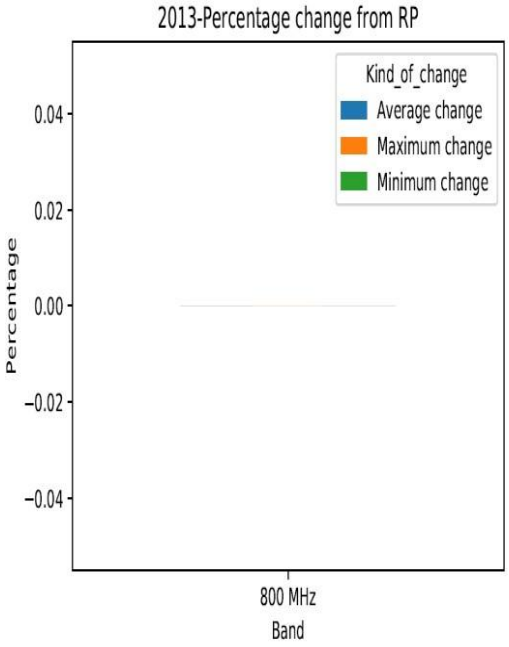
Auction	Band	Kind of change	Percentage	Service area where the change is observed.
2010 -3G	2100 MHz	Minimum change	1%	J & K
		Maximum change	936%	Delhi
		Average change	270%	-
2010-BW	2300 MHz	Minimum change	18%	WB
		Maximum change	1333%	Mumbai
		Average change	42.3%	-
2012	1800 MHz	Minimum change	0%	Sold at RP in 17 Service Areas
		Maximum change	9%	Bihar
		Average change	0.5%	-
2013	800 MHz	Minimum change	0%	Sold at RP in all 8 Service Areas
		Maximum change	0%	-
		Average change	0%	-
2014	1800 MHz	Minimum change	0%	Sold at RP in 11 Service Areas
		Maximum change	415%	Assam

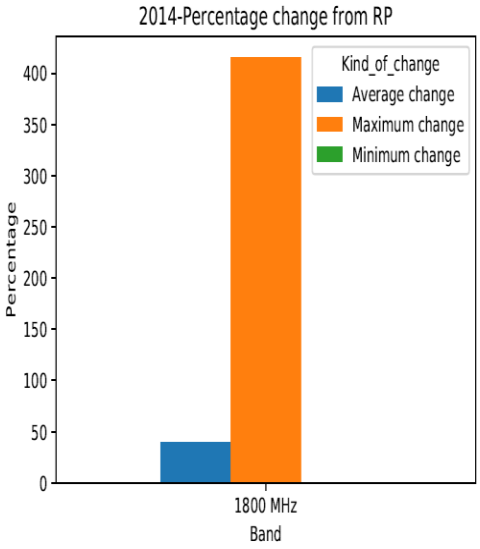
		Average change	40%	-
	900 MHz	Minimum change	55%	Kolkata
		Maximum change	105%	Delhi
		Average change	77%	-
2015	800 MHz	Minimum change	0%	Sold at RP in 4 Service Areas
		Maximum change	348%	MP
		Average change	28%	-
	900 MHz	Minimum change	47%	Maharashtra
		Maximum change	334%	UP (W)
		Average change	130%	-
	1800 MHz	Minimum change	0%	Sold at RP in 5 service areas
		Maximum change	104%	Kolkata
		Average change	28%	-
	2100 MHz	Minimum change	0%	Sold at RP in 4 Service Areas
		Maximum change	334%	Rajasthan
		Average change	12%	-
2016	800 MHz	Minimum change	0.02%	UP (E)
		Maximum change	17%	Gujarat
		Average change	11%	-
	1800 MHz	Minimum change	0%	Sold at RP in 12 service areas
		Maximum change	64%	Mumbai
		Average change	5%	-
	2100 MHz	Minimum change	0%	Sold at RP in all 12 service areas
		Maximum change	0%	-
		Average change	0%	-
	2300 MHz	Minimum change	0%	Sold at RP in 10 Service Areas
		Maximum change	56%	Gujarat
		Average change	5%	-
	2500 MHz	Minimum change	0%	Sold at RP in 20 Service Areas
		Maximum change	0.5%	Kerala
		Average change	0.025%	-

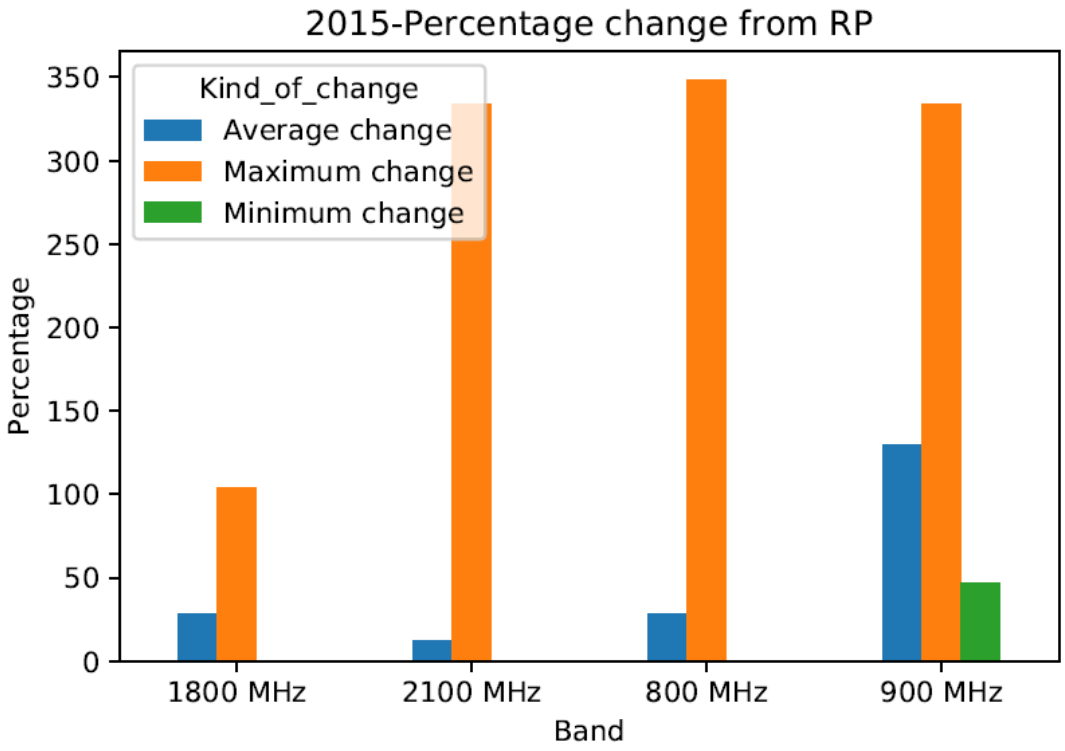


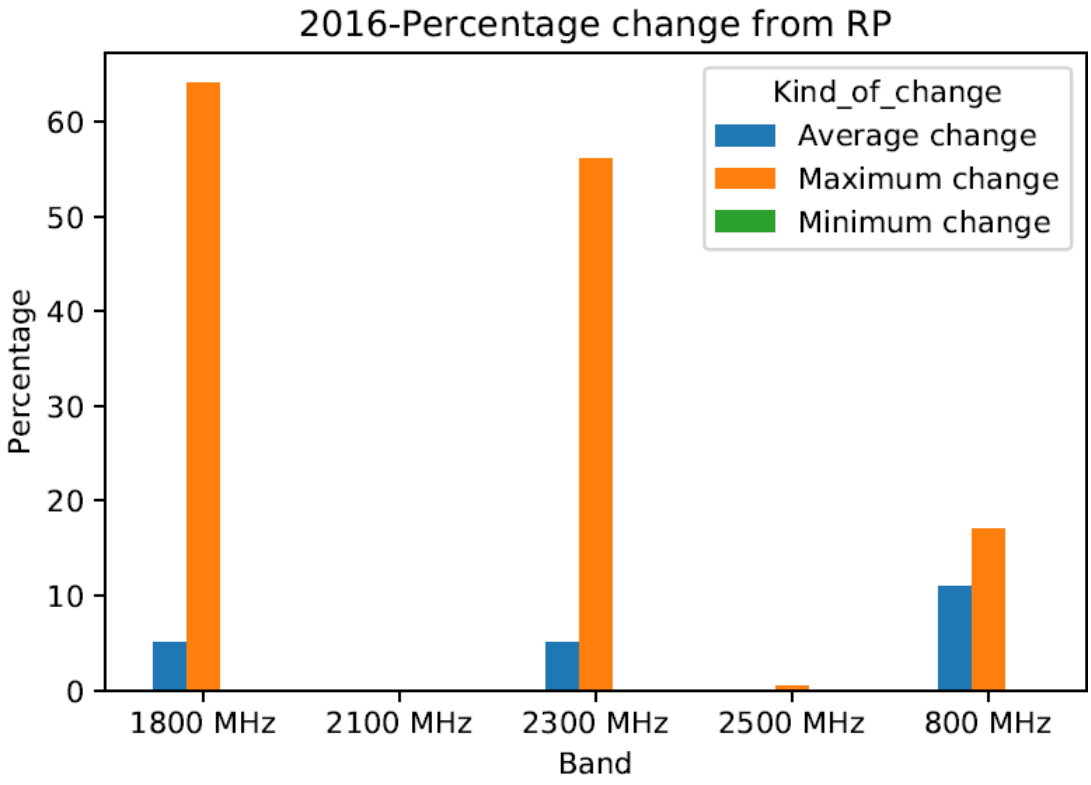



2012-Percentage change from RP
Kind_of_change
Average change
Maximum change
Minimum change
Percentage
0
2
4
6
8
1800 MHz
Band


2013-Percentage change from RP
Kind_of_change
Average change
Maximum change
Minimum change
Percentage
0.04
0.02
0.00
−0.02
−0.04
800 MHz
Band


2014-Percentage change from RP
Kind_of_change
Average change
Maximum change
Minimum change
Percentage
0
50
100
150
200
250
300
350
400
1800 MHz
Band


2015-Percentage change from RP
Kind_of_change
Average change
Maximum change
Minimum change
Percentage
0
50
100
150
200
250
300
350
1800 MHz
2100 MHz
800 MHz
900 MHz
Band


2016-Percentage change from RP
Kind_of_change
Average change
Maximum change
Minimum change
Percentage
0
10
20
30
40
50
60
1800 MHz
2100 MHz
2300 MHz
2500 MHz
800 MHz
Band

The following facts are obvious from the above:

1. The highest margin above the reserve price is in the price obtained in BWA auction held in 2010 for Mumbai circle (1333% gain). The 2010 auction overall yielded better return among all the auctions.
2. In 2013, the spectrum whatever was sold was only at reserve price. No increase in any circle price wherever there was activity.
3. The 'average percentage change' for the auctions of year 2014 and 2015 gives a healthy figure across the various bands whereas the same in the year yields poor value across all the bands.
4. In 2016 auction, the spectrum wherever was sold, it was sold more or less at the reserve price in most of the bands. This point to the fact that auctions held in 2014 and 2015 were better compared to the 2016 auction in terms of the spectrum sold above the reserve price.
5. In the various auctions, the spectrum was sold at RP in many service areas as shown below:

