SOCIAL AND ECONOMIC BENEFITS OF USING THE LOWER PORTION OF THE UHF BAND FOR IMT

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Authors

- **Raul Katz** (Ph.D., Management Science and Political Science, Massachusetts Institute of Technology) is currently Director of Business Strategy Research at the Columbia Institute for Tele-Information, Adjunct Professor in the Division of Economics and Finance at Columbia Business School (New York), and President of Telecom Advisory Services, LLC. He worked for twenty years at Booz Allen Hamilton, where he was the Head of the Telecommunications Practice in North and Latin America and member of its Leadership Team.

- **Ernesto Flores-Roux** (Ph.D., Statistics, University of Chicago) is a researcher at the Centro de Investigación y Docencia Económicas (Mexico) and Director of Telecom Advisory Services LLC. He was a partner at McKinsey & Co, Inc. in charge of the Rio de Janeiro office, a VP of Marketing and Strategy at Telefónica Mexico, and VP of Strategy for Telefónica Asia. He was also Chief of Staff of Mexico's Undersecretary of Communications.

- **Fernando Callorda** (MA, Economics, Universidad de San Andrés - Argentina) is a researcher affiliated with the Universidad de San Andrés Centro de Tecnología y Sociedad. He was also a staff member at Argentina's National Congress and an auditor at Deloitte Touche.

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EXECUTIVE SUMMARY

Towards the end of 2013 there was only an average of 270 MHz of spectrum used for mobile telecommunications in Latin American countries. This amount is far from the 1340 to 1960 MHz that has been estimated by the International Telecommunication Union to support mobile services by 2020[1]. In light of this estimate, the 90 MHz in the 700 MHz band that is in the process of being assigned will not be enough to support future growth of mobile broadband. This is the reason why the lower part of the UHF (470-698 MHz) band represents a key resource to be considered as the "second digital dividend". Except for a channel allocated to radio astronomy services (608-614 MHz), the band is allocated to mobile services as well as broadcasting in several countries of the region. The success of the digital dividend so far has shown that the 470-698 MHz band can also be used for both broadcast and mobile services.

An analysis of the situation in **five countries** of the region has shown that the lower part of the UHF band – from 470 to 698 MHz – is allocated, on a primary basis, to broadcasting services **i**n Latin America (except for the 608-614 MHz). Nevertheless, in many countries[2] the allocation of portions of this band to mobile services has already being agreed to. Furthermore, some countries, such as Mexico and Colombia, are considering the future allocation of this band to IMT[3].

In order to provide an assessment of the potential impact of a policy change that would add an allocation of the band to IMT on a primary basis, it is relevant to study the social and economic benefits of such a measure. These were estimated for the following effects:

- Incremental contribution to GDP (direct, in terms of additional mobile broadband revenues, and indirect, in terms of economic spill-overs);
- Job creation (direct employment - within the industry- and indirect – from suppliers to the mobile broadband industry);
- Additional tax contribution of the wireless sector to the treasuries of Latin American countries; and
- Increase in consumer surplus resulting from price declines.

To begin with, this band has the possibility of extending coverage to unserved rural and isolated areas. The reach of 470-698 MHz band is 20% higher than the 700 MHz band, which means that wireless broadband coverage could increase between 1.5 and 2.5 percentage points beyond 700 MHz with little additional site infrastructure, resulting in 3.7 million additional mobile broadband subscribers in rural areas. In addition, because of its propagation advantage, the usage of this band would result in a reduction in the number of base stations of 6%, which is estimated to represent a present value of US$ 897 million[4] between 2015 and 2020. This reduction will allow mobile operators to reduce their prices by almost 1% (in addition to the 10% resulting from the utilization

[1] See studies conducted by AI 1.1 and Working Party 5D. Additionally Coleago estimates that 2020 spectrum needs for Argentina, Brazil, Chile, Colombia and Mexico range from 893 MHz (low usage scenario) to 1676 MHz (high usage scenario for Brazil).
[2] Argentina, Ecuador and Venezuela (470-512 MHz), Peru, Chile and Panama (470-512 and 614-698 MHz), Costa Rica and El Salvador (512-608 MHz).
[3] In Mexico while the band is allocated, it would require still a lengthy process to be assigned.
[4] Discounted at 10%.

of the 700 MHz). By considering the price of the most economical mobile broadband product in the region, the net impact of transferring a portion of the producer surplus derived from savings in capital expenditures to prices jointly with the increased coverage, would result in an increase of 19.35 million mobile broadband subscribers. These new subscribers are generally located at the bottom of the socio-demographic pyramid. (8 % increase over the current base of mobile broadband subscribers).

