Digital Dividend Auction Process in Colombia

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Abstract

The following article presents a follow-up summary of the spectrum auction process scheduled for this year 2017, which includes the auction of blocks of the digital dividend, and on which the interested firms have already been asked to show interest to the Ministry of Information Technologies and telecommunications. It is also raised in the following article, a light analysis of scenarios, according to the conditions on draft document for the auction. All that is considered the proposal of the ministry, it is to change the spectrum boundaries in the bands from which the license of the main market players participate in the process of auction blocks.

Keywords: Blocks, low bands, digital dividend, spectrum, auction

1 Introduction

It is known as a digital dividend to the frequency band that surrounds the 700MHz. In Colombia the frequency band between 689 and 806 Mhz, is from 2012 according to [1] the land mobile service and provide IMT networks and services. With the
advent of open digital television and the impending shutdown of analogue television (scheduled for 2019 according to the National Spectrum Agency) this portion of spectrum is freed on which the national government already seeks through regulations to advance adjudication processes that allow it to the country make use of this. It is of greater economic benefit for the country to replace the broadcasting usage of the band, with the use of mobile data [2]. The advantages of its use are focused on expanding the connectivity of rural areas and isolated populations of the country. It requires less infrastructure investment because of its long reach. It has a coverage area 1.7 times greater than the 900 Mhz band in addition to presenting less interference [3]. The boost to productivity and education that would bring its proper use to the development of isolated communities is enormous, beyond the business that is taken advantage of by a network operator.

2 Background

The use of auctions for spectrum allocation is already common in many parts of the world. The last one in the country was the auction of 4G that was realized in the year 2013. In this auction the country acquired important profits, 70% more than the conservative projections calculated, in addition to a diverse allocation of the goods auctioned [4]. Each participant benefited from an award made commitments to deliver digital tablets and extended coverage. It proved to be a successful formula for both parties. Certainly employing auctions is already the dominant method over others a little older as lotteries. The first spectrum auction was conducted in 1989 in New Zealand, and the first closed-loop combinatorial auction in telecommunications was conducted in Nigeria in 2002 with notable success [5]. The combinatorial auctions applied to telecommunications are then somewhat more or less new, however with a broad theoretical description [6-8]. UK and Holland have already used them in auctions of licenses 4G [9], but not combinatorial closed envelope as proposed by the ministry ICT but clock combinations. Auction analyzes are a broad theoretical field analyzed by professionals of the exact sciences and the computer. This is due to the varied use of auctions for the allocation of strategic goods, and the large amounts of money that move according to their results.

3 Discussion

The purpose of this proposal of modification is that the two dominant operators of the mobile communications market, Claro and Movistar, can access the next spectrum auction. Claro and Movistar currently have 25MHz spectrum in low bands. They are the only ones along with Avantel, which have a portion of spectrum in this range. Current bands in low bands are at 30 Mhz, according to decree 1078 of 2015. Of the blocks of spectrum that are planned to auction so far none is less than or equal to 5MHz, which would immediately disable these two companies to perform some
kind of offer. Apparently this would favor the arrival of new bidders that expand the offer of the market, to the benefit of the consumers. However according to [10]. The three main operators in the market, Movistar, Claro and Tigo-Une have had some qualms about the process, especially Tigo-Une. Claro has expressed its disagreement that the state maintains its participation in Colombia Telecomunicaciones (Movistar), and would be acting as an auctioneer and buyer. In addition, this has some doubt in the transparency of the bidding process. Movistar has brought up again the non-intervention of the State in controlling the dominant position of Claro in the market, and that with the process of amending decree 1078 this has to remain the same

4 Auction

From the requirements of the auction process and its mechanism so far has a draft proposal on which those interested in the process should have already sent their comments to the Ministry of Information Technologies and Telecommunications [12]. It is still unknown if the blocks were awarded this year, or who could participate. The draft intends to auction four paired spectrum blocks. Block A of 2x15MHz, block B of 2x10MHz, Block C of 2x5MHz and block D of 2x5MHz. Each participant can bid for individual blocks, or bid for the combination of several blocks, in addition to making several offers with different combinations of blocks. Any offer that violates the spectrum caps will be immediately disqualified and will not be considered during the selection process. It should be noted that this draft resolution assumes the approval of amendment of article 2.2.2.4.1 of decree 1078 of 2015 to expand the caps. See Sheet No. 7 [12]. This modification would expand the bands in low bands by 15MHz, allowing Claro and Movistar to increase their spectrum allocation by 20 Mhz.