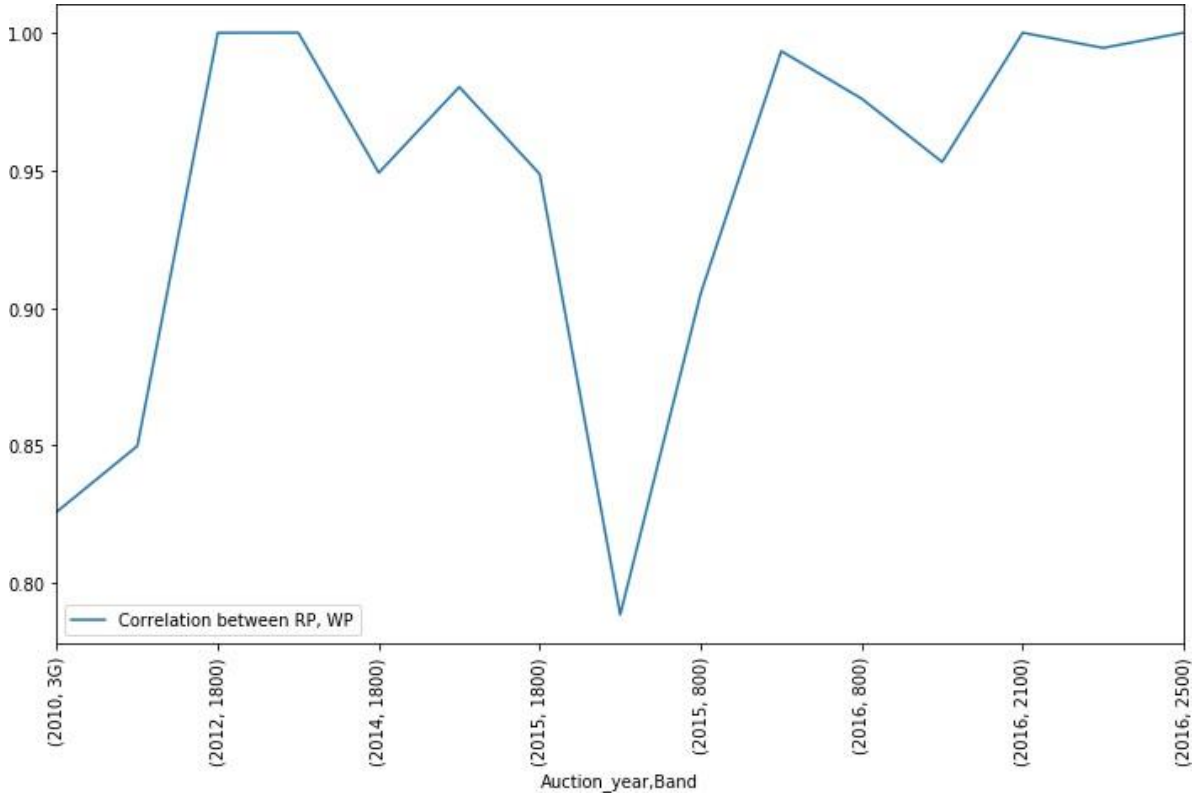
Year	Band	No of service area in which spectrum was offered. **A**	No of service area in which Spectrum was sold. **B**	No of service areas in which spectrum was sold at Reserve Price. **C**	Percentage of service areas in which spectrum was sold at Reserve Price. **C/B*100**
2012	1800 MHz	22	18	17	94.44
2013	800 MHz	21	8	8	100
2014	1800 MHz	22	22	11	50
	900 MHz	3	3	0	0
2015	800 MHz	20	18	4	22.22
	900 MHz	17	17	0	0
	1800 MHz	15	12	5	41.67
	2100 MHz	17	14	4	28.57
2016	800 MHz	19	4	1	25
	900 MHz	3	0	0	No spectrum sold
	1800 MHz	21	18	11	61.11
	2100 MHz	22	12	12	100
	2300 MHz	16	16	10	62.5
	2500 MHz	22	20	19	94.44

6. The spectrum in 2014 and 2015 were sold at a higher price (w.r.t. RP) compared to spectrum sold in years 2012, 2013 and 2016.

The correlation of the spectrum offered and spectrum sold is also tabulated in the following table:

Auction year	Band	Correlation between RP, WP
2010	3G	0.825852172
2010	BWA	0.849754456
2012	1800	0.99995948
2013	800	1
2014	1800	0.949073259
2014	900	0.980270134
2015	1800	0.948592026
2015	900	0.788449473

2015	800	0.905211439
2015	2100	0.993295157
2016	800	0.97601431
2016	1800	0.952973926
2016	2100	0.99999
2016	2300	0.994457884
2016	2500	0.99999



It may be seen from the above graph that the reserve price and winning price are positively correlated through the various auctions and across bands. The only exception that can be observed is the 900 MHz auction in the year 2015. The reserve price and winning price of 900 MHz in the year 2015 show that there is no linear relationship between the winning price and the reserve price. The competitions in the bidding in the circles were so high that the demand did not reflect the reserve price truly.

II). Quantity of spectrum sold in each auction: - The quantity of spectrum put to auction and the spectrum sold in each auction is highlighted in the table below. The percentage of the same is shown in the next table below it. If the quantum of spectrum sold is the criteria, then auctions held in 2010, 2014 and 2015 can be considered comparatively better than other auctions. The throughput in 2016 auction is also higher than the quantum offered in the previous auctions altogether from year 2012 onwards. But the outcome in terms of percentage of spectrum sold, the 2016 auction does not fare well though slightly better than 2012 and 2013 auction.

Auction	700 MHz Spectrum		800 MHz Spectrum		900 MHz Spectrum		1800 MHz Spectrum		2100 MHz spectrum		2300 MHz spectrum		2500 MHz spectrum	
	Put for auction	Sold	Put for auction	Sold	Put for auction	Sold	Put for auction	Sold	Put for auction	Sold	Put for auction	Sold	Put for auction	Sold
2010	-	-	-	-	-	-	-	-	465.00	465.00	1320.0	1320.0	-	-
2012	-	-	95.00	0.00	-	-	295.00	127.50	-	-	-	-	-	-
2013	-	-	95.00	30.00	42.50	0.00	57.50	0.00	-	-	-	-	-	-
2014	-	-	-	-	46.00	46.00	385.20	307.20	-	-	-	-	-	-
2015	-	-	108.75	86.25	177.80	168.20	99.20	93.80	85.00	70.00	-	-	-	-
2016	770.00	0.00	73.75	15.00	9.40	0.00	221.60	174.80	360.00	85.00	320.00	320.00	600.00	370.00

Auction period	Total spectrum put to auction	Total Spectrum Sold	Percentage of spectrum sold.
May-10	1785	1785	100
Nov-12	390	127.5	32.69
Mar-13	195	30	15.38
Feb-14	431.2	353.2	81.91
Mar-15	470.75	418.25	88.85
Oct-16	2354.75	964.8	40.97

III. No of rounds in the auction:-

No of clock rounds in an auction is another indicator for the activity in an auction. The number of rounds is shown in the following table.

2010(3G) : 183 rounds
2010(BWA) : 117 rounds
2012 : 14 rounds
2013 : 3 rounds
2014 : 68 rounds
2015 : 115rounds
2016 : 31 rounds

As is expected the number of rounds in the 2013 auction is lowest which confirms the lowest activity in that auction. The clock rounds in auction 2010, 2014 and 2015 are moderately high indicating the healthy auction. The activity in terms of number of clock rounds the auction in 2012 and 2016 also fare poor.

IV.The provisional winning bid and provisionally winning rank in each clock round:-

The two indicators namely, ‘‘pwb_end’’ and ‘‘pwb_rank_end’’, are the provisionally winning bid and provisional rank in each clock round of the auction respectively. The tracing of these

parameters give an idea of the progress of an auction. If the movements are vibrant, it shows the competition in the respective service area. If they remain flat, the response would be lukewarm. The movement of these indicators can be seen from the respective plots.

In order to plot the index *'pwb_end'*, the x-axis shows the number of clock rounds and the y-axis value is the bidding price in Crores. In the case of plotting of the other index *'pwb_rank_end'*, the x-axis is again showing the number of clock-rounds and the y-axis is the rank position in each round for the relevant service area. The plots of the various auctions for selected instances (generally maximum activity service area and least activity area are selected) may be seen in the pages below. The complete plots for different service areas for each auction arearchived in the Annexure.

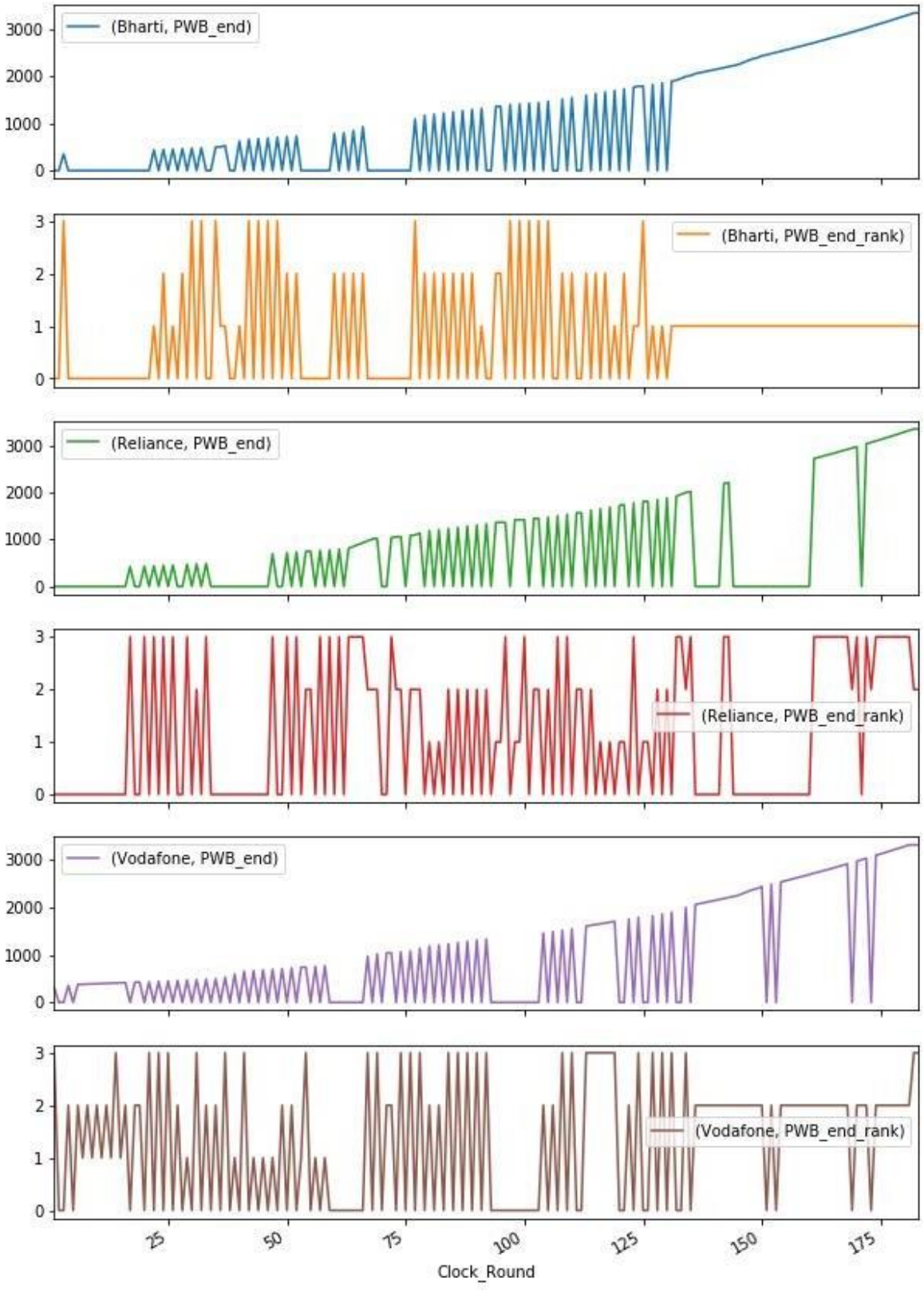
(i) 2010 3G auction:-

The data for the Delhi service area is plotted below. There are three blocks of spectrum and three winners in the bidding. The movement of the two parameters for the three winners may be seen from the plot below. The *'pwb_end'* indicator is linearly increasing proportional to the progressive bidding among the various bidders. The ranking indicator *'pwb_end_rank'* accordingly is shared among the users. The ranks keep on changing from 1 to 3 among the operators as the rounds progress. At the end of the clock rounds, the winning price of Rs.3316 crores is reached and as per the bidding the ranking is shared among the three major operators M/s Bharti, M/s Reliance and M/s Vodafone. Another example from 3G auction is that of West Bengal where the winning price is only slightly increased from the reserve price.