New subscribers represent additional revenues to operators, which should be considered as a direct contribution to the national GDP of US$ 12 billion through 2020 (at present value). On the other hand, the increased penetration of mobile broadband has a spill-over impact on the economy as a whole by enhancing market reach for new products, improving efficiency in businesses, and ultimately promoting innovation. Our assumption, based on prior research, is that a percentage point increase in mobile broadband penetration yields an increase in 0.022 percentage points of GDP. Based on this multiplier, the estimated future increase in GDP resulting from spill-over effects could reach US$ 37 billion in net present value (NPV).

The increase in the number of mobile broadband connections will also require the hiring of new employees. Based on the current user to employee ratio in the region, the estimated number of incremental direct jobs could reach 11,000 (an increase of 13 % over the current base). In addition, the number of additional jobs in industries supplying to the mobile telecommunications industry could reach 36,000.

The increase in revenues generated by mobile broadband service providers could also result in an increase in tax contributions. By relying on each country's current corporate tax rate, the estimated incremental contribution to the treasuries could reach US$ 2.8 billion.

Finally, assigning the 470-698 MHz band to IMT could result in an increase in consumer surplus (a metric not captured in GDP statistics representing the difference between a consumers' willingness to pay, as a measure of value, to the actual price paid). By assuming constant falling nominal prices and a stable demand, the estimated increase in consumer surplus could reach US$ 3.8 billion through 2020 (NPV).

Beyond the quantifiable economic benefits, the allocation of the 470-698 MHz band to mobile broadband in Latin America will have a positive social contribution in several areas. For example, the expansion of mobile broadband to unserved zones will allow the population without current coverage to gain access to more educational resources, improved health services, and financial services. At the same time, introducing wireless broadband in rural areas will enable the efficient provision of public services at a greater speed of access, improving the interrelationship between civil society and governments.

Thus, the results of the study indicate the benefits to be generated as a result of using the 470-698 MHz band to provide mobile broadband services in Latin America:

- An increase in broadband coverage resulting from increased availability of mobile broadband, a fundamental variable to ensure economic growth in Latin America;
- More optimal deployment and operation of new networks, resulting in a reduction of capital

investment of US $ 897 million compared to deployment of infrastructure in higher frequency bands, while achieving better coverage;

- Direct (additional revenues to the industry) and indirect contribution (positive externalities) to GDP reaching US$ 49 billion;
- Creation of more than 47,000 direct and indirect additional jobs;
- Additional tax contribution in excess of US $ 2.8 billion;
- A consumer surplus of US $3.816 billion.

All these effects amply justify the inclusion of the lower part of the UHF band to IMT across Latin America, while including provisions for protection of broadcasting from interference. This would give regulators the flexibility to license mobile broadband in a portion of the band when – and if – they see fit.

1. INTRODUCTION

Spectrum, an essential element for the provision of wireless telecommunications, is, for technical and economic reasons, a scarce element. In many situations, this scarcity has been augmented due to artificial restrictions, most of them caused by regulation. Though Latin America's approach to spectrum licensing has significantly changed in the last decade, towards the end of 2013 there was only 270 MHz being used per country, on average, for mobile telecommunications (IMT). This amount of spectrum is far from the 1340 to 1960 MHz that has been estimated by the International Telecommunication Union for these services by 2020[5]

Around the year 2010, the debate on the allocation of the digital dividend (700 MHz band) intensified in the region, and through diligent work of many people, institutions, associations, governments, academia, consultants, and corporations, all countries in Latin America decided to allocate the digital dividend band to IMT services, realizing the benefits of the analog switch-off. Today, most countries have started the process to assign this band for the deployment of LTE networks.

Nevertheless, the 90 MHz in the 700 MHz band will probably not be enough to support future growth of mobile broadband. Even though other bands are still partially available (mostly, AWS and 2.6 GHz), Latin America will need to allocate, identify, and later assign, further spectrum bands for IMT services. There are several candidate bands (e.g., L band, 2.7 GHz, 3.4 GHz), but the sub-700 MHz band is key band for coverage for rural areas. This band is sometimes referred to as the "second digital dividend". The United States, through its "incentive auctions" approach, will become a pioneer in using part of this band for mobile telecommunications.

