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Design Recommendations for the 700MHz Auction

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1. Introduction

The context of this submission is provided by the state of competition in the mobile sector in Colombia. This arises because our submission, which contains proposals to use the forthcoming spectrum award consciously to insert more competition into the market place, is predicated on the proposition that i) there are deficiencies in the level of competition in current market place, and ii) that there is a means of improving the situation.

Section 2 of this report briefly sets out the competitive context. Section 3 discusses ways in which competition can be promoted. Section 4 presents some modelling of the effects of alternative measures. Section 5 presents our conclusions and recommendations.

2. Competition in the Colombian mobile sector, and the role of mavericks

We deal with the first part of this section concisely, since the CRC has recently published two long, detailed and well-evidenced reports on these matters.[1] [2]

The market contains three established operators of unequal size – Claro, Movistar and Tigo, and a more specialist operator with expansionary ambitions, Avantel. Market shares of traffic in percent (which we regard as being a more significant metric than shares of subscribers) are shown for 2016 (with the 2008 figure in brackets). They are: Claro - 59 (67); Movistar – 21 (26); Tigo – 13 (7); and Avantel 4 (0).

The HHI in 2016 was 4756, down from 5185 in 2008. This figure is relatively high compared with the threshold vale of 2500 used in the USA for filtering mergers requiring fuller investigation. It is high but not remarkably so in terms of international comparisons in the mobile market.

Summarising its views on competition, the CRC November paper notes (at page 108 – own translations):

> *"As regards the structure of mobile markets, this Commission observes such behavioural outcomes as the reduction of Claro's market share of subscribers, which has been translated into a drop in HHI concentration index. It is also observed that the measures implemented by the CRC have contributed positively to the proportion of on-net traffic - favouring off-net traffic. However, it still notes with concern the low response of the traffic and revenue shares of the leading operator in the market to the regulatory measures implemented by the CRC."*

[1] CRC , Revisión de los mercados de servicios móviles Regulación de Mercados, Junio de 2016 (CRC June) ; CRC. Revisión de los mercados de servicios móviles Regulación de Mercados Noviembre de 2016, Documento Soporte (CRC Novembre).

[2] For a somewhat older external review, see further: OECD,

And (page 129), in relation to voice traffic.

> *"There are still significant levels of concentration in terms of subscribers, traffic and revenues; market shares with considerable differences; inefficient user traffic and a dominant operator with highly impactful market performance indicators, which have enabled it to increase its market shares at all levels in just one semester."*

In relation to the market as a whole the CRC notes (at pp. 130-131):

> *"By...bundling services, an operator can leverage its position in the mobile services market from its position in the outgoing mobile voice market; this is reflected in operators having similar market shares in different services and in carrying over the competitive environment in voice to data.*
>
> *In this sense, it is observed that the structure of the mobile services market, exhibited equally by indicators of both voice and data, is that of a concentrated market, with large differences in the market shares of the different operators, and tending to a greater concentration.*
>
> *Although the prices of mobile telephony services in the country are low by international standards, the Commission notes with concern that competition in this dimension represents risks for the market dynamics in terms of innovation and investment. In this sense, it is possible to observe a relative backwardness of the mobile Internet service, closely linked to the mobile voice service, compared to developed countries throughout the world, and a stagnation in service growth in 2016, which accounts for problems in the market that limit the adoption of fourth generation technologies.*
>
> *...*
>
> *Reductions in barriers to administrative entry to the market are evidenced in the measure through which new network operators and virtual mobile operators co-exist in the market – which could boost competition in the "mobile services" market. Nevertheless, the market shares of such agents in respect of subscribers, revenue and traffic are hardly worth mentioning. In view of the above, it is necessary to review the conditions that the MVNOs face in the wholesale market in order to identify the existence of any non-administrative barriers to entry."*

The expression of these misgivings on the part of the CRC about the current state of competition encourages us to consider possible ways of promoting further competition. We think it is worth emphasising the application to this case of a famous remark of Einstein, to the effect that it is generally a mistake, or worse, to suppose that if you carry on doing the same things that you did in the past you will start to get different results. In this context, this means that if the Government of Colombia, including the Minister of ICT and the CRC, want to make a difference to competition, it must decide to introduce new policies to promote competition. The problem is not self-correcting. A new policy, such as the encouragement of a 'maverick' operator (see below) is required.