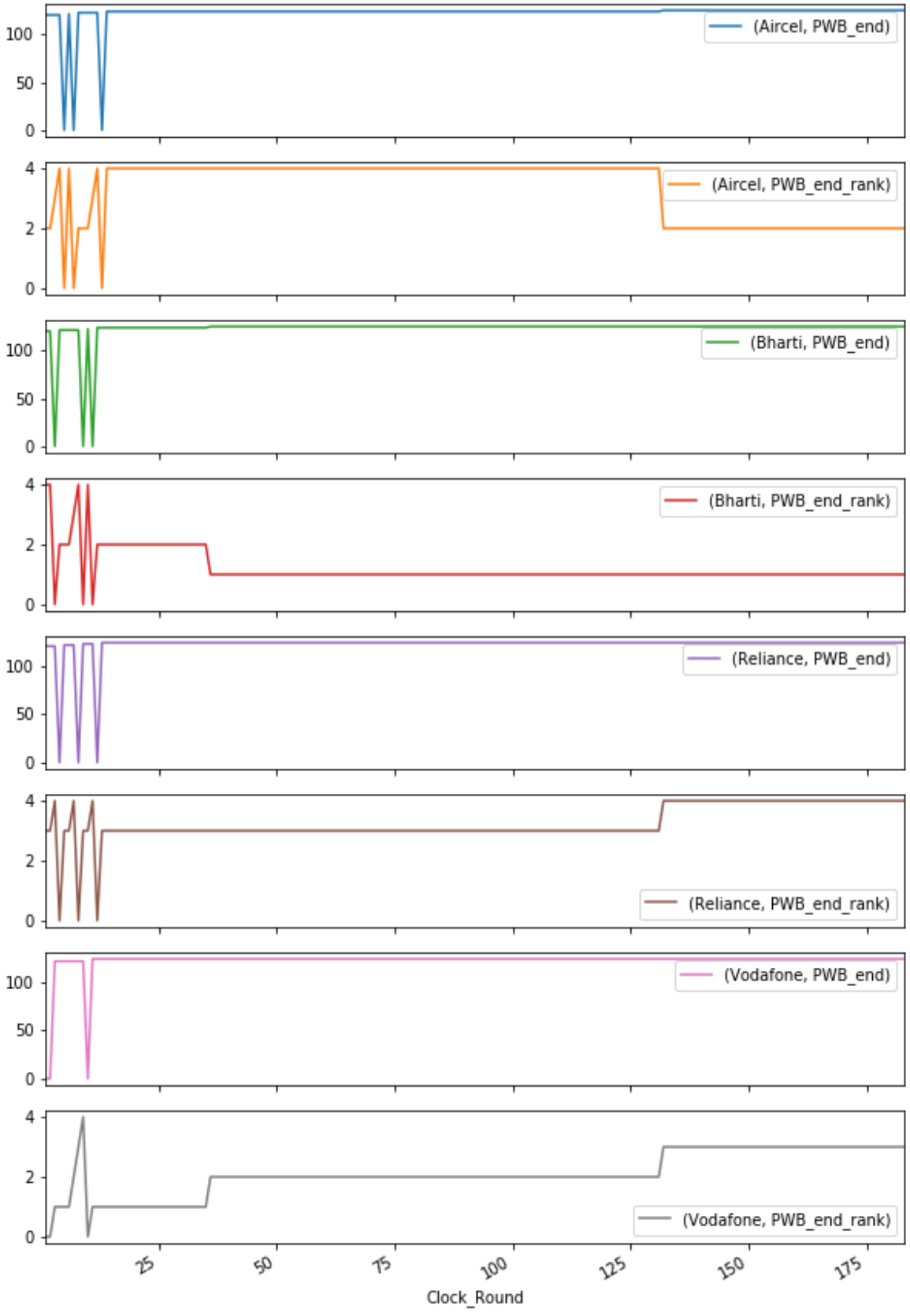
In the second example it can be seen from the plot that the activity is muted as is reflected in the final price which has only changed 3 % from the reserve price. The four blocks of 3G spectrum available in West Bengal service area is won by the four operators namely M/s Aircel, M/s Bharti, M/s Reliance and M/s Vodafone.

The difference in activity between Delhi and West Bengal can be clearly gauged from the map in which in the first case, the plot is more bubbly whereas in the latter case it is muted, which are in agreement with the price escalation.

Delhi


(Bharti, PWB_end)
(Bharti, PWB_end_rank)
(Reliance, PWB_end)
(Reliance, PWB_end_rank)
(Vodafone, PWB_end)
(Vodafone, PWB_end_rank)
Clock_Round

West Bengal


(Aircel, PWB_end)
(Aircel, PWB_end_rank)
(Bharti, PWB_end)
(Bharti, PWB_end_rank)
(Reliance, PWB_end)
(Reliance, PWB_end_rank)
(Vodafone, PWB_end)
(Vodafone, PWB_end_rank)
Clock_Round

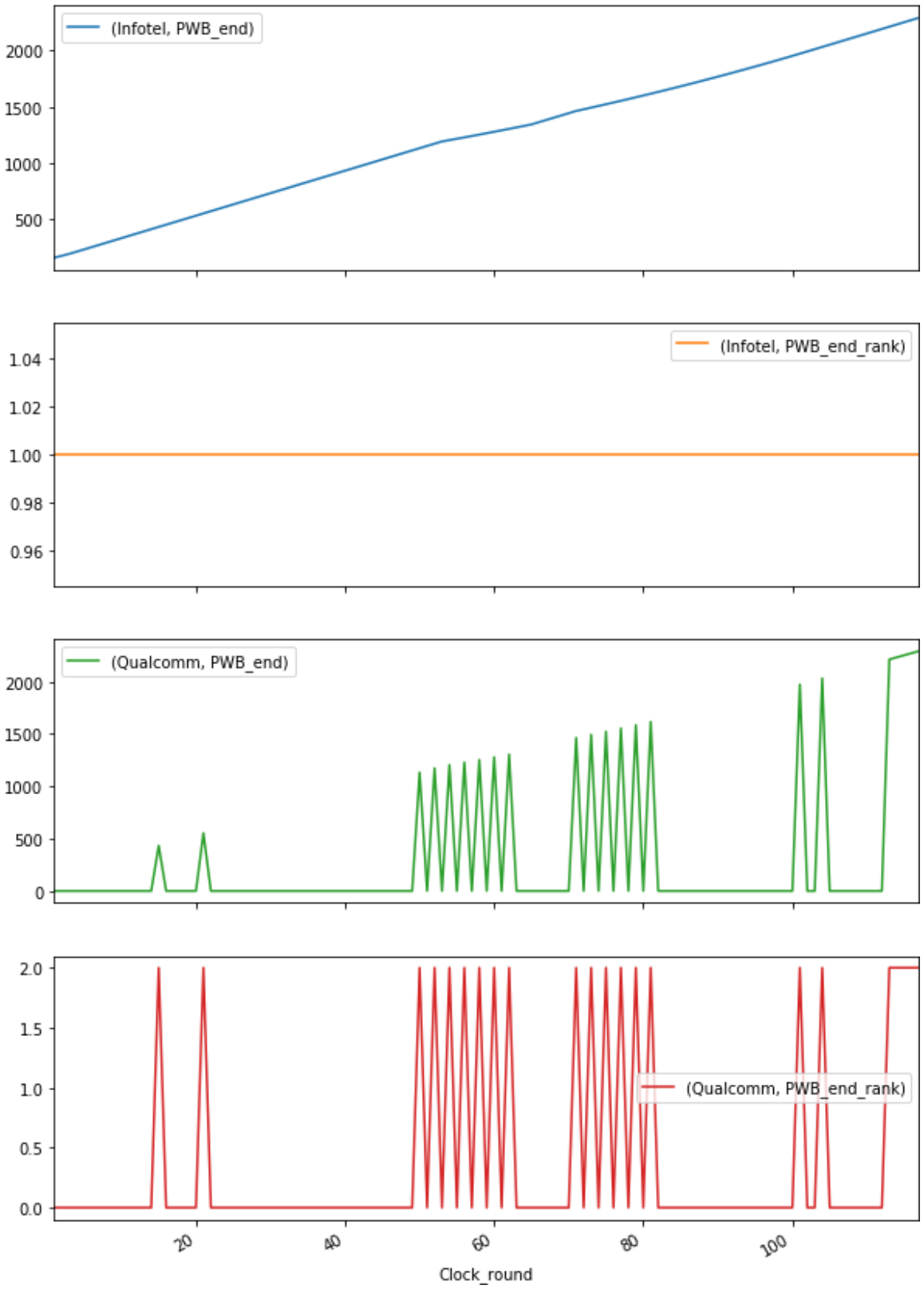
(ii) 2010 BWA auction: -

In order to appreciate the contrast more vividly, two examples from the BWA instance is plotted here in the following pages, that of Mumbai and HP. In the former case, the graph is livelier whereas in the second case it is low key. These outcomes are in the expected line with reference to the dispersion of winning price from the reserve price. In both service areas, there are two blocks of BWA spectrum. The first block is won by M/s Infotel in both service areas whereas the second is won by M/s Qualcomm in Mumbai and M/s Tikona in HP. In Mumbai, the first rank is always retained by M/s Infotel as can be seen from the parameter *''pwb_rank_end''* which is a straight line in the graph. In the second rank holders, M/s Qualcomm has to face competing bidding from other operators as is visible from the trail of *''pwb_rank_end''* which fluctuate between rank 0 (no rank) and rank 2 and finally settling down with rank 2. In the case of HP service area, M/s Tikona was able to seize the rank no 2 at the end of the clock rounds.

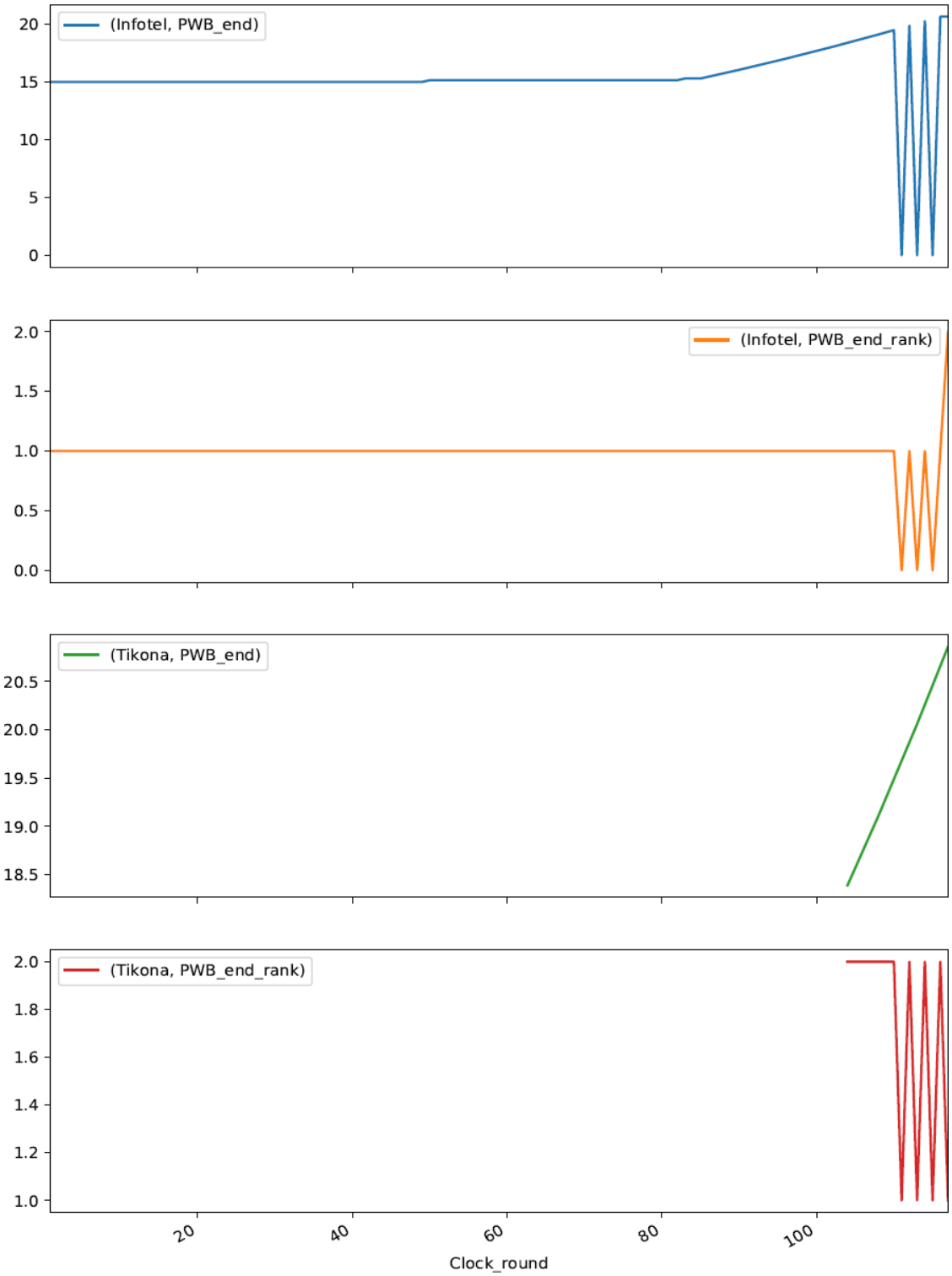
Service Area	Winner-1	Winner-2	Reserve Price	Winning Price
Andhra Pradesh	Infotel	Aircel	160	1059.12
Assam	Infotel	Aircel	15	33.02
Bihar	Infotel	Aircel	15	99.28
Delhi	Infotel	Qualcomm	160	2241.02
Gujarat	Infotel	Tikona	160	613.85
Haryana	Infotel	Qualcomm	60	119.9
Himachal Pradesh	Infotel	Tikona	15	20.66
Jammu and Kashmir	Infotel	Aircel	15	21.27
Karnataka	Infotel	Bharti	160	1543.25
Kerala	Infotel	Qualcomm	60	258.67
Kolkata	Infotel	Bharti	60	523.2
Madhya Pradesh	Infotel	Augere	60	124.66
Maharashtra	Infotel	Bharti	160	915.64
Mumbai	Infotel	Qualcomm	160	2292.95
North East	Infotel	Aircel	15	21.27
Orissa	Infotel	Aircel	15	63.63
Punjab	Infotel	Bharti	60	332.27
Rajasthan	Infotel	Tikona	60	97.32
Tamil Nadu	Infotel	Aircel	160	2069.45
Uttar Pradesh (E)	Infotel	Tikona	60	142.5
Uttar Pradesh (W)	Infotel	Tikona	60	183.87
West Bengal	Infotel	Aircel	60	70.97

It may be observed from the table above that the bidder M/s Infotel was able to win the first block of the two slots in each of the service areas. The movement of the rank index 1 is therefore stagnant throughout the clock rounds in all service areas. The bidding activity is more pronounced in the case of number 2 ranks in all circles where the competition for the second block is higher compared to the first block. This is the situation in all the service areas for the BWA auction. The only peculiar thing to notice in this BWA auction is the shallow net-worth of the company M/s Infotel which has aggressively bid in all circles and won the first block unchallenged. The net-worth of the company is paltry sum of Rs.30 Crores. This is in contrast with the total value of the spectrum won at a cost of Rs. 12847.77crores.The worth of the company is a miniscule of the total value of the spectrum won by the company. The auction theory suggests that the winning company should have the wherewithal to deploy the spectrum it won in the auction. After winning such a huge spectrum, the necessary infrastructure has to be developed by the company in order to make use of the spectrum. But the net worth of the company shown is not adequate enough to ensure the efficient utilization of the spectrum.