The following paper addresses the potential value to be generated by allocating the 470-698 MHz band to IMT in Latin America. It begins by assessing the current situation in terms of utilization of the band. It proceeds then, to assess the social and economic benefits of allocating this band to IMT. The conclusion summarizes the policy implications of the evidence provided in the prior sections of the report.

2. CURRENT SITUATION OF THE 470-698 MHz BAND IN LATIN AMERICA

Except for channel 37 (608-614), which is reserved for radio astronomy services, the lower part of the UHF band – from 470 to 698 MHz – is allocated, on a primary basis, to broadcasting services in all countries in Latin America (see table 1) [6].

[5] See studies conducted by AI 1.1 and Working Party 5D. Additionally, Coleago estimates that 2020 spectrum needs for Argentina, Brazil, Chile, Colombia and Mexico range from 893 MHz (low usage scenario) to 1676 MHz (high usage scenario for Brazil).

[6] Most countries already have parts of the band allocated to fixed and mobile services: Mexico, Honduras and Dominican Republic (470-608 MHz and 614-698 MHz); Chile, Peru and Panama (470-512 MHz and 614-698 MHz; Argentina, Uruguay, Ecuador and Venezuela (470-512 MHz); Guatemala, El Salvador and Costa Rica (512-608 MHz). Nicaragua, Bolivia, Brazil, Paraguay and Bolivia have only allocated the band to broadcasting. Source: National frequency allocation tables.

Table 1. Allocation of the lower UHF band in Latin America (selected countries)

Band	Brazil	Chile	Colombia	Mexico	Peru
470-512	BROADCASTING	MOBILE, FIXED	BROADCASTING	BROADCASTING FIXED MOBILE	BROADCASTING
512-608	BROADCASTING	BROADCASTIING, Fixed	BROADCASTING	BROADCASTING FIXED MOBILE	BROADCASTING
608-614	RADIO ASTRONOMY	RADIO ASTRONOMY Mobile satellite system except aeronautical mobile telecommunication service via satellite	RADIO ASTRONOMY Mobile satellite system except aeronautical mobile telecommunication service via satellite	RADIO ASTRONOMY Mobile satellite system except aeronautical mobile telecommunication service via satellite	RADIO ASTRONOMY Mobile satellite system except aeronautical mobile telecommunication service via satellite
614-698	BROADCASTING FIXED	BROADCASTING Fixed /FIXED/*	BROADCASTING	BROADCASTING FIXED MOBILE	BROADCASTING

Note: Upper-case words refer to primary services; lower-case refers to secondary services.
* Denotes a service which is permitted on a primary basis, except during the preparation of frequency plans, where primary services receive priority

A significant difference with the 700 MHz band, which is now allocated to IMT but was previously used for broadcasting, is that it is heavily utilized in the region. As this band is also an essential part of the transition to terrestrial digital television, which is currently being implemented, its use will become more intense in the near future. This is particularly relevant for those countries that had assigned multiple broadcasting licenses in the 700 MHz band and are relying on the full 470-698 MHz band for refarming purposes (e.g., Brazil).

During this transitional period, there seems to be a pattern where most countries are inclined to use, for migration purposes, the lower parts of the band, but, given ample demand and need for spectrum, they have not been able to use these channels, 38-52 (614-698 MHz band).

2.1 Country Analysis

A few countries in the region have been studied in detail to evaluate the current situation. It is important to mention that the transition plans to digital television are still in the making, and as such, evaluation will probably change significantly in the near term. For example, Chile approved in May 29, 2014 the new law that allows the introduction of digital television[7]. Mexico determined in its Constitutional Reform of 2013 that the transition would be completed by the end of 2015, but in its recently approved Telecommunications and Broadcasting Law[8] (July 2014), it has already allowed for the possibility of extending the peremptory date.