Before considering some detailed options, we offer some short reflections on recent international, especially European, experience in the mobile sector. The matter is apposite as the trend in the last few years has been in favour of consolidation of the European mobile sector, especially by attempts to accomplish four-to-three mobile mergers. Some of these were approved – in Ireland, Austria,

Germany and Italy. Other were withdrawn (Denmark) or prohibited (UK). Recent decisions have been more inclined to resist rather than approve such mergers.

A second point of interest concerns the nature of the firm 'disappearing' as a result of the merger. In several cases this has been a so-called maverick – typically a smaller or late entering operator in an increasingly saturated market trying to build a customer base from zero. This is likely to encourage use of non-standard approaches to customer acquisition, which adds innovation and new dimensions to the market place.

The loss of a maverick is expressly mentioned in the EU Horizontal Merger Guidelines:

> *"37. Some firms have more of an influence on the competitive process than their market shares or similar measures would suggest. A merger involving such a firm may change the competitive dynamics in a significant, anticompetitive way, in particular when the market is already concentrated. For instance, a firm may be a recent entrant that is expected to exert significant competitive pressure in the future on the other firms in the market.*
>
> *38. In markets where innovation is an important competitive force, a merger may increase the firms' ability and incentive to bring new innovations to the market and, thereby, the competitive pressure on rivals to innovate in that market.....Similarly, a firm with a relatively small market share may nevertheless be an important competitive force if it has promising pipeline products."*

As a result, the competition authorities pay particular attention to the loss of mavericks in mobile mergers. This is relevant to the present context because the *promotion* of a maverick has the potential to have the same *beneficial* effect on competition as the elimination of a maverick competitor has a *harmful* effect.

3. Ways of rectifying competition deficits in the mobile sector

There are a variety of regulatory or policy instruments to deal with inadequate competition in the mobile sector.

One is to regulate mobile operators in an asymmetric fashion, applying a harsher regime to the larger operators or operators. In Europe, this solution can be imposed following a finding of dominance or significant market power in a relevant mobile market. In Mexico, a regime intended to put this into effect has been in place since 2013/14. It incorporates a provision for declaring certain firms to enjoy 'preponderance' in specified markets. Such a finding exposes them to special forms of regulation. In Colombia, the regulator has already applied some asymmetric remedies. Thus it has adopted asymmetric mobile termination rates and excluded Claro from the AWS spectrum auction in 2013. But competition problems in the market have not gone away.

A second means of preventing a lessening of competition is by means of merger policy. Thus, a merger with anti-competitive consequences can either be prohibited, or it can be allowed to occur only after the merging parties have committed themselves to undertakings designed to reverse the anti-competitive effects (which might include divestment of spectrum holdings which can then be used to support a new entrant or an existing operator).

However, the most frequently used instrument is spectrum policy – in particular designing new spectrum awards to incorporate pro-competitive objectives, or to prevent anti-competitive ones.

These can take several forms:[3]

1) Set-asides
2) Spectrum caps
3) Spectrum floors.

3.1. Set-asides

These involve taking a part of a spectrum award and limiting eligibility to participate either to entirely new entrants or to a subset of existing operators defined either by size or by a lack of spectrum in the band(s) being awarded. The goal is to achieve the object of more competitors, different competitors and more competition in the market, by ensuring that the relevant operators get the spectrum they need.

Set-asides have been used in a number of countries, including Canada, the Netherlands and Singapore. This experience has identified several potential pitfalls:

- it is important to ensure that successful bidders obtain sufficient spectrum to make a significant challenge to incumbent operators
- care should be taken to avoid a situation in which not all the spectrum set aside is awarded; this risks an outcome in which unsold spectrum is unavailable for use while alternative arrangements are made.
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In a 2008 auction, the Canadian Government set aside 40 MHz out of 90 MHz for a series of regional and new national players. The latter group subsequently made a very limited impact on the market, possibly because each had too little spectrum.

The recent experience of a set-aside in Singapore is instructive. In 2014, the regulator (the Info-communications Development Authority or IDA) decided to

> 'leverage the 2016 Spectrum Auction to facilitate the entry of a new MNO, given the market interest reflected in the First Public Consultation and the potential benefits that may be brought about by a new MNO. IDA will facilitate the entry of one new MNO only as IDA's study showed that the market structure and growth potential of Singapore's mobile market can likely only support one more MNO in the next few years.'
>
> 'On balance, given the strong interest from potential new players, IDA is of the view that there may be scope for greater competition and service innovation in the market. Furthermore, with consumers' increasing reliance on mobile broadband for connectivity, and the technology and service evolutions in the industry (such as Internet of Things ("IoT") and M2M

[3] For more details, see M Cave and Rob Nicholls, 'The use of spectrum auctions to attain multiple objectives: Policy implications,' *Telecommunications Policy*, 2017

communications), there may be attractive and viable business opportunities and market segments for a new MNO.'[4]

Of the total of 235 MHz available in the 900 and 2300 MHz bands, the IDA set aside 60 MHz to be allocated to an entrant. The remainder would be auctioned to all comers.