The draft proposes a combinatorial auction of closed envelope at the first price. Initially 16 proposals can be made \(2^4\) bidding for individual blocks and combinations of 4 indivisible blocks. 

\[A+B - A+B+C - A+B+D - A+C+D - A+B+C+D\]

These combinations exceed 45MHz. Resulting ten possible combinations plus the combination of zero units.

The following is an example of possible bids by blocks, which can be made by Claro, Movistar, Tigo-Une and Avantel companies, according to the draft resolution that establishes the requirements of the auction.

**Possible offers of Claro and Movistar:**

\[B - C - D - C+D\]

**Possible offers Tigo-Une**

\[A – B – C - D - A+C - A+D -B+C - B+D - B+C+D - C+D\]
Possible Avantel offers.

\[ A - B - C - D - B+C - B+D - C+D \]

TIGO-UNE, is the only one of the three operators in this example that does not have permission to operate in low bands. It is therefore the active operator in the Colombian market that would be most interested in this auction, and access a portion of that spectrum. According to the president of Tigo-Une Marcelo Cataldo, maintaining its operations only in high bands has implicated the company between 20\% and 30\% more in operating costs \[11\]. As it lacks low bands, it is also the one that can make the most offers without exceeding the stops.

Claro and Movistar only with 4 combinations of valid offers. Avantel, although with more possible combinations than the two dominant market operators, is unlikely to bid, or even had a public pronouncement on the auction process, as if they had the other three operators. For this reason, and its market position is not taken into account hereafter. The ICT ministry will set a minimum price per block. In accordance with the draft requirements, conditions and regulation of the auction process, bids for a block or a combination of blocks of less than this amount will be discarded and will not be taken into account in determining the winner. This will be the minimum bid amount. Bids for combinations of blocks cannot be less than the sum of the minimum prices of the combination blocks.

<table>
<thead>
<tr>
<th>Table 1. Minimum Price Values Set by the Ministry</th>
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<tbody>
<tr>
<td>Block</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
</tbody>
</table>

Of all these possible offers of each operator, it must be taken into account that each will offer an amount of money equal to the minimum bid value plus another positive amount of surplus money that determines his intention to stay with the good. Of course this amount should ideally be less than the value that each participant has of each block.

<table>
<thead>
<tr>
<th>Table 2. Combination of offers by participant</th>
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</thead>
<tbody>
<tr>
<td>Participant 1</td>
</tr>
<tr>
<td>Claro</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Movistar</td>
</tr>
<tr>
<td>Participant 2</td>
</tr>
</tbody>
</table>
Table 2. (Continued): Combination of offers by participant

<table>
<thead>
<tr>
<th>Participant 3</th>
<th>Combination of offers by participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tigo-Une</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>$v_{RA} + x_3A$</td>
</tr>
<tr>
<td>B</td>
<td>$v_{RB} + x_3B$</td>
</tr>
<tr>
<td>C</td>
<td>$v_{RC} + x_3C$</td>
</tr>
<tr>
<td>D</td>
<td>$v_{RD} + x_3D$</td>
</tr>
<tr>
<td>A+C</td>
<td>$v_{RA} + v_{RC} + x_3AC$</td>
</tr>
<tr>
<td>A+D</td>
<td>$v_{RA} + v_{RD} + x_3AD$</td>
</tr>
<tr>
<td>B+C</td>
<td>$v_{RB} + v_{RC} + x_3BC$</td>
</tr>
<tr>
<td>B+D</td>
<td>$v_{RB} + v_{RD} + x_3BD$</td>
</tr>
<tr>
<td>C+D</td>
<td>$v_{RC} + v_{RD} + x_3CD$</td>
</tr>
<tr>
<td>B+C+D</td>
<td>$v_{RB} + v_{RC} + v_{RD} + x_3BCD$</td>
</tr>
</tbody>
</table>

Then, if the Tigo-Une bid for block A, fulfills $v_{RA} + x_3 \geq v_{RA}$, now it will be taken into account in the evaluation process.

The participants of course aim to become the blocks for which they aspire. However, this aspiration is limited by the gain or utility on the goods. Each auction situation can be analyzed as a Bayesian game. Under the requirements of the game and Draft of auction, no participant knows the economic offer of the other players. Everyone knows that raising puja increases the odds of winning, but this at the cost of minimizing their earnings according to their own valuation.