Mumbai


(Infotel, PWB_end)
2000
1500
1000
500
(Infotel, PWB_end_rank)
1.04
1.02
1.00
0.98
0.96
(Qualcomm, PWB_end)
2000
1500
1000
500
0
2.0
1.5
1.0
0.5
0.0
(Qualcomm, PWB_end_rank)
20
40
60
80
100
Clock_round

Himachal Pradesh



(iii) 2012 Auction: -

In this auction, 1800 MHz and 800 MHz spectrum were auctioned simultaneously. This was the first time that two different bands were auctioned at the same time. Both the 1800 MHz and 800MHz were of 1.25MHz block size. This was also the spectrum auction done under the court directions after the administrative licenses were cancelled by the court. Therefore there was a compulsion to complete the task within a limited time frame which might influence the outcome.

The data shows that the spectrum was sold at the reserve price in 17 service areas and at a slightly higher rate in Bihar and none in the remaining 4 service areas, namely Mumbai, Delhi, Karnataka and Rajasthan. In Bihar there is marginal increase (9%) in the final price above the reserve price. It may also be noted that Bihar is the only service area where four operators participated. Each block of spectrum was of 1.25 MHz slot in the 1800 MHz band. In Bihar total 11 blocks were bought by the operators. In 20 service areas 11 blocks of 1.25 MHz spectrum and in two service areas (Mumbai and Delhi) 8 blocks of 1.25 MHz were offered making it a total of 295 MHz . The rules of bidding were different for existing TSP and new TSP in each service areas. The new operator should bid for 4 blocks minimum and 5 blocks maximum whereas existing operators were allowed to bid for 1 and 2 blocks respectively in each service areas. Out of the total 295 MHz spectrum offered for sale, only 127.5 MHz spectrum was only sold in the 1800 MHz band. The auction was completed in 14 clock rounds which gives an idea of the low activity in the auction. From the auction aggregated data it can be seen that the excess demand remained negative throughout the auction. This accelerated the activity rate from 80% to 100 % within a few clock rounds. The activity in Bihar also can be seen from the plot that it is lackluster. The 4 operators maintained the same ranking throughout this 14 clock rounds except in case of Videocon and Vodafone where the ranks 2 and 3 switched few times between them. Apart from this, no clues can be seen from the auction history data. The net result of 1800 MHz spectrum auction is:

- In 17 service areas, the spectrum was won at the reserve price.
- In one service area, there was slight change of 9% rise in the price.
- In 4 service areas, no bid was received.
- Out of the 295 MHz spectrum offered, only 127.5 MHz (43%) was sold.

In the 800 MHz band no bid was received for the total 90 MHz spectrum offered for sale in various circles.

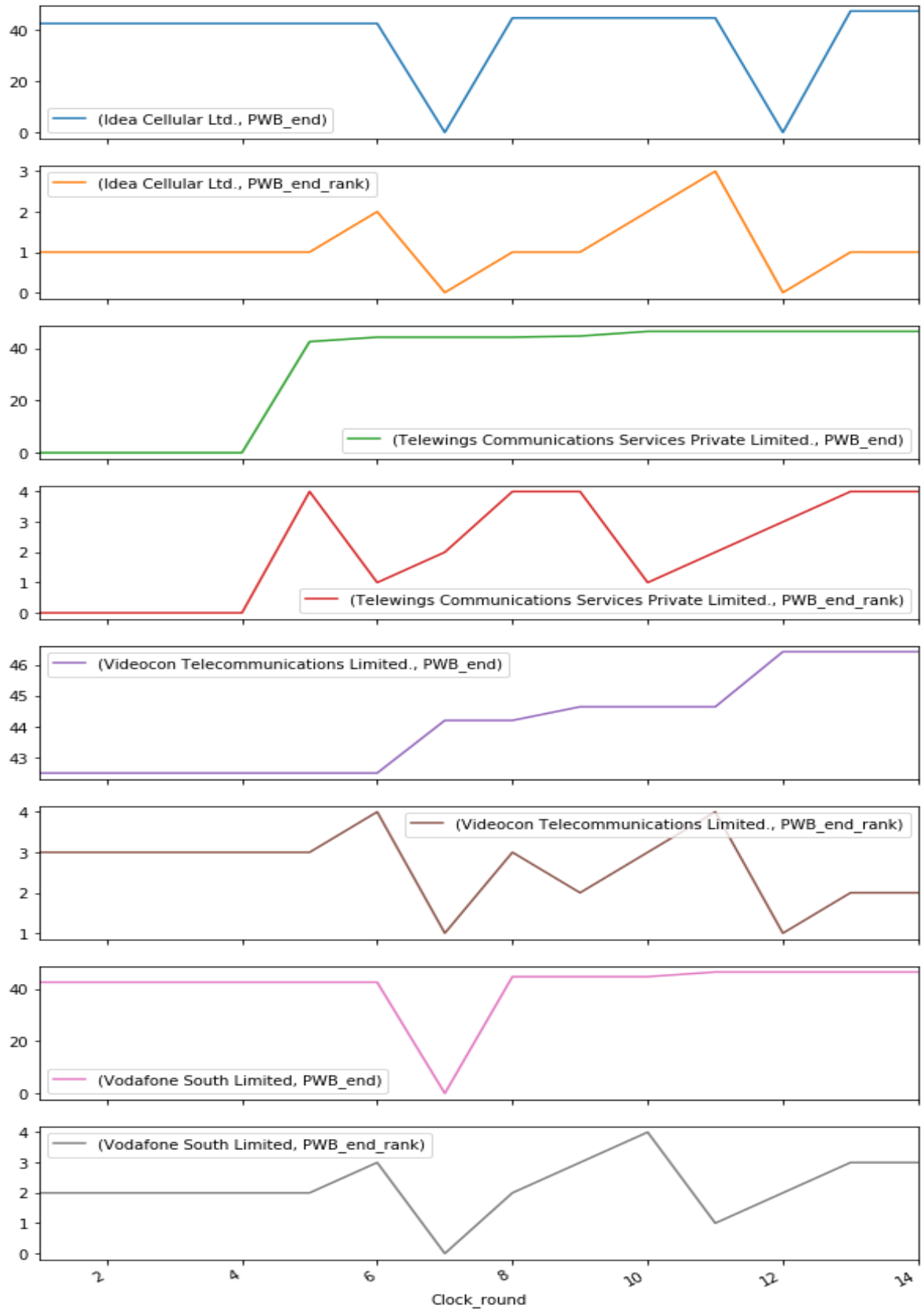
There are many reasons attributed to the low response to the auction held in 2012:

1. This auction held within 2 years after the 2010 auction, in which service providers have heavily invested in purchasing the spectrum. They were therefore deprived of the financial capacity.
2. The technology upgrade path for investing in the 1800 MHz and 800 MHz were not available at that time nor there was any option was available to the TSP to trade the spectrum.
3. 1.25 MHz spectrum slots were inconvenient from a technological point for the 2G purpose.
4. The impact of 2G case verdict was still lingering on.
5. Number of operators providing 2G service were far too many and the feasibility of breaking even was remote.
6. The reserve price fixed might have been another barrier.

Sl. No.	Service Area	1800 MHz-Reserve Price per Block per Service Area (Rs. Crore)	1800 MHz-Winning Price	Percentage change	800 MHz-Reserve Price per Block per Service Area (Rs. Crore)	800 MHz-Winning Price
1	West Bengal	25.84	25.84	0	33.59	No bid
2	Andhra Pradesh	286.91	286.91	0	372.99	No bid
3	Assam	8.67	8.67	0	11.27	No bid
4	Bihar	42.51	46.43	9.22	55.26	No bid
5	Gujarat	224.84	224.84	0	292.29	No bid
6	Haryana	46.52	46.52	0	60.47	No bid
7	Himachal Pradesh	7.78	7.78	0	10.11	No bid
8	Jammu & Kashmir	6.33	6.33	0	8.23	No bid
9	Karnataka	330.12	No bid	Not sold	429.16	No bid
10	Kerala	65.3	65.3	0	84.89	No bid
11	Madhya Pradesh	53.99	53.99	0	70.18	No bid
12	Maharashtra	262.81	262.81	0	341.66	No bid
13	North East	8.84	8.84	0	11.49	No bid
14	Orissa	20.27	20.27	0	26.35	No bid
15	Punjab	67.28	67.28	0	87.47	No bid
16	Rajasthan	67.08	No bid	-	87.2	No bid
17	Tamil Nadu	306.09	306.09	0	397.92	No bid
18	Uttar Pradesh(W)	107.41	107.41	0	139.63	No bid
19	Uttar Pradesh(E)	76.17	76.17	0	99.02	No bid
20	Delhi	693.06	No bid	Not sold	900.98	No bid
21	Kolkata	113.72	113.72	0	147.84	No bid
22	Mumbai	678.45	No bid	Not sold	881.99	No bid

The plots for Bihar service area may be seen below.

Bihar


(Idea Cellular Ltd., PWB_end)
(Idea Cellular Ltd., PWB_end_rank)
(Telewings Communications Services Private Limited., PWB_end)
(Telewings Communications Services Private Limited., PWB_end_rank)
(Videocon Telecommunications Limited., PWB_end)
(Videocon Telecommunications Limited., PWB_end_rank)
(Vodafone South Limited, PWB_end)
(Vodafone South Limited, PWB_end_rank)
Clock_round

(iv) 2013 auction:

This was supposed to be another multiband auction which offered 1800MHz, 900 MHz and 800 MHz together. The 1800 MHz and 900 MHz were considered as a single auction and the 800 MHz auction as a separate auction. The 1800 MHz spectrum was to be auctioned in Mumbai, Delhi, Karnataka and Rajasthan and 900 MHz in Delhi, Mumbai and Kolkata. 800 MHz were to be auctioned in 21 service areas. The result shows that only 800 MHz spectrum was sold whereas for 900 MHz and 800 MHz bands there was no demand. The 800 MHz was sold in 8 service areas, that too to a single bidder M/s SSTL. The winning price in all these service areas also capped at the reserve price. That meant the bidding activity was also nil. The overall statistics can be seen in the following table.

Service Area	Band	Spectrum put to auction	Number of Blocks (1.25MHz paired)	Reserve Price per Block (In Rs in Crores)	Winning price	Percentage change
Delhi	1800	15MHz	12	485.15	No bid	Not sold
Mumbai	1800	15MHz	12	474.92	No bid	Not sold
Karnataka	1800	10MHz	8	231.08	No bid	Not sold
Rajasthan	1800	10MHz	8	46.96	No bid	Not sold
Delhi	900	15MHz	12	970.3	No bid	Not sold
Mumbai	900	15MHz	12	949.84	No bid	Not sold
Kolkata	900	12.5 MHz	10	227.44	No bid	Not sold
Andhra Pradesh	800	2.50MHz	2	186.5	No bid	Not sold
Assam	800	3.75MHz	3	5.64	No bid	Not sold
Bihar	800	3.75MHz	3	27.63	No bid	Not sold
Delhi	800	3.75MHz	3	450.49	450.49	0
Gujarat	800	3.75MHz	3	146.15	146.15	0
Haryana	800	3.75MHz	3	30.24	No bid	Not sold
HP	800	3.75MHz	3	5.06	No bid	Not sold
J &Kashmir	800	3.75MHz	3	4.11	No bid	Not sold
Karnataka	800	3.75MHz	3	214.58	214.58	0
Kerala	800	3.75MHz	3	42.45	42.45	0
Kolkata	800	3.75MHz	3	73.92	73.92	0
Madhya Pradesh	800	3.75MHz	3	35.09	No bid	Not sold
Maharashtra	800	3.75MHz	3	170.83	No bid	Not sold
Mumbai	800	3.75MHz	3	441	No bid	Not sold
North East	800	3.75MHz	3	5.75	No bid	Not sold
Orissa	800	3.75MHz	3	13.18	No bid	Not sold
Punjab	800	2.50MHz	2	43.74	No bid	Not sold
Tamil Nadu	800	3.75MHz	3	198.96	198.96	0
Uttar Pradesh	800	3.75MHz	3	49.51	No bid	Not sold
Uttar Pradesh (W)	800	3.75MHz	3	69.82	69.82	0
West Bengal	800	3.75MHz	3	16.79	16.79	0

Since the auction ended in 3 rounds, there is no data to plot. Therefore the key indicators are not captured.

(v) 2014 auction:-

In this action, spectrum was offered in 1800 MHz and 900 MHz. The auction of 1800 MHz and 900 MHz was conducted as a single auction, as both bands are considered complementary spectrum. Block size was kept 200 KHz (Paired) in 1800 MHz Band and 1 MHz (Paired) in 900 MHz Band. Minimum number of blocks to be bid was 25 in 1800 MHZ band for new entrant while 'existing' licensee have to bid for minimum of 3 blocks in 1800 MHz band. Each Bidder is required to bid for a minimum of 5 Blocks in 900 MHz Band. The result of the auction can be seen from the following table.

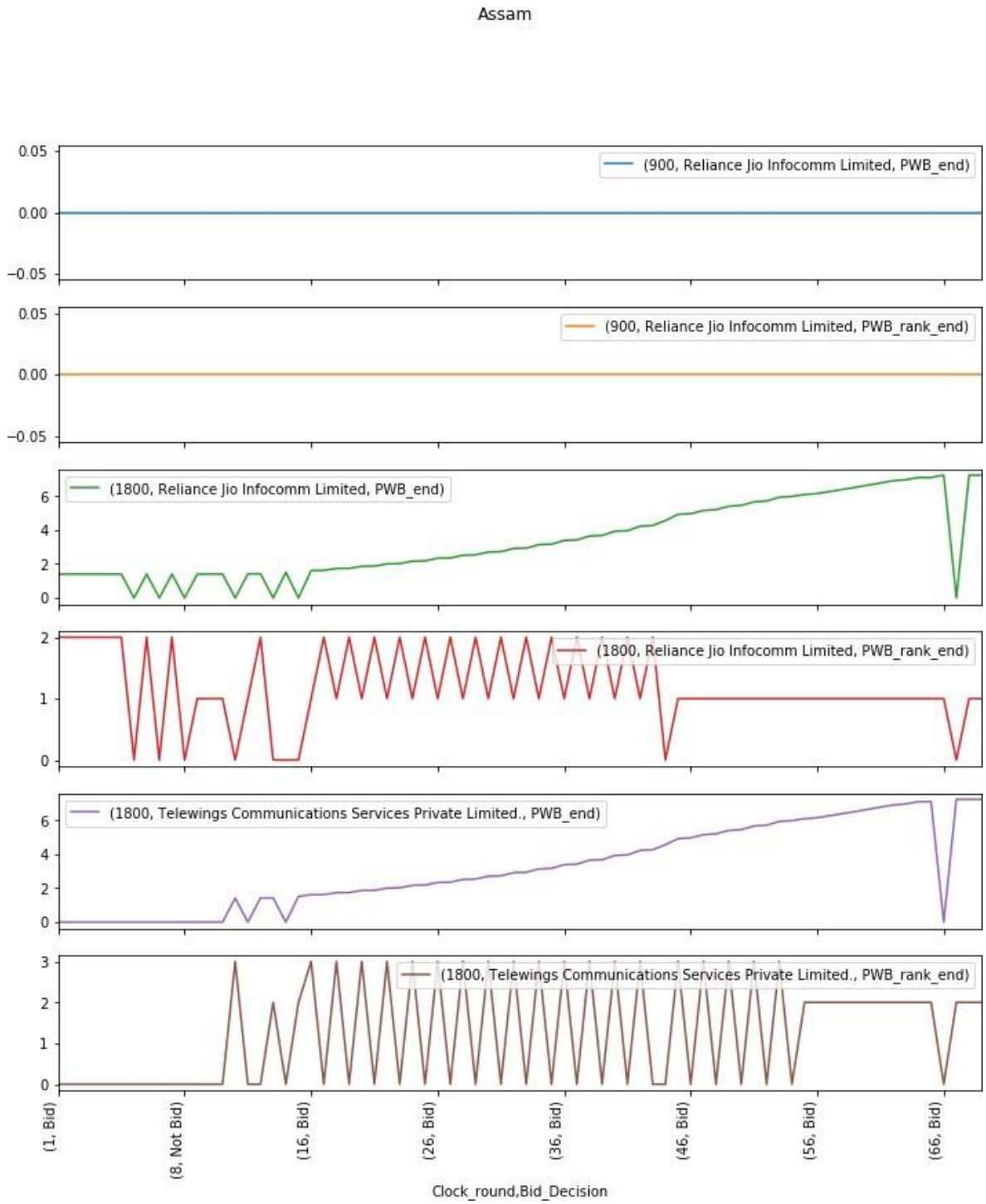
1800 MHz

Sl. No.	Name of Service Area	Spectrum put to Auction (In MHz)	Number of Blocks	Reserve Price per Block (In INR in Cr.)	Winning Price (In INR in Cr.)	Percent change
1	Andhra Pradesh	22.6	113	32.6	32.6	0
2	Assam	11.4	57	1.4	7.22	415.71
3	Bihar	4.2	21	7.4	8.62	16.49
4	Delhi	22.8	114	43.8	72.8	66.21
5	Gujarat	12	60	28.6	47.56	66.29
6	Haryana	16.4	82	5.4	5.4	0
7	HP	20.4	102	1.2	1.2	0
8	Jammu &Kashmir	6.2	31	1	1.22	22
9	Karnataka	24.6	123	31	31	0
10	Kerala	28	140	10.4	10.4	0
11	Kolkata	26.8	134	14.6	14.6	0
12	Madhya Pradesh	19.2	96	8.6	10.08	17.21
13	Maharashtra	14	70	34.6	58.07	67.83
14	Mumbai	25.2	126	41.4	54.4	31.4
15	North East	26.8	134	1.4	1.4	0
16	Orissa	28	140	3.2	3.2	0
17	Punjab	18.4	92	10.8	10.8	0
18	Rajasthan	20.8	104	5.2	5.2	0
19	Tamil Nadu	30.2	151	41.6	41.6	0
20	Uttar Pradesh(East)	9.8	49	12.2	12.8	4.92
21	Uttar Pradesh(West)	2.4	12	12.4	18.99	53.15
22	West Bengal	13	65	4.2	4.92	17.14
	900 MHz					
1	Delhi	16	16	360	740.96	105.82
2	Kolkata	14	14	125	194.63	55.7
3	Mumbai	16	16	328	563.09	71.67

In 1800 MHz band, spectrum was offered in all 22 service areas totalling 385.20 MHz out of which 307.20 were won by the operators. In 11 service areas spectrum was sold only at the reserve

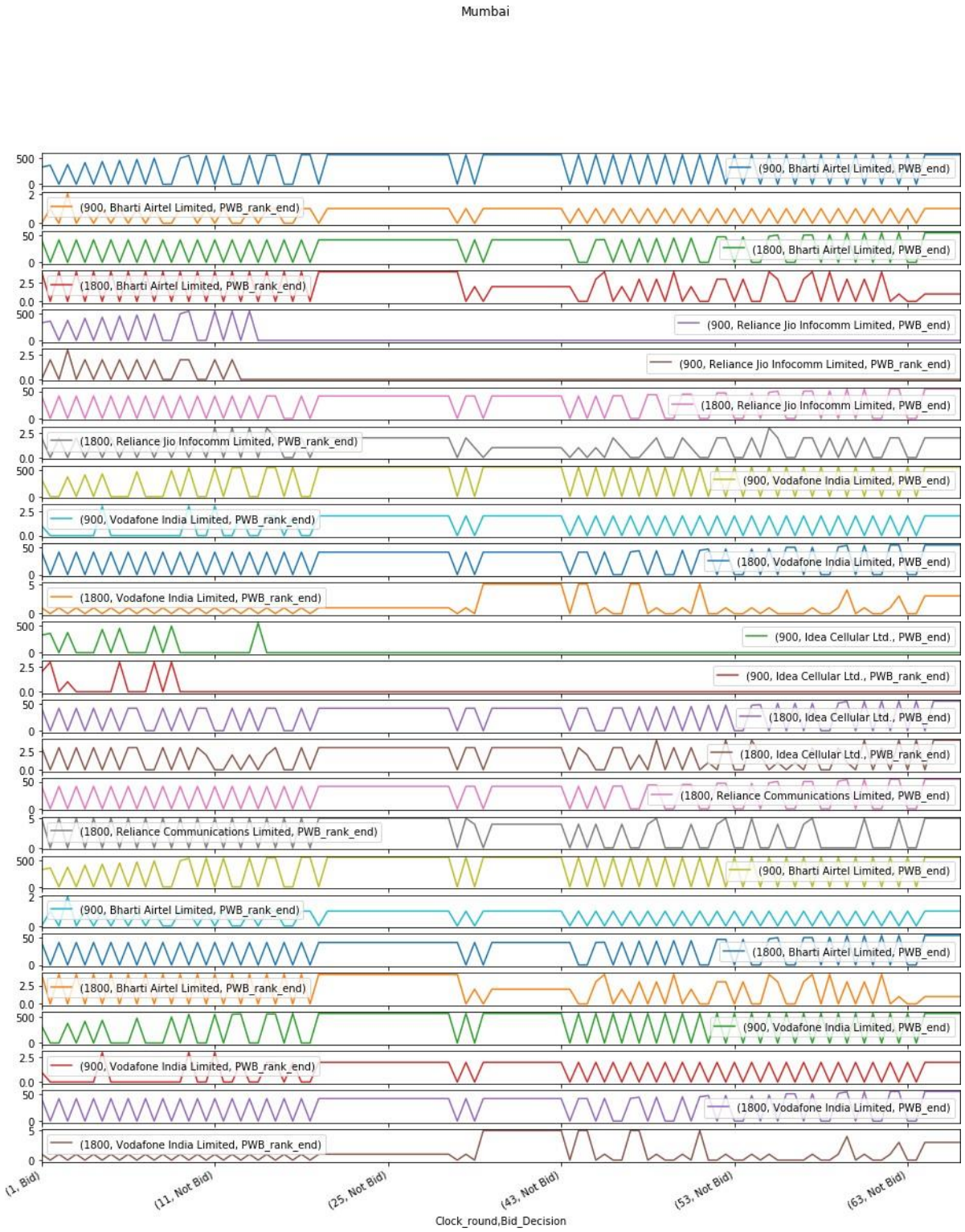
price. In other 11 service areas, moderate activity is witnessed. In 900 MHz, 46 MHz spectrum in three service areas was offered and the entire spectrum was taken by the operators.

In 1800 MHz auction maximum activity is seen in Assam service areas. The plot is here .The plot of Mumbai where both 1800 MHz and 900 MHz were sold is also produced here:



There are two operators in Assam who won the spectrum M/s Reliance Jio and M/s Telewings. Both are slowly and steadily reaching the target without resistance may be seen from the parameter ‘*‘pwb_end’’*. The rank parameter ‘pwb_end’_rank also shows the 1 and 2 ranks shared by these two

operators. Some activity can be witnessed upto round 56 (due to a third operator in the bidding) after which it become stagnant.



In Mumbai service area, in the 900 MHz band M/s Bharti and M/s Vodafone persistently bid and won whereas M/s Reliance Jio and M/s Idea withdrawn after few initial rounds into the bidding. In the 1800 MHz band, there are 5 winners of the 16 MHz spectrum- M/s Bharti, M/s Vodafone, M/s Jio, M/s RCL and M/s Idea.

(vi) 2015 Auction: -

In this auction there were 4 bands offered-800 MHz, 900 MHz, 1800 MHz and 2100 MHz. The bidding conditions of these bands were as follows.

- 1800 MHz: Block size of 200 kHz in 1800 MHz Band. The existing licensees would be required to bid for a minimum of 0.6 MHz spectrum. New entrants and expiring licensees have to bid for a minimum of 5 MHz.
- 900 MHz: Block size of 200 kHz in 900 MHz Band. New entrant / licensees whose licenses are expiring in 2015-16/ Existing licensees whose licenses are not expiring in 2015-16 & holding spectrum only in 1800 MHz band would bid for a minimum of 5 MHz of spectrum in the 900 MHz band

- 800 MHz: - Block size of 1.25 MHz in 800 MHz Band. II. A new entrant is required to bid for a minimum of 4 blocks/3 Blocks/2 Blocks subject to availability. Existing licensees holding spectrum in 800 MHz band may bid for a minimum of 1 block.