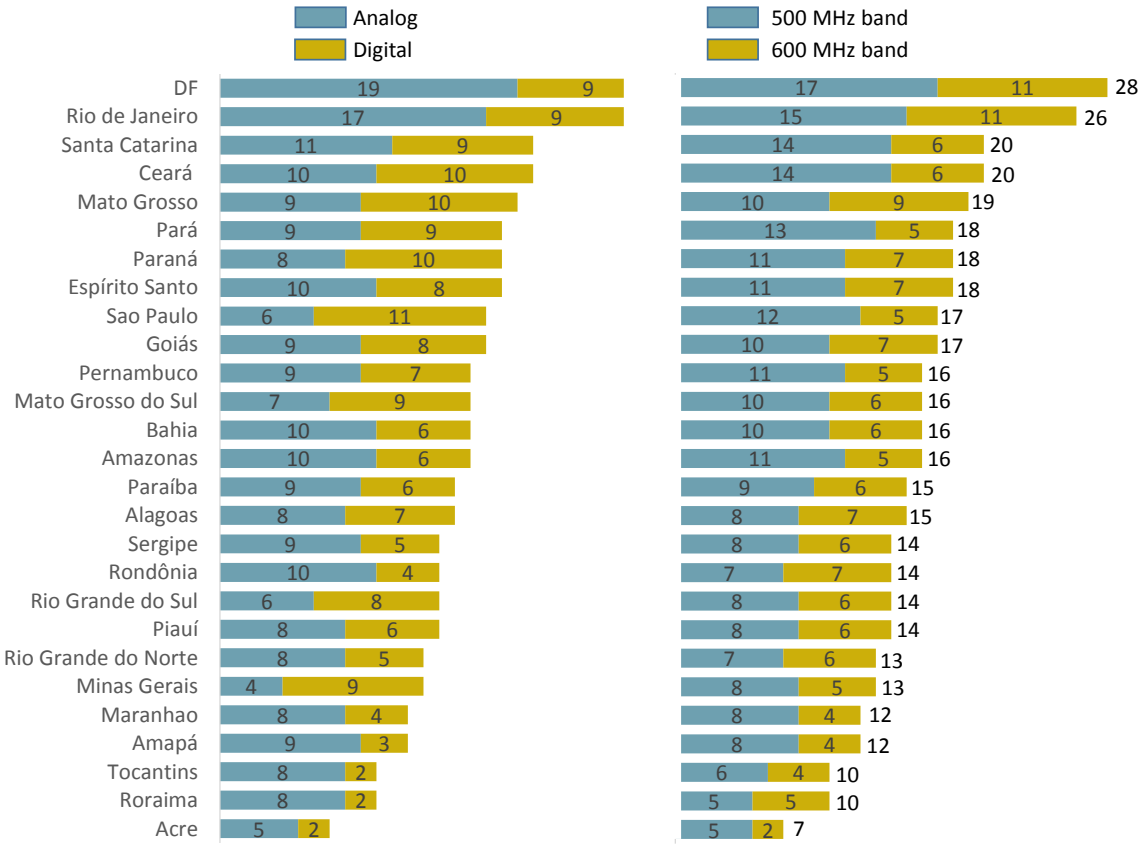
[7] Ministerio de Transportes y Telecomunicaciones, Chile, Ley 20,750 de 29 de mayo de 2014, "Permite la introducción de la televisión digital terrestre".
[8] Secretaría de Comunicaciones y Transportes (SCT), 08 de julio de 2014, Ley Federal de Telecomunicaciones y Radiodifusión.

2.1.1. Brazil:

Anatel reports that there are currently 10,849 analog TV broadcasting licenses in the 470-698 band, all municipalities are covered, serving more than 95% of the population. They have also awarded 2,921 digital TV broadcasting licenses[9], covering 11% of municipalities and serving 50% of the population. After the analog switch-off, all licenses will be used for digital broadcasting.

Figure 1 shows the number of outstanding licenses in the capitals of the 27 Brazilian states, as an example of where the band is most utilized. As the maximum number of channels is 33 in the 494-698 MHz band, it can be seen that on average, the band is 48% utilized, with only 10 capitals showing an occupation rate of 50% or more. The 500 MHz and 600 MHz[10] bands have on average 9.8 and 6.1 outstanding licenses respectively (51% and 43% occupation).

Figure 1. Number of licenses in the capitals of Brazilian states



Source: Anatel; TAS analysis

The Ministry of Communications generally awards new licenses for a 15-year period and renews them indefinitely for additional 10-year periods. Almost all licenses are up for renewal in the next

[9] Source: CITEL. OEA/Ser.L/XVII.4.2. CCP.II-RADIO/doc.3289/13. (11 April 2013). Compilation of responses to questionnaire on current and planned services on the 470-698 MHz band in the Americas

[10] In this document, we refer to the 500 MHz band to channels 18 thru 36 (494-602 MHz) and the 600 MHz to channels 38 thru 51 (614-698 MHz)

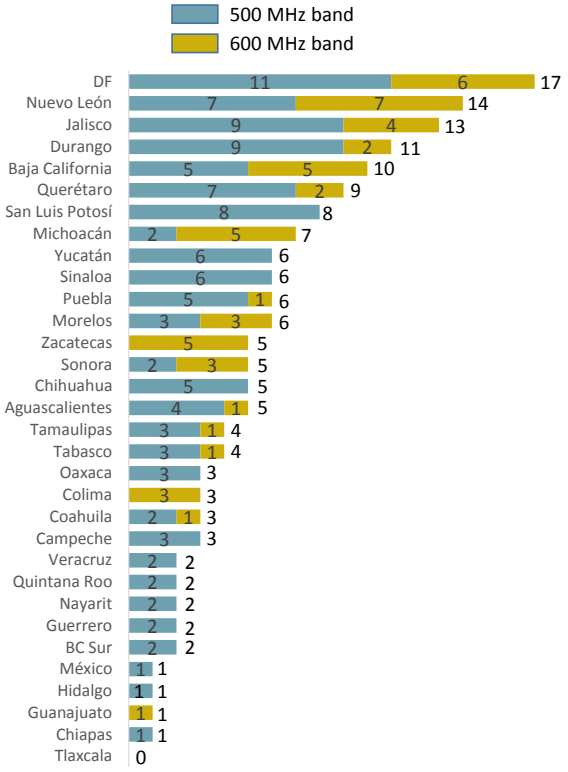
ten years, with approximately the same number every year[11].

2.1.2. Mexico:

Of the five countries analyzed in detail, Mexico is the only one that has allocated fixed and mobile services to this band on a primary basis, together with broadcasting. Nevertheless, the band is so far mostly licensed to broadcasters, though the 470-512 MHz band can also be used for fixed or mobile services in places close to the US border or densely populated areas (Mexico City, Guadalajara, Monterrey)[12]. Mexico signed an agreement with the US in 1994 for the use of this segment for mobile communications along the common border.

The 470-698 MHz band is not heavily occupied in Mexico. Nationwide, there are around 325 and 150 licenses in the 500 and 600 MHz spectrum, out of a total of 1,046, 745 of which are analog. Figure 2 shows the lower UHF band licenses in the capitals of the 32 Mexican states. The 500 and 600 MHz bands have on average 3.5 and less than 2 licenses awarded, which imply an occupation of around 15%. The regulation that defined the digital standard in 2004 also set the expiration of all TV concessions to be December 31, 2021, except for around 50, which were awarded to government-related entities[13].

Figure 2. Number of licenses in the capitals of Mexican states



Source: IFT; TAS analysis

[11] This assertion is based on an analysis of a random sample of the outstanding licenses performed by TAS.
[12] Source: Cofetel. (February 2012). Cuadro nacional de atribución de frecuencias.
[13] State governments, public television (OPMA), Congress, and universities (UNAM, IPN).

The Constitutional Reform, approved in 2013, stipulated that the regulator had to award two national TV licenses in 2014. Thus, Mexico is in the process of assigning two new 20-year national concessions, composed of 246 regions. Of these, 56 are in the 600 MHz band and 181 in the 500 MHz band.

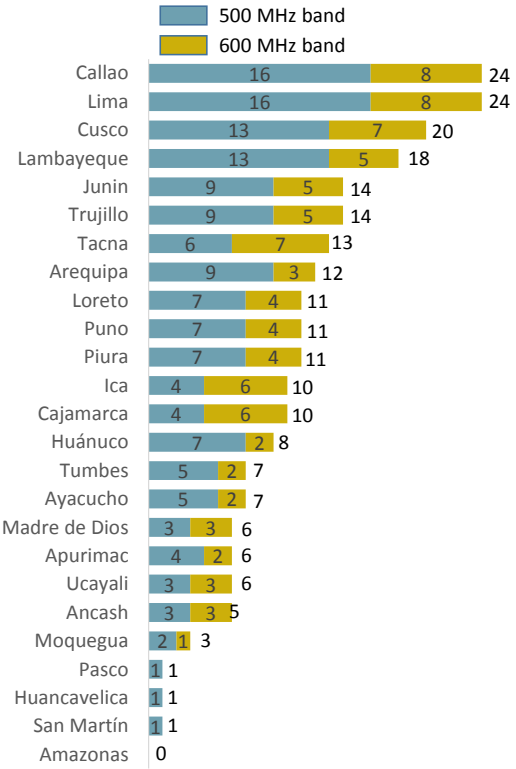
The Mexican regulator has already stated that it is considering analyzing the 600 MHz for future use in IMT services, probably by the end of the decade.

2.1.3. Peru:

The lower part of the UHF band, which is only assigned to television broadcasting services in