Let $m$ be the number of individual blocks of the auction. Let VIA... be the valuation that each participant gives to the block $a$. The profits or payments that each participant receives are given by the following expression:

$$u_i((v_y + x_i)_a, v_{IA...}) = \begin{cases} 
(v_y + x_i)_a, & \text{if } (v_y + x_i)_a + \sum_{j \neq i} (v_y + x_j)_a > \gamma_i \\
0, & \text{if } (v_y + x_i)_a + \sum_{j \neq i} (v_y + x_j)_a < \gamma_i \\
\frac{v_y - (v_y + x_i)_a}{2}, & \text{if } (v_y + x_i)_a + \sum_{j \neq i} (v_y + x_j)_a = \gamma_i 
\end{cases}$$

(1)

Where $\gamma_i$ is the second set of offers among all the participants that generates the most profits to the state. If within the sum of money offered that generates more profitability to the state is the offer for the block $a$ made by the participant $i$, that block will be awarded and will have as payment or profit the difference between what the participant $i$, considers worth and what he paid in total for that block. No participant should know the ratings of their competitors. This value will depend in part on the value of the quantity $x_{ia}$ of each participant $i$.

The number of offers that each participant can make ($Ov$), having exceeded the spectrum restrictions, results from:

$$Ov = 2^m - 1$$

(2)
Where \( m \) is the number of combinations per participant as in table 2. The empty offer or empty offer is discarded. According to Table 2, considering only these three market players as bidders, there would be 23075 possible auction options with each possible offer, under the modality of a closed envelope combinatorial auction.

Consider, for example, the case in which Claro (participant 1) presents offers for block C, and block D, Movistar (Participant 2) offers for block B, block C and block D, and Tigo-Une presents offers for Block A, block B, block C, block D, blocks together A + C, A + D and B + C + D.

Table 3. Offers 1 - Participant 1

<table>
<thead>
<tr>
<th>Combination</th>
<th>Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>( x1C )</td>
</tr>
<tr>
<td>D</td>
<td>( x1D )</td>
</tr>
</tbody>
</table>

Table 4. Offers 2 - participant 2

<table>
<thead>
<tr>
<th>Combination</th>
<th>Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>( x2B )</td>
</tr>
<tr>
<td>C</td>
<td>( x2C )</td>
</tr>
<tr>
<td>D</td>
<td>( x2D )</td>
</tr>
</tbody>
</table>

Table 5. Offers 3 - Participant 3

<table>
<thead>
<tr>
<th>Combination</th>
<th>Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>( x3A )</td>
</tr>
<tr>
<td>B</td>
<td>( x3B )</td>
</tr>
<tr>
<td>C</td>
<td>( x3C )</td>
</tr>
<tr>
<td>D</td>
<td>( x3D )</td>
</tr>
<tr>
<td>A+C</td>
<td>( x3AC )</td>
</tr>
<tr>
<td>A+D</td>
<td>( x3AD )</td>
</tr>
<tr>
<td>B+C+D</td>
<td>( x3BCD )</td>
</tr>
</tbody>
</table>

As each participant knows the minimum own valuation of each block, only positive surpluses over the minimum price per block are taken into account. With the three participants and their valid offers the plurality rule of the auction is fulfilled. It is evident how the third participant has the only opportunity to adjudicate block A. This situation immediately affects the interests of the state, since the bidder can bid for this block the minimum valuation value plus a very low value positive amount and the more likely it is to secure its award. Based on Tables 3, 4 and 5, the following cases may occur:

1. Block A is assigned to the participant 3. Block B is assigned to the participant 2, block C according to: \( \max \{x_{1C};x_{3C}\} \) and block D assigned according to: \( \max \{x_{1D};x_{3D}\} \), being the assignment of the Blocks C and D mutually exclusive for the participant 3 in order not to violate the spectral stops.
2. Block A + C assigned to participant 3, block B assigned to participant 2 and block D assigned to participant 1.
3. Block A + D assigned to participant 3, block B assigned to participant 2 and block C assigned to participant 1.
4. Block B + C + D is assigned to participant 3, and block A is deserted. (Participant 3 would overcome the stops in low bands with all the blocks).
5. Block B assigned to participant 3, Block A desert, block C according to: max \( \{x_{1C}; x_{2C}; x_{3C}\} \) and block D according to: max \( \{x_{1D}; x_{2D}; x_{3D}\} \)
6. Block B assigned to participant 2, block A assigned to participant 3, block C according to: max \( \{x_{1C}; x_{3C}\} \) and block D according to: max \( \{x_{1D}; x_{3D}\} \).