It also invited potential bidders to run limited geography trials using spectrum that would be subsequently offered at auction. This attracted the 3 existing MNOs and an entrant My Republic, which was thereby assisted to pre-qualify for the set-aside auction.

In the event My Republic was beaten in the 2016 auction by the Australian operator TPG. Thus, the set-aside spectrum was sold to a qualified operator in a manner which maintained a degree of competitive tension.

3.2. Spectrum caps

These are used widely to achieve a desired competitive balance, or alternatively to prevent anti-competitive conduct by larger operators in an auction. The former motive is in place when a regulator is dissatisfied by the performance of a mobile sector which is insufficiently competitive, and not delivering for its customers. The latter might be exhibited in the following circumstances. Bidding in an auction might be governed via an efficiency motive – that of acquiring sufficient spectrum to meet expected demand at lowest cost; but it might also be derived from what the US Department of justice called a 'foreclosure motive' – a desire by a more financially secure firm to bid up the price of spectrum to a level which excludes or weakens its smaller rivals.

Putting a limit on how much spectrum a firm can acquire in an award, or in total via a sequence of awards, is a means of achieving either or both of these goals.

Caps are used in very many jurisdictions, including Colombia, where two caps are imposed, one for spectrum below 1 GHz and the other for spectrum above 1 GHz. In these circumstances, it is natural to review the caps as more spectrum is made available, but this can be done in the light of the regulator's competitive objectives.

One concern about caps is that they may lead to lower auction revenue since they restrict the number of bidders for particular pieces of spectrum. A possible solution for this is to set two price levels for the spectrum, a conventional reserve price and a higher threshold price. While bidding is below the threshold price then no caps apply since it is assumed that all MNOs are able to afford to buy spectrum and therefore none are being excluded through anti-competitive bidding. Above the threshold price the caps apply, preventing strong incumbents excessively bidding up prices, but ensuring that the spectrum has not been sold at a discount. Threshold prices can be based on previous auction price levels or on price levels in similar auctions in comparable countries.

[4] *IDA,* FRAMEWORK FOR THE ALLOCATION OF SPECTRUM FOR INTERNATIONAL MOBILE TELECOMMUNICATIONS ("IMT") AND IMT-ADVANCED SERVICES AND FOR THE ENHANCEMENT OF COMPETITION IN THE MOBILE MARKET 18 February 2016, paras. 21,23.

3.3. Spectrum floors

A third possibility is to introduce a provision in the auction which allows specified bidders to acquire a limited amount of high-powered spectrum (say, spectrum below 1 GHz) at a price beneath the final market-clearing one.

This was utilised in the '4G' auction of 800MHz and spectrum in higher bands carried out in the UK in 2013. The auction was designed to reserve in a flexible way a small quantity of necessary spectrum for either a new entrant or the smallest UK operator. In the event, that smallest operator was able to acquire 10 MHz of 800 MHz spectrum at a significantly reduced price, in a way which minimised any disruption of the buying intentions of the larger operators.[5]

The auction design used to achieve this goal - a combinatorial auction - was unusually complex (but successful), and it has not been repeated in any other country. But the goal – to maintain the presence in the UK market of a maverick operator – is clear.

3.4. Conclusion on intervention options

The previous section noted that the CRC is concerned about inadequate levels of competition on the Colombian mobile market. This section has noted that a standard method of dealing with such issues, widely used internationally, is to design spectrum assignment methods in order to prevent anti-competitive practices and/or to pursue the goal of more competition – notably by the encouragement of maverick operators.

Three mechanisms for dealing with this approach have been discussed – set-asides, spectrum caps and spectrum floors.

In our view, use of a spectrum floor is too complex a mechanism to employ at short notice. It risks not being fully understood by the stakeholders, including the operators, in the mobile market place, and is thus not a practicable solution.

In order to evaluate the remaining options (and the alternative of doing nothing), we need to identify the problem or problems which have to be solved. For the purpose of what follows, we provisionally see this as comprising the need to promote competition in one or more of price, quality and innovation, by enhancing the scale of the competitive constrain now facing incumbents, including the largest operator Claro. In our opinion, this goal can be achieved either by promoting a wholly new entrant, or by encouraging Avantel to mount a more effective competitive challenge.

To this there may be added the goal of ensure that Tigo, the 'third operator' has sufficient spectrum to build out a network with widespread geographical coverage both outdoors and indoors, which international experience suggests would require access to some sub-1GHz spectrum. Note that we do not consider Tigo to be in the same position as Avantel. Tigo is well established and has a market share approaching that of the second operator whereas Avantel is much smaller and much less well established. Hence, we do not consider that Tigo needs support in general, but in the same way that

[5] Geoffrey Myers, *The innovative use of spectrum floors in the UK 4G auction to promote mobile competition*, CARR Discussion Paper, LSE, November 2013 , available at http://www.lse.ac.uk/accounting/CARR/pdf/DPs/DP74-Geoffrey-Myers.pdf

the UK sought for all operators to have access to sub 1GHz spectrum we believe the same arguments to apply in Colombia.

In order to investigate the interventions further, we first explore - using a modelling technique – the implications of current assignments of spectrum and the likely future configuration of shortages.

4. Modelling the impact of spectrum assignments in the Colombian mobile market place

4.1. Introduction

This section describes the model we use to determine network capacity and valuations for Colombian operators.

The initial purpose of the model is to understand what the outcome of an auction would be if there were no constraint on the bidding operators. We do this by determining the value of additional spectrum to the operators, each of which has its own traffic demand to meet, its own infrastructure in terms of base stations, its own legacy of spectrum from earlier awards and its own level of revenue per subscriber. This tells us what each operator would be willing to bid as a maximum for additional spectrum.

We can then estimate how the valuations change when we impose restrictions on the amount of spectrum each operator can buy. This tells us how these restrictions affect the assignment of spectrum in the award, and how much revenue the auction will deliver as a maximum.

4.2. Overview of the model

The model is an Excel spreadsheet based calculation which determines the likely costs and subscriber gains or losses for each operator according to their circumstances and spectrum acquired. It calculates:

- the level of capacity that is likely to be demanded by subscribers based on specified assumptions as to how quickly the demand for data grows;
- the level of capacity that an MNO can provide based on improving spectrum efficiency and adding to its spectrum holdings; and
- the way in which loss of subscribers on the part of congested networks moves revenues among operators and benefits networks with spare capacity.

The model then determines the value of additional spectrum to the operators. There are two ways of determining value depending on whether the operator has the option of increasing their network capacity by investment (eg in additional cells) or whether they have reached the practical limits of technical expansion of capacity.

If they can increase network capacity then additional spectrum allows them to avoid the cost of doing so via technical means (“cost avoidance”). We judge all MNOs except Claro to be in this position.

If they cannot increase network capacity then additional spectrum allows them to avoid the loss that would come from subscribers churning off a congested network ("intrinsic value"). We judge Claro to be in this positon.

4.3. Key assumptions

The model needs a good understanding of the status of the current mobile networks in terms of their current number of base stations, spectrum holdings and subscriber numbers. The key assumptions made are as follows:

- We do not know the number of base stations for the major mobile networks in Colombia so we have made the assumptions that Claro's network has similar dimensions to the key UK networks for which we have some data (around 16,000 base stations). This seems reasonable given that the populations of the UK and Colombia are roughly the same, the number of subscribers that Claro has is in line with the largest UK MNO and the technologies used come from the same 3GPP standards.

- We assume that other networks (than Claro) will have built out sufficient base stations to provide capacity for their current subscriber numbers, usage levels and spectrum resources. If they increase subscriber numbers or data usage grows they will need to increase capacity in some way such as additional spectrum, more base stations or upgraded technology. We do not have evidence to support this, but it would be a sensible deployment strategy, delaying investment until needed.

- The model uses assumptions as to the improvements in spectrum efficiency that are likely to be delivered through refarming other technologies to 4G and adding known technical improvements such as 2x2 MIMO antennas. We assume that Claro have already implemented many of these and therefore have few options to increase network capacity other than by additional spectrum.

- Data demand varies across the MNOs from between 0.7GBytes/month to 1GByte/month. We assume demand grows to 3Gbytes/month per subscriber in 2021 for all MNOs, with a linear growth curve[6]. This is broadly in line with industry growth forecasts and a level at which growth appears to slow in some countries such as Singapore.

- Constant ARPUs are assumed for all operators, with the same value assumed for all. They are held constant despite the predicted growth in data usage. This implies that subscribers will be getting more GBytes per month for the same fees.

- We assume that of the ARPUs, 50% are profit after the direct per-subscriber costs are taken into account. Hence, if a subscriber churns, the loss to the MNO is 50% of their ARPU.

- We assume that 50% of customers that experience congestion will churn to a different network. A consumer that churns owing to congestion is separate from normal operating churn that is assumed to have no overall effect (since as many will churn to an operator as churn away from it).

With these assumptions we can build a model of each network, showing its capacity and its data demand both now and predicted into the future. The results are illustrative given the lack of evidence

[6] While it is likely that growth will follow an S-curve, industry predictions for the period 2017-2021 are to be on the central part of the S-curve where a linear approximation is a good fit.

across all key inputs and the relatively simple modelling approach. Nevertheless, they can be valuable in informing regulatory strategy.

4.4. Starting point

We have populated the model with the information we have available. We believe we have reasonably accurate sources for subscriber numbers, data usage per subscriber and spectrum holdings as shown in the table below.

	Subscribers (millions)	**Usage Gbytes/sub/month**	**Spectrum holdings (MHz)**
Claro	28.5	0.7	85
Movistar	13.5	0.8	85
Tigo	11.0	1.0	135
Avantel	1.1	0.7	40

[Source: Quaterly Bulletin published by MINTIC (http://colombiatic.mintic.gov.co/602/w3-channel.html)]

A critical part of determining network capacity is the number of base stations per operator. We do not have access to this, other than for Avantel. Hence, we have:

1. We assume that Claro has about the same number of base stations as UK MNOs – around 16,000. Using this assumption the model predicts that they have sufficient network capacity for around 18 months, which seems reasonable.

2. We use this number to derive the number of base stations that other MNOs would have to be in a similar capacity position to Claro. So, for example, if an MNO had the same spectrum holdings as Claro but half the subscriber numbers we would assume half the number of base stations[7].

3. We used our knowledge of the number of Avantel base stations to check the assumptions. The model predicts a number close to the real answer.

If the numbers we have assumed are inaccurate then this would change the timing of when investment is required but not the relative amounts nor value of spectrum. We provide sensitivity modelling to show the effect of other base station numbers on the results.

4.5. Unconstrained auction

The model shows that Claro are by far the most spectrum constrained. The table below show the current spectrum per subscriber.

	Spectrum Hz/Subscribers
Claro	3.0
Movistar	6.3
Tigo	12.3
Avantel	35.9

[7] This ignores the number of base stations needed for coverage of rural areas. We assume here that this number is not sufficiently large to materially change the results.

Our model suggests that different operators will value 700MHz spectrum in different ways as follows:

- We assume that the only way that Claro can add capacity is using more spectrum[8]. If they do not get enough spectrum they will not be able to serve subscribers well as their data rate requirements grow. These subscribers will churn onto other networks and Claro will lose the profit gained from them. Hence, their value for spectrum equates to lost profit from churning subscriber.

- We assume all the other MNOs can expand their capacity with either more spectrum or more cells (since they have not yet reached the limits of cell densification). The value of the spectrum is the same as the cost of the cells needed to generate the same increase in capacity as the spectrum would bring.

- If subscribers churn from Claro we assume they move to the other MNOs in proportion to the level of spare capacity on each of their networks. These MNOs then gain the profit from these subscribers.

- In addition, Avantel uses roaming to support voice traffic and provide coverage in areas where Avantel does not have cells. We assume that using 700MHz would largely remove the need for roaming and hence the fees associate with this would stop.

Using these assumptions, and without any constraints whatsoever on the auction outcome, the model predicts that Claro would attempt to buy all of the spectrum. The total profit or loss over a five-year period[9] for a range of different scenarios are given below. Note that in all cases throughout the rest of this report, the numbers reported are excluding any payments for spectrum in the auction.

Value US$m	**No spectrum auction**	**Equal share (17.5MHz each)**	**All Claro**	**Claro 40MHz, others 10MHz each**
Claro	-1106	-533	0	-155
Movistar	332	209	0	84
Tigo	277	163	0	52
Avantel	57	184	0	92

This shows that without winning additional spectrum in the 700MHz auction Claro will see a decline in potential future revenue of over $1bn over 5 years due to loss of subscribers, a value which is distributed across the other MNOs[10]. Whereas if Claro gains 40 MHz, it will suffer a decline in net revenue of about $155 million per year, before paying for the spectrum. Note that this does not plunge it into loss, since the starting point for the calculation is its financial position in 2017, which reflects the use which it is currently making of the power in the Colombian mobile market place which it already possesses[11]. The benefit from the sector (and the economy) is a more even distribution of

[8] For a discussion as to why MNOs cannot readily use a dense network of small cells to increase capacity see W Webb, "Limits of small cells in dense networks", http://www.webbsearch.co.uk/publications/

[9] While the licence will extend for 10 years or more, forecasting further out than 5 years is increasingly uncertain and so we restrict the analysis to a five year period of 2017 to 2021.

[10] The gain for the other MNOs is somewhat less than the loss to Claro as the other MNOs need to build additional infrastructure to provide sufficient capacity to handle the traffic generated by the migrating subscribers.

[11] To put this into perspective, America Movil, the group owning Claro, made a profit of, on average, around $1.5bn per year over the last three years across its global operations (figures for Colombia alone do not appear to be available). A

subscribers and of market power, which is likely to result in more vibrant competition in the Colombian market. Hence, it is a good outcome for the other MNOs, for the Government and for the citizens of the country[12]. Note that under our assumptions that ARPU does not grow and subscriber numbers are static then the total revenue available to MNOs is fixed. Growth for one MNO can therefore only come if another MNO sees a decline. Hence, all modelling outcomes will involve a fall in revenues for at least one MNO. If we relaxed this assumption, the outcome would be less stark, but the detrimental effect on Claro would be muted not eliminated. This reflects the truth that pro-competition measures must hurt the player with the greatest market power – compared with the alternative of a continuation or further accumulation of such power.

Summary If Claro win a substantial amount of spectrum, eg 40MHz, then they can mostly avoid this loss and if they win 70MHz they can grow their market share slightly. This is because the extra spectrum allows them to increase the capacity of their network in line with the growth in demand, avoiding subscriber dissatisfaction and churn. Hence, the value to Claro of, eg 40MHz would be the difference between the status quo loss of $1,106m and the loss with 40MHz of $155m, which is approximately $950m. This is much greater than the value to the other MNOs of winning eg 17.5MHz each and hence a plausible outcome of an unconstrained auction is that Claro win the majority of the spectrum. The table suggests that Claro winning 40MHz or more would be highly likely.

4.6. The impact of constraints on the auction

As discussed in Section 2, a more symmetrical market structure across the MNOs could signify increase competition in the market with beneficial effects for consumers. The previous section shows that absent intervention Claro would likely win most or all of the new spectrum, which would entrench their leading position. This can be changed with auction rules that limit the ability of Claro to buy spectrum. There are an infinite number of different scenarios, here we provide three different scenarios, namely:

1. 10MHz of spectrum is reserved for either Avantel or a new entrant.

2. 20MHz of spectrum is reserved for two of Avantel, Tigo and a new entrant with no one operator being allowed to acquire more than 10MHz of this reserved spectrum.

3. 30MHz of spectrum is reserved as above.

Note: we assume that the minimum size of a spectrum block is 2x5MHz=10MHz. Any smaller blocks would not fit well with the 4G spectrum bandwidth.

We further assume that, as suggested by the regulator, caps of 45MHz will apply to all MNOs below 1GHz. Since Claro and Movistar both already have 25MHz this limits them to acquiring an additional 20MHz each. Under these assumptions, the results are as shown below. Note, we do not give the results for the new entrant as it is too uncertain to construct their business case without an understanding of the resources that they might be able to utilise or share.

reduction in profit of $1bn over 5+ years represents around a 12% reduction, more realistic reductions of $100m only just over 2%.

[12] For those subscribers that churn from Claro there will be some temporary costs associated with lower utility of communications while they remain on Claro (eg until their contracts expire) and the time and effort needed to switch. As long as switching is straightforward these costs will be minimal.

Value US$m	10MHz reserved	20MHz reserved	30MHz reserved
Claro	-452	-452	-452
Movistar	205	205	205
Tigo	158	148	137
Avantel	8	138	158

The implications from these results are:

1. Under all scenarios, Claro is able to acquire 20MHz of spectrum, placing it in a much better position than if it were to acquire none.

2. Movistar is also able to acquire 20MHz of spectrum under all scenarios.

3. The difference for Tigo between 10MHz reserved and 30MHz reserved is relatively small.

4. Avantel hardly benefit with 10MHz reserved as the revenue from additional subscribers mostly passes to Tigo, leaving little for Avantel, while they have some network expansion costs. There needs to be at least 20MHz reserved for them to benefit to the same extent as Movistar and Tigo.

The table suggests that reserving 20MHz would achieve a reasonably even distribution of the subscribers churning away from Claro, enhancing competition.

The numbers in this table can also be used to inform reserve prices. In principle, the numbers in this table are the maximum amounts that the MNOs would be willing to bid, and reserve prices are normally set some way below the maximum.

4.7. Sensitivity analysis

Here we examine how the results vary according to the assumptions we have chosen.

We firstly consider the implications of differing numbers of base stations assumed for Claro. This leads to the following results for 20MHz of reserved spectrum:

Value US$m	Assumed case: 16,000	High case 20,000	Low case 12,000
Claro	-452	-105	-1444
Movistar	205	133	343
Tigo	148	62	483
Avantel	138	90	422

In the high case, Claro does not suffer much network congestion since it has sufficient capacity to accommodate anticipated subscriber growth. The other operators are less affected by this change since the model still assumes that they have just sufficient base stations at present. In the low case, Claro is much more strongly affected resulting in subscriber churn to the other operators. However, we would anticipate in this case that Claro could address some of the capacity issues through deploying base stations up to the base level assumed and so mitigate some of these loses. Hence, we would not change our conclusions even if there were different numbers of base stations than we have assumed.

We next consider the impact of differing rates of growth in data demand on the case where 20MHz is reserved as follows:

Value US$m	**Assumed case: 3GBytes/month by 2020**	**High case: 5GBytes**	**Low case 1GBytes**
Claro	-452	-1760	0
Movistar	205	123	64
Tigo	148	661	22
Avantel	138	582	83

The results are very similar in form to those for varying the numbers of base stations – which is unsurprising as both have effects on whether network capacity can meet demand. In particular, a high demand leads to increased congestion on Claro's network, resulting in more churn of subscribers to the other operators. If we consider the high case across the various set-aside options, we obtain the following results:

Value US$m	**10MHz reserved**	**20MHz reserved**	**30MHz reserved**
Claro	-1716	-1760	-1760
Movistar	126	123	123
Tigo	781	661	640
Avantel	280	582	582

We see a similar effect as to the assumed 3GByte/month case in that 20MHz clearly leads to a more even distribution of subscribers away from Claro while 30MHz does not materially change the position of the operators.

Finally, we consider the case for 5 year versus 10 year analysis. The results are shown below.

Value US$m	**5 year**	**10 year**
Claro	-452	-3549
Movistar	205	308
Tigo	148	1395
Avantel	138	988

While it may appear preferable to adopt the 10 year analysis since the licence terms will be for at least this long, we caution against this as the model assumes no further spectrum is auctioned throughout this period while data demands continue to grow. It seems unlikely that both of these will hold to be true and therefore the results 10 years out must be considered highly uncertain.

In general, we believe that if those assumptions for which we lack strong evidence prove incorrect it will change the magnitude of the overall values but not their relative positions. It is the relative positions that are used to determine auction approaches as discussed further in the next section and so the impact of the assumptions on this decision will be small.

4.8. Value of coverage

One of the key benefits of the 700MHz band is its relatively good propagation. This enables the same area to be covered with fewer base stations, or greater indoor penetration to be achieved. Operators have typically shown through auction payments and similar that they have a higher value associated with low frequency spectrum up to a point where they have sufficient. The improved coverage enables them to both directly increase their subscriber base by covering areas where new subscriber live, and indirectly through the competitive benefit that accrues from good coverage which is generally valued by consumers.

Understanding the additional value of lower frequency spectrum compared to higher frequency is difficult as it will vary between operator and will depend on the current levels of coverage and the concern about good coverage among the subscriber base. For example, if most subscribers rarely travel outside of the large cities they may be indifferent to coverage.

It seems likely that Claro and Movistar, who both already have substantial spectrum holdings below 1GHz would see relatively less value from the lower frequencies. For these operators, they may be somewhat indifferent between lower or higher frequency spectrum. Tigo has no low frequency spectrum and hence may value it highly. Avantel does have some low frequency spectrum but has put it into use for iDEN technology. This means that non-iDEN subscribers cannot be well-served outside of urban areas. These non-iDEN (LTE) subscribers roam onto other networks and so we have captured the value of the lower frequency spectrum through the elimination of roaming fees should Avantel win and deploy lower frequency spectrum. Also, because Avantel cannot provide voice services (using VoLTE) with their AWS spectrum, all voice calls currently must be handled via roaming to other networks. If Avantel gain 700MHz spectrum they will be able to implement VoLTE systems and hence avoid these roaming fees. At present, we have not considered roaming fees paid by Tigo, hence we may be under-estimating the value that Tigo would place on the spectrum.

More generally, by ensuring that all MNOs have access to sufficient low-frequency spectrum to be able to deploy a viable LTE network, this should enable competition across a broader geography, resulting in a more vibrant market for the greatest number of Colombian citizens. Hence, there are good reasons to construct an auction that allows Avantel and Tigo the ability to acquire at least 10MHz each.

5. Discussion and recommendations

In Section 2 we showed that competition in the Colombian mobile market is a concern to regulators; (and this is a view which we share). This was due to the presence of a dominant player leading to results that seem likely to reduce innovation, decrease price competition and delay the arrival of new services.

In Section 0 we discussed ways that regulators can improve the competitive position through techniques such as set-asides and caps in the auction process.

Finally, in Section 4, we used illustrative modelling to show that, in the absence of any restrictions, Claro would likely acquire the majority of the spectrum since it has few other ways to deliver the increased capacity needed as subscriber demand grows. Restrictions on Claro, as already proposed by the regulator in the form of caps below 1GHz, would result in it being unable to expand capacity at the rate required which would likely lead to subscribers churning onto other operators until an equilibrium is reached where the demands on Claro's network met the available capacity. This is

exactly the outcome needed to reduce the dominance of Claro and hence deliver a more competitive marketplace. The proposed caps will limit Claro but it is important to then ensure that the subscribers that migrate away from Claro do so to all the other operators rather than just the strongest players.

In consider the best form that such an intervention might take that achieves this relatively even distribution of churning subscribers we note that:

1. There seems little benefit in focussing the promotion of rivalry on an entirely new entrant. Few markets support more than four mobile operators and the latest entrant – Avantel – is eager to develop its footprint and enter the mass market. Hence, there is no reason to set aside spectrum exclusively for new entrants. Equally, there is no reason to exclude a new entrant from bidding in any set aside auction, if one should emerge.

2. There is a strong argument that all operators should have access to sufficient spectrum below 1GHz to provide good coverage both in rural areas and in buildings. Tigo do not have any spectrum below 1GHz and Avantel cannot use their current 850MHz holdings for latest-generation LTE solutions because of its current use for iDEN technology. Hence, ensuring Tigo and Avantel are put in a position where they have an opportunity to acquire at least the minimum useful 10MHz of spectrum to deploy LTE-based solutions would have beneficial effects. (However, this does not imply that in general Avantel and Tigo should be treated equally, since Tigo is a well-established player, this recommendation purely applies to this "coverage" spectrum.)

The modelling suggests that there is no single clear "right answer" as to how the spectrum should best be distributed to meet regulatory requirements. Instead, there is a progressive change as the amount of spectrum set aside is increased. Making 20MHz available to Avantel and Tigo (and potentially any other new entrant) –with a maximum of 10MHz per operator from within this reservation[13] - appears to be the most economical way of meeting the competition goal.

We therefore recommend:

1. Caps be applied of 45MHz below 1GHz as currently proposed.

2. Given that the minimum viable block size for LTE is 2x5MHz we suggest that this be the size of the blocks in the auction, resulting in seven 2x5MHz blocks being made available.

3. That at least 20MHz of the 700MHz spectrum be set aside for any bidders other than Claro and Movistar, with no bidder allowed to win more than 10MHz from the set-aside.

4. That, if the regulator is concerned about the set-aside resulting in lower auction revenues, that the approach of a threshold price (as discussed in Section 3.2) below which all are allowed to bid be adopted.[14]

[13] To be clear, an operator could acquire 10MHz of the reserved spectrum and, say, 10MHz of the non-reserved spectrum as well.

[14] It should be borne in mind that one of the effects of a set-aside is to heighten the competition for the remaining spectrum in the award; this can increase the prices realised there.