- 2100 MHz: Block size of 5 MHz in 2100 MHz band.

At the time of auction spectrum was available in 15 service areas in 1800 MHz, 17 service areas in 900 MHz, 20 service areas in 800 MHz and 17 service areas in 2100 MHz bands. There was sufficient spectrum available in all the four bands. The quantum of spectrum sold band-wise is indicated in the table below:

Band	Quantum offered	Quantum sold	Percentage
800 MHz	108.75	86.25	79.31
900 MHz	177.80	168.20	94.6
1800 MHz	99.20	93.80	94.56
2100 MHz	85.00	70.00	82.35
Total	470.75	418.25	88.85

The outcome with respect to the quantum of spectrum sold can be considered very positive as 89% of spectrum was sold. But from the point of revenue, it is a successful auction considering the spectrum sold above the reserve price, especially in the 900 MHz band.

		1800 MHz band				
	Name of Service Area	Spectrum put to Auction (In MHz)	Number of Blocks	Reserve Price per Block (In INR inCr.)	Winning price	Percentage Change
1	Andhra Pradesh	3.8	19	33.8	48.56	43.67
2	Bihar	2	10	12.4	No bid	Not sold
3	Gujarat	3.4	17	47.6	47.6	0
4	Haryana	8	40	6.4	9.32	45.63

5	HP	10.2	51	1.8	3.18	76.67
6	Karnataka	1.8	9	37	37	0
7	Kerala	1	5	15	No bid	Not sold
8	Kolkata	7	35	14.6	29.82	104.25
9	North East	8.4	42	2.2	2.2	0
10	Odisha	16.2	81	4.6	6.62	43.91
11	Punjab	1.6	8	14.2	14.2	0
12	Rajasthan	10.4	52	12	14.55	21.25
13	Tamil Nadu	19	95	45	45	0
14	UP(E)	4.2	21	19.4	No bid	Not sold
15	UP(W)	2.2	11	19	19.19	1
		900 MHz band				
1	Andhra Pradesh	14	70	91.8	136.15	48.31
2	Assam	6.2	31	14.8	36.99	149.93
3	Bihar	6.2	31	29.6	88.86	200.2
4	Gujarat	14	70	84.8	134.6	58.73
5	Haryana	12.4	62	15.2	30.24	98.95
6	HP	12.4	62	5.4	11.49	112.78
7	Karnataka	14	70	74	111.5	50.68
8	Kerala	12.4	62	33.6	73.88	119.88
9	MP	12.4	62	35	61.9	76.86
10	Maharashtra	14	70	105	154.6	47.24
11	North East	8.8	44	5.8	10.38	78.97
12	Odisha	6.2	31	13.4	27.8	107.46
13	Punjab	15.6	78	30.2	72.15	138.91
14	Rajasthan	12.4	62	39.4	141.73	259.72
15	UP(E)	6.2	31	45.6	155.12	240.18
16	UP(W)	6.2	31	34	147.71	334.44
17	West Bengal	4.4	22	22.2	41.5	86.94
		800 MHz band				
1	Andhra Pradesh	6.25	5	292.5	757.48	158.97
2	Assam	11.25	9	35	102.77	193.63
3	Bihar	5	4	106.25	107.31	1
4	Delhi	3.75	3	771.25	1059.62	37.39
5	Gujarat	2.5	2	343.75	347.18	1
6	Haryana	7.5	6	47.5	70.71	48.86
7	HP	8.75	7	23.75	24.46	2.99
8	J & K	8.75	7	35	35.35	1
9	Karnataka	1.25	1	378.75	No bid	Not sold
10	Kolkata	1.25	1	183.75	183.75	0
11	MP	6.25	5	113.75	510.49	348.78
12	Maharashtra	3.75	3	423.75	999.27	135.82
13	Mumbai	7.5	6	548.75	909.37	65.72
14	North East	11.25	9	13.75	31.72	130.69
15	Odisha	7.5	6	47.5	51.3	8

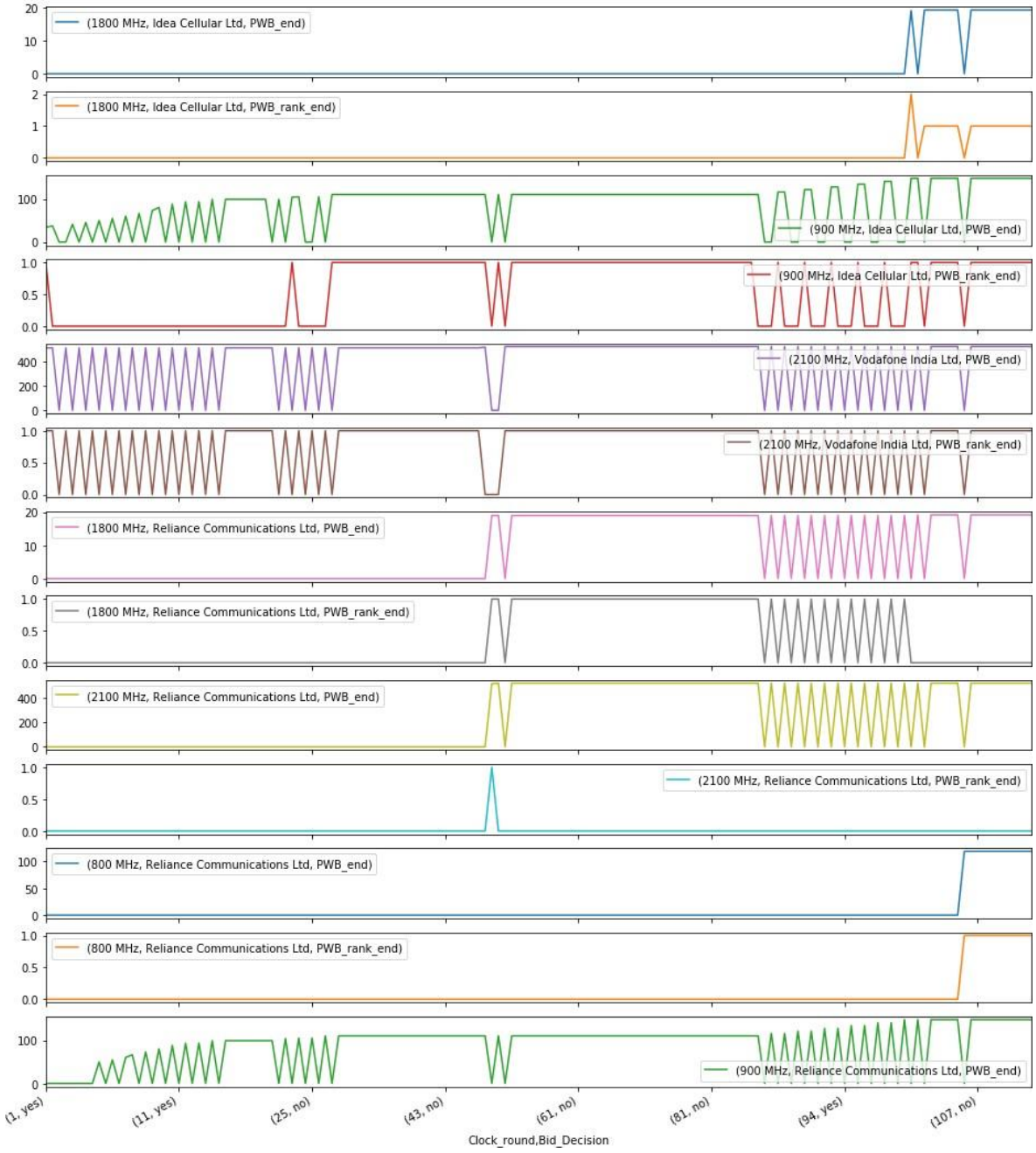
16	Punjab	3.75	3	106.25	107.31	1
17	Tamil Nadu	1.25	1	450	No bid	Not sold
18	UP(E)	3.75	3	167.5	167.5	0
19	UP(W)	1.25	1	118.75	118.75	0
20	West Bengal	1.25	1	71.25	71.25	0
		2100 MHz band				
1	AP	5	1	1375	No bid	Not sold
2	Assam	5	1	145	193.18	33.23
3	Delhi	5	1	3315	No bid	Not sold
4	Gujarat	5	1	1290	1290	0
5	Haryana	5	1	230	230	0
6	Karnataka	5	1	1610	1642.36	2.01
7	Kerala	5	1	555	588.57	6.05
8	Kolkata	5	1	545	577.97	6.05
9	MP	5	1	435	456.75	5
10	Maharashtra	5	1	1505	1505	0
11	Mumbai	5	1	3245	No bid	Not sold
12	North East	5	1	40	55.35	38.38
13	Odisha	5	1	165	180.26	9.25
14	Rajasthan	5	1	435	699.12	60.72
15	Tamil Nadu	5	1	1720	1720	0
16	UP(E)	5	1	430	451.5	5
17	UP(W)	5	1	515	525.35	2.01

The activity is moderately strong across the bands and across the different service areas. Two examples are plotted below to indicate the movement of the key indicators, *''pwb_end''* and *''pwb_rank_end''*.

From the plot of UP (E) it can be seen the activity in 800 MHz and 1800 MHz is low key whereas the activity in 900 MHz and 2100 MHz bands are comparatively better in the UP (E) service area. This confirms with the outcome of these bands from the table above.

In Gujarat service area, the activity is minimum to moderate across all the bands. The activity however stops midway after 60 rounds of bidding.

Uttar Pradesh (West)



Gujarat

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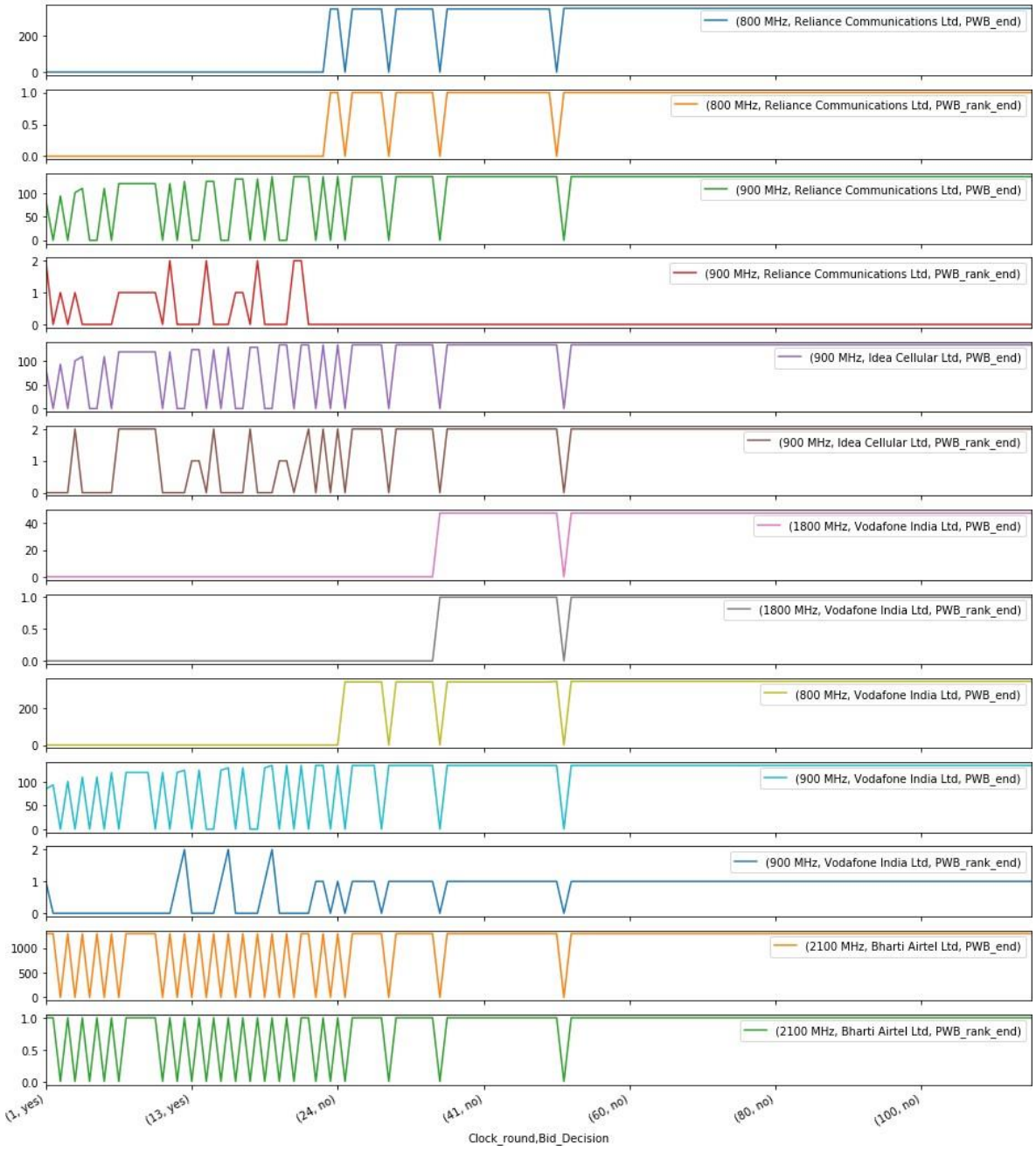
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(800 MHz, Reliance Communications Ltd, PWB_rank_end)
(900 MHz, Reliance Communications Ltd, PWB_end)
(900 MHz, Reliance Communications Ltd, PWB_rank_end)
(900 MHz, Idea Cellular Ltd, PWB_end)
(900 MHz, Idea Cellular Ltd, PWB_rank_end)
(1800 MHz, Vodafone India Ltd, PWB_end)
(1800 MHz, Vodafone India Ltd, PWB_rank_end)
(800 MHz, Vodafone India Ltd, PWB_end)
(900 MHz, Vodafone India Ltd, PWB_end)
(900 MHz, Vodafone India Ltd, PWB_rank_end)
(2100 MHz, Bharti Airtel Ltd, PWB_end)
(2100 MHz, Bharti Airtel Ltd, PWB_rank_end)
(1, yes)
(13, yes)
(24, no)
(41, no)
(60, no)
(80, no)
(100, no)
Clock_round,Bid_Decision

(vii) 2016:-

A single auction process was carried out for assigning Spectrum blocks in various bands viz. 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz Bands. The bidding conditions were as follows.

(a) 1800 MHz: Block size of 200 kHz in 1800 MHz Band. The existing licensees would be required to bid a minimum of 0.6 MHz spectrum. New entrants and expiring licensees have to bid for a minimum of 5 MHz.

(b) 900 MHz: Block size of 200 kHz in 900 MHz Band. New entrant would bid for a minimum of 5 MHz of spectrum in the 900 MHz band and existing licensees would bid for a minimum of 0.6 MHz

(c) 800 MHz: - Block size of 1.25 MHz in 800 MHz Band. A new entrant is required to bidfor a minimum of 4 blocks/3 Blocks/2 Blocks subject to availability. Existing licensees holding spectrum in 800 MHz band may bid for a minimum of 1 block.

(d) 2100 MHz: Block size of 5 MHz in 2100 MHz band.

(e) 2300 MHz: Block size of 10 MHz (TDD) in 2300 MHz band.

(f) 2500 MHz: Block size of 10 MHz (TDD) in 2500 MHz band.

The outcome of the auction with respect to quantum of spectrum sold is given below, band-wise:

Band	Quantum offered	Quantum sold	Percentage
700 MHz	770.00	0.00	0
800 MHz	73.75	15.00	20.34
900 MHz	9.40	0.00	0
1800 MHz	221.60	174.80	78.88
2100 MHz	360.00	85.00	23.61
2300 MHz	320.00	320.00	100
2500 MHz	600.00	370.00	61.67
Total	2354.75	964.80	40.97

It may be seen from the above table that 700 MHz and 900 MHz were ignored by the bidders. The overall response is also mediocre across all bands except 1800 MHz band. The 800 MHz and 2100 MHz fared poorly in the auction because of low demand. The 1800 MHz band was reasonably sold. Incorporating the 7 different bands into a single auction was a challenging task since the software became extremely complex with a number of in built entry restrictions. The price at which the spectrum was sold with reference to the reserve price and the percentage change in price can be seen in the following table. The spectrum wherever was sold was mostly at the reserve

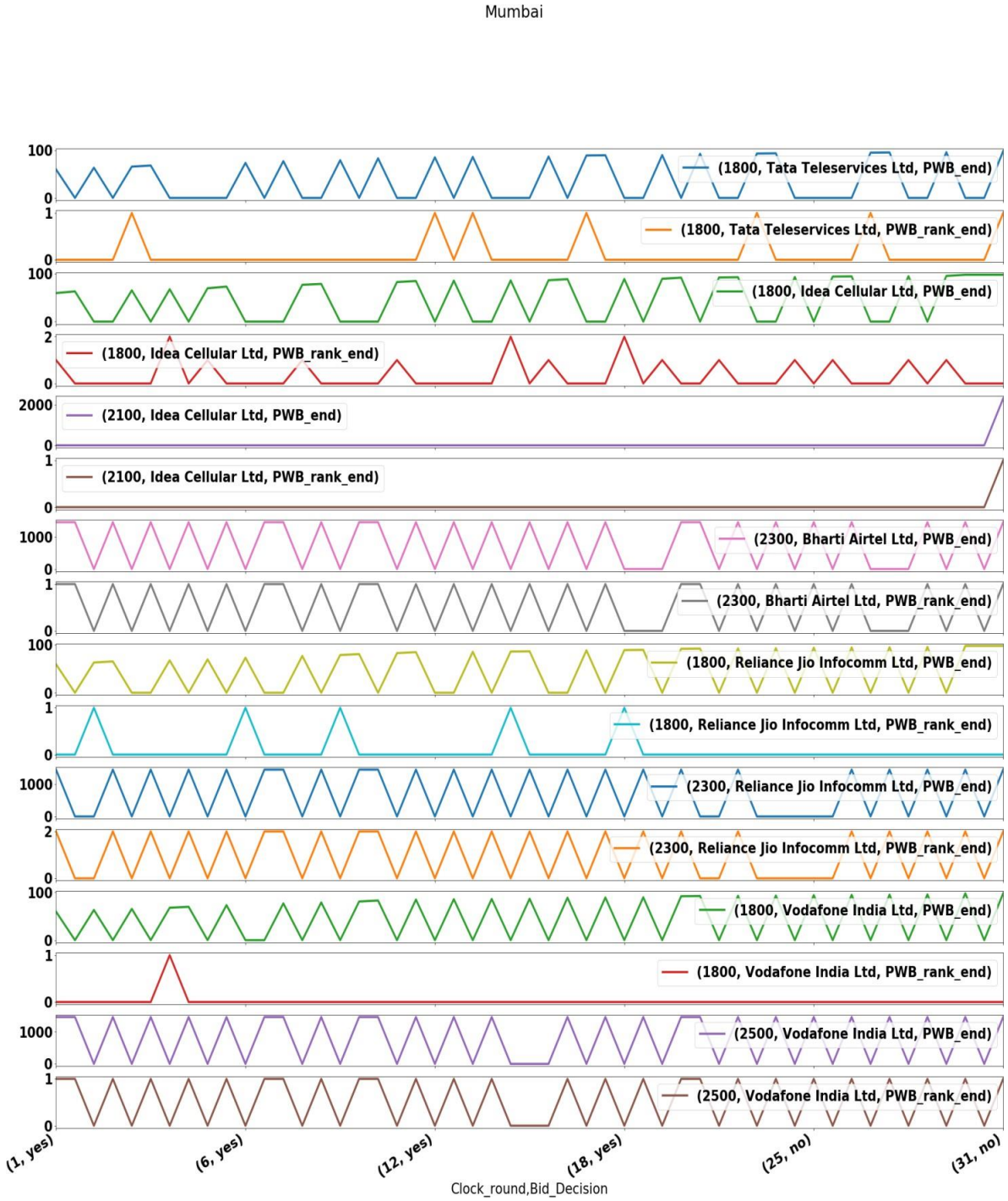
price. In few service areas, there was a marginal increase in the price with respect to the reserve price.

The reserve price and winning price of spectrum in the various bands:-

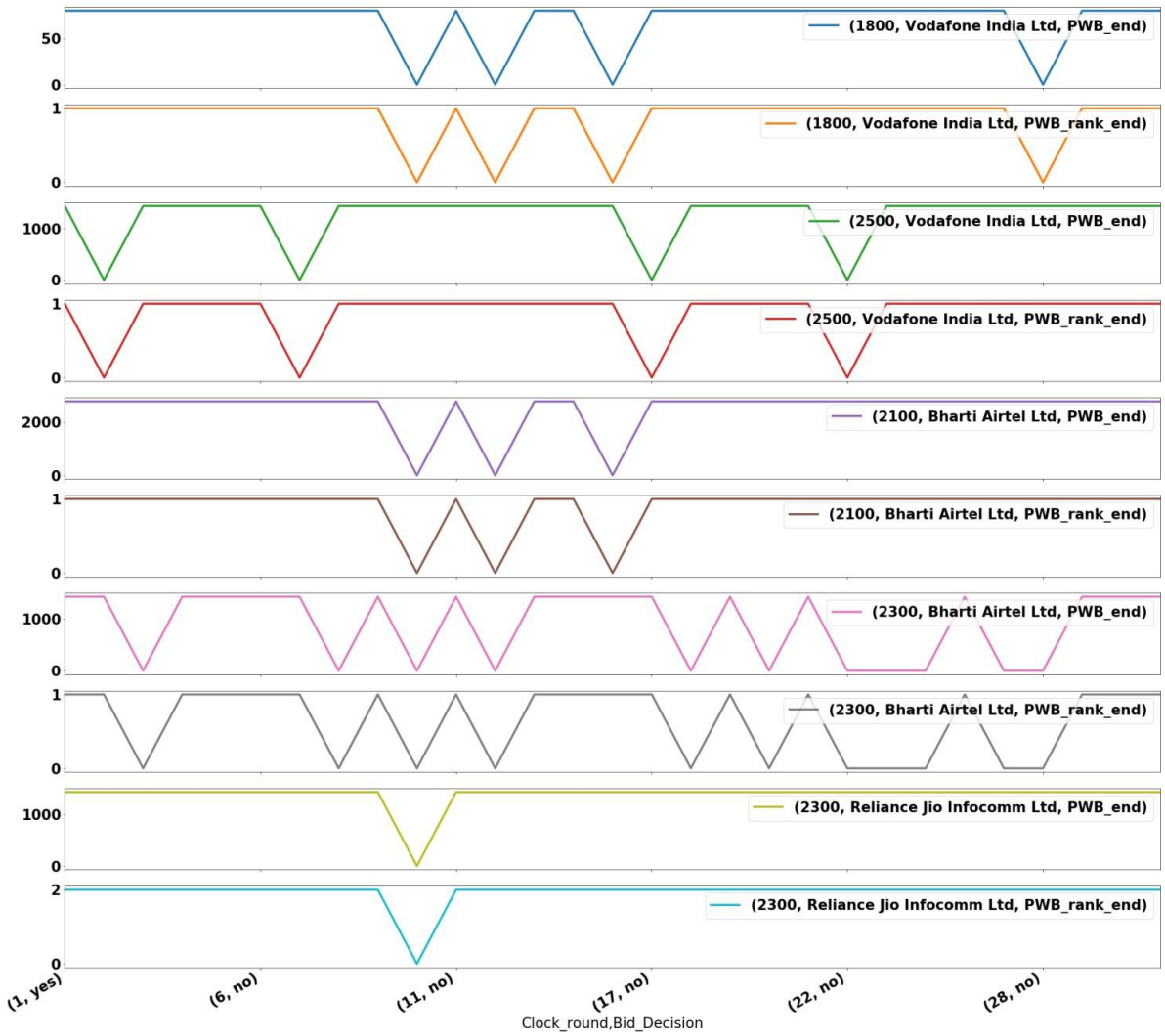
Service area	RP_700	RP_800	WP_800	%change	RP_900	WP_900	RP_1800	WP_1800	%change
AP	4855	757.5	No bid	Not sold	N/A	-	48.6	48.6	0
Assam	790	N/A	-	-	N/A	-	8	8	0
Bihar	1240	170	No bid	Not sold	88.8	-	12.4	12.4	0
Delhi	7975	1060	No bid	Not sold	N/A	-	79.8	79.8	0
Gujarat	4760	356.25	419.3	17.7	134.6	No bid	47.6	47.6	0
Haryana	930	71.25	No bid	Not sold	N/A	-	9.4	9.86	4.89
HP	320	30	No bid	Not sold	N/A	-	3.2	3.2	0
J & K	260	N/A	-	-	N/A	-	2.6	2.6	0
Karnataka	3700	378.75	0	Not sold	N/A	-	37	No bid	Not sold
Kerala	1670	303.75	0	Not sold	N/A	-	16.6	16.6	0
Kolkata	2980	200	0	Not sold	N/A	-	29.8	30.23	1.44
MP	1655	510	0	Not sold	N/A	-	16.6	16.6	0
Maharashtra	6360	998.75	0	Not sold	N/A	-	63.6	63.6	0
Mumbai	5960	908.75	0	Not sold	N/A	-	59.6	97.84	64.16
NE	220	N/A	-	-	N/A	-	2.2	2.2	0
Odisha	760	71.25	No bid	Not sold	N/A	-	7.6	No bid	Not sold
Punjab	1540	148.75	170.9	14.89	N/A	-	15.4	15.4	Not sold
Rajasthan	1820	255	290	13.73	N/A	-	18.2	18.38	0.99
TN	4500	450	No bid	Not sold	N/A	-	N/A	0	-
UP (E)	2295	273.75	273.8	0.02	155.2	No bid	23	26.63	15.78
UP (W)	1920	227.5	No bid	Not sold	147.8	No bid	19.2	20.06	4.48
WB	915	102.5	No bid	Not sold	N/A	-	9.2	No bid	Not sold

Service area	RP_2100	WP_2100	%change	RP_2300	WP_2300	%change	RP_2500	WP_2500	%change
AP	1360	No bid	Not sold	680	683.4	0.5	680	680	0
Assam	230	No bid	Not sold	20	20	0	20	20	0
Bihar	430	430	0	60	61.5	2.5	60	60	0
Delhi	2770	2770	0	1430	1430	0	1430	1430	0
Gujarat	1290	No bid	Not sold	390	611.88	56.89	390	390	0
Haryana	275	275	0	N/A	-	-	80	80	0
HP	100	No bid	Not sold	10	10	0	10	10	0
J & K	55	55	0	N/A	-	-	10	10	0
Karnataka	1640	No bid	Not sold	980	980	0	980	No bid	Not sold
Kerala	885	885	0	160	175.67	9.79	160	160.8	0.5
Kolkata	580	No bid	Not sold	330	330	0	330	330	0
MP	615	No bid	Not sold	80	82	2.5	80	80	0
Maharashtra	1705	1705	0	580	630.61	8.73	580	580	0
Mumbai	2305	2305	0	1460	1460	0	1460	1460	0
NE	60	No bid	Not sold	10	10	0	10	10	0
Odisha	190	190	0	40	40	0	40	40	0
Punjab	455	455	0	N/A	-	-	210	210	0
Rajasthan	700	700	0	N/A	-	-	60	60	0
Tamil Nadu	1720	1720	0	1320	1320	0	1320	No bid	Not sold
UP (E)	550	550	0	N/A	-	-	90	90	0
UP (W)	555	No bid	Not sold	N/A	-	-	120	120	0
WB	260	No bid	Not sold	50	50	0	50	50	0

The activity plot of three service areas-Mumbai, Delhi and Gujarat- are selected and plotted here. In Mumbai, activity in the three bands, 1800 MHz, 2100 MHz and 2300 MHz are stronger compared to other bands. In Delhi, moderate activity can be noticed in the 2300 MHz band only. In rest of the bands, there is not much competition in Delhi service area. In Gujarat service area, activity is reasonably good across all bands that were sold. The trail of two indicators *''pwb_end''* *and ''pwb_rank_end''*would give the details of the progress of the activity in various clock rounds.



Delhi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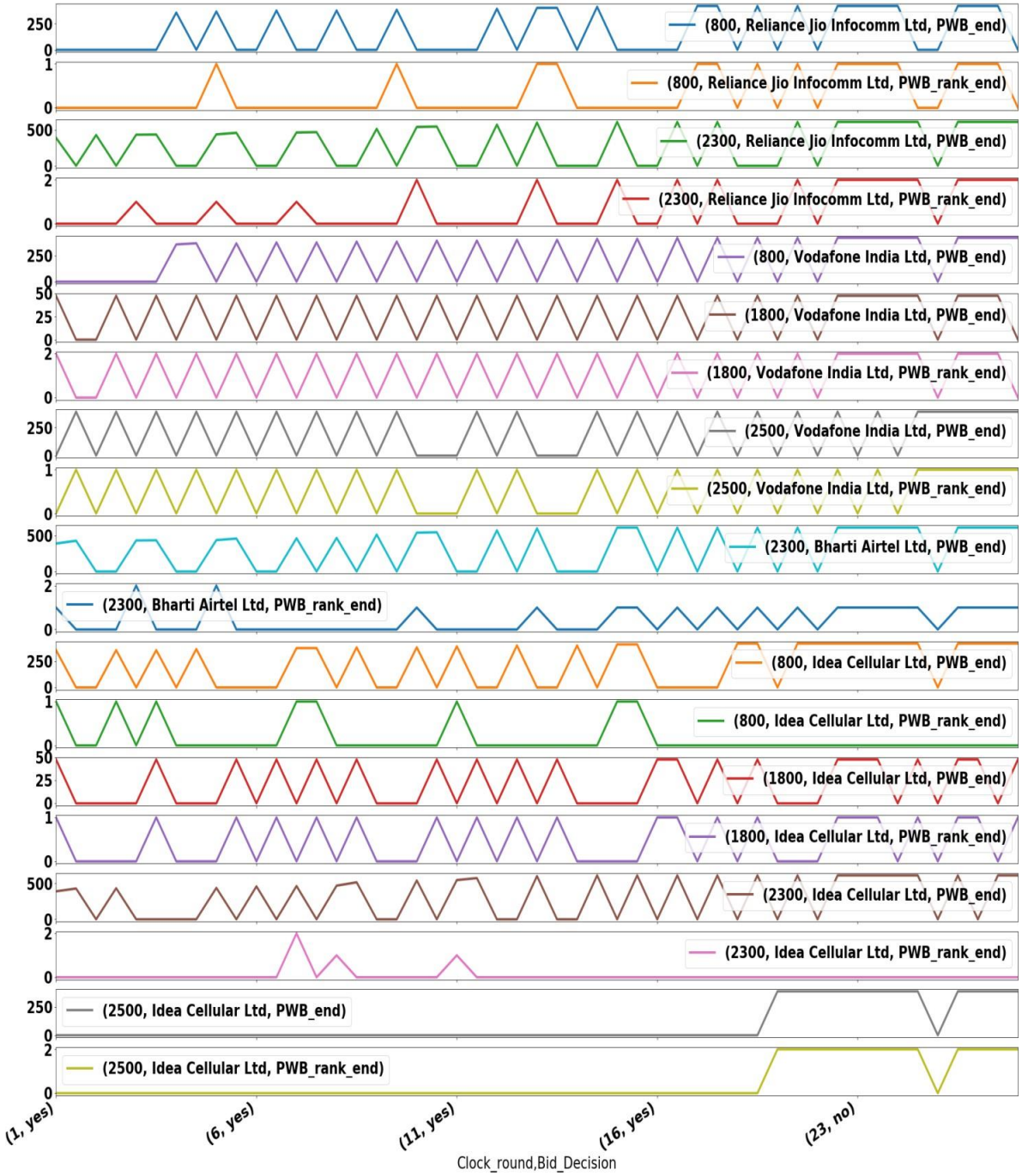
(17, no)
(22, no)
(28, no)
Clock_round,Bid_Decision

Gujarat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(2500, Idea Cellular Ltd, PWB_rank_end)
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(6, yes)
(11, yes)
(16, yes)
(23, no)
Clock_round,Bid_Decision

(viii) Net worth of the participants and the auction outcome:-

A carefully designed auction allocates the resources to those who value it most by extracting information which otherwise is not available. Further, auction can generate large sum of money that can be utilised for social purposes. Economic theory has shown that ascending auctions are particularly likely to allocate the prizes to the bidders who value them the most, as the bidder with higher value can always bid again to top a lower-value bidder that might have bid higher initially. There are also particularly suited in the case of complementaries between the auctioned objects. Conducting multiple rounds gave bidders the option to switch at any time between any of the offerings if the price became unaffordable.

The net-worth of a company is an important parameter that reflects the capacity of a company to take part in the auction. If a company has sound financial fundamentals that guarantee the spectrum procured by the bidder is most likely to put to efficient use. A big net worth company is likely to buy more spectrum and more likely to use it effectively than a small company with less resources. The net-worth is therefore considered as an eligibly criteria. The bidders are generally screened with regard to their net worth to determine the eligibility to participate in the auction. The net worth of a company is an indicator to determine the potential of the company to bid in the auction. Therefore there is a strong relation between the net worth and the total revenue collected in a particular auction. The correlation between revenue and net worth is examined in the following table.

Correlation between revenue and networth	
2012	-0.682602
2014	0.488511
2015	0.5062
2016	0.664834

** No comparison possible as only one bidder in year 2013*

**Net worth data unavailable in year 2010.*

The correlation between the revenue earned by the Government and the net worth of the company as given in the documents is indicated above. There is positive correlation between them in years 2014, 2015 and 2016. The negative correlation in the year 2012 is due to the asymmetry between the spectrum bought by M/s Bharti in year 2012 action and the net worth as recorded in the year 2012 for the same company. Further there was a shortfall in the spectrum purchased with reference to the spectrum offered for auction (Only 40% of the 1800 MHz spectrum was sold). These factors might be causing a negative correlation. The positive correlation between the net worth and the payment in other cases shows that the spectrum was won by the companies who are more likely utilize it optimally.

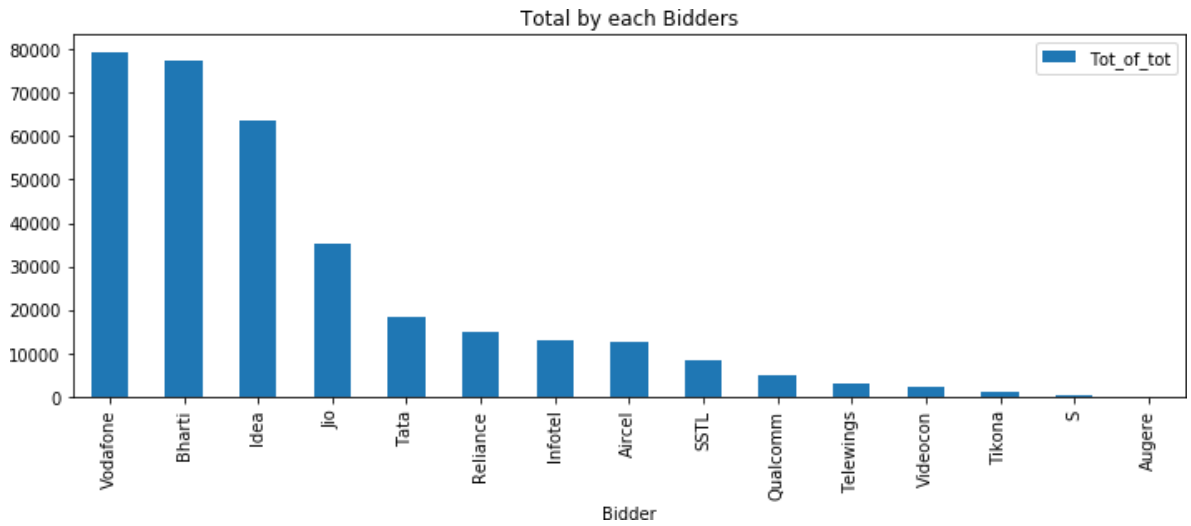
5. The total revenue collected in various auctions:

The total revenue earned from the various auction has been compiled here. There are two methods of payment –upfront payment and deferred payment. In 2010 auction only upfront payment provision was only available. In the subsequent auctions, a provision was made for

payment in 10 equal instalments in 10 years after a moratorium of 2 years. The table shown below consider the revenue as collected in one instance for simplicity of calculation. The highest revenue was earned in the 2015 auction followed by 2010 and 2016

In Rs.Crores

Bidder	2010 (3G+BWA)	2012	2013	2014	2015	2016	Total revenue
Vodafone	11617.86	1127.94	0	19644.72	26673.55	20279.3	79343.369
Bharti	15609.82	8.67	0	18529.64	29129.09	14243.58	77520.796
Idea	5768.59	4062.62	0	10715.63	30252.88	12797.98	63597.698
R-Jio	0	0	0	11054.41	11650.14	12692.46	35397.013
Tata	5864.29	0	0	0	7851.33	4619.2	18334.82
Reliance	8585.04	0	0	163.2	6125.241	65	14938.48
Infotel	12847.77	0	0	0	0	0	12847.77
Aircel	9937.47	0	0	209.9	2250	111.6	12508.97
SSTL	0	0	4113.65	0	0	0	4113.65
Qualcomm	4912.54	0	0	0	0	0	4912.54
Telewings	0	2221.44	0	844.72	0	0	3066.16
Videocon	0	2221.44	0	0	0	0	2221.44
Tikona	1058.2	0	0	0	0	0	1058.2
S-Tel	337.67	0	0	0	0	0	337.67
Augere	124.66	0	0	0	0	0	124.66



From the table and graph, it may be seen that in auction the top four companies- namely M/s Vodafone, M/s Bharti, M/s Idea and M/s Jio- together has contributed for more than 75% of the total revenue received from auction.

“You have your way. I have my way. As for the right way, the correct way, and the only way, it does not exist.”

- Friedrich Nietzsche