Of the six possible situations, the most money will guarantee the auctioneer. The Ministry [13] already establishes the algorithm of selection and profit maximization. The draft in the draft is the use of a technological aid to automate the process of selection of the winner.

According to [14], for this type of combinatorial survey, the adjudication solution can be solved using the CAP2 (combinatorial auction problem 2) formulation:

\[
\text{max } \sum_{S \subseteq M} b(S)f_S \tag{3}
\]

\[
\sum S \ni j \ f_S \leq 1 \ \forall \ j \in M \tag{4}
\]

\[
f_S = 0,1 \ S \ \forall \subseteq M \tag{5}
\]

From the above formulation, \(b(S)\) the maximum bid for a block or set of blocks among all participants. The factor \(f_S\) has a value of 1 if that maximum bid for the block is accepted and awarded, or zero if it is not accepted. The condition of equation 4 ensures that no single block is assigned to more than one participant.

Using the formulation in the example, with all possible combinations of offers according to the example and tables 3, 4 and 5:

\[
\text{max: } bAfA + bBfB + bCfC + bDfD + bA+CfA+C + bA+DfA+D + b_{B+C+D}f_{B+C+D} \tag{6}
\]

With the conditions:

\[
+ f_{A+C} + f_{A+D} \leq 1 \\
+ f_{B+C+D} \leq 1 \\
+ f_{A+C} + f_{B+C+D} \leq 1 \\
+ f_{A+D} + f_{B+C+D} \leq 1 \\
f_A, f_B, f_C, f_D, f_{A+C}, f_{A+D}, f_{B+C+D} \leq 1 \tag{7}
\]

Maximizing the value of equation 6, it guarantees to those who offer, in this case the state, the maximum income of money, fulfilling the conditions of equations 7.
It is also clear that in addition to the conditions of 7 is also the condition of no exceed the spectral stops. The participation of Tigo-Une is likely to be a more risky participation, so you would expect a change in the relationships of the game based on your position. It is to be expected that riskier attitude because it does not have operation in range of low bands and it requires to expand to this portion of the spectrum.

5 Discussion of Results

As mentioned, the results of the award depend, of course, on the valuation made individually by each participant of the block or set of spectrum blocks of their interest and their offer, of the minimum bid price established by the ministry, of the ceilings Spectrum and the set of offers. Of the six situations described above, the first would have the following formulation:

$$\max \sum_{S \in M} b(S)f_S = x_{3A}f_A + x_{2B}f_B + \max f(X_{1C};X_{3C};)f_C + \max f(X_{1D};X_{3D};)f_D$$

(8)

For the assignment of blocks individually: $f_{A+C} = f_{A+D} = f_{B+C+D} = 0$ and $f_A = f_B = f_C = f_D = 1$. This satisfies the constraint of equations 7. If $x_{1C} > x_{3C}$, and $x_{1D} < x_{3D}$, block C would be assigned to participant 1 and block D to participant 3. It tends to think that this situation would be the same as case number 2, where the block A + D is assigned to the participant 3; however, the conditions for this are different, since the maximization was given for individual offers. The offer for the individual blocks A and D in this case is greater than the offer in aggregate A + D, although the same participant does. For a participant it may be more valuable to have a combination of blocks than a single block, in fact a small block may be less attractive than none at all.

In this way, the 23075 possible combinations of offers with these three participants and each case analyzing the relations of their economic offers must be carried out. It is necessary first, the computational support to perform all calculations with the algorithms appropriate to the supply mechanism, and second, the expansion of information about each offer or, their willingness or risk aversion, the probabilities of offers, the economic statements of each Participant, their business expansion projects, etc.

6 Conclusions and Recommendations

While you might think that the spectrum auction process should have started longer, current market conditions show no. It requires first the answer to the doubts of those interested in the auction, answers that in turn require analysis of the regulation process, regulation of mobile market, completion of the process of sale of the part that has the state in Colombia Telecommunications, etc. There is still no clear environment to start the auction process and what the ministry has been doing to launch proposals and receive comments is most logical. Of course this makes sense
if the ministry gives some kind of satisfactory answer to all the doubts that have the possible offers.
The few active participants that has so far the process, show of some which firms are willing to bid. If only the major companies in the market participate, the revenue that the state would receive would tend to the minimum auction price, or blocks would be postponed if the award were abandoned. Under the current conditions of dissatisfaction on the part of the current operators who are serious candidates to push for the blocks of the digital dividend, the predictions that are fixed on its behavior and probabilities of offer are very broad still. Its advance is a priority for the interests of the nation, but caution should not be absent from the process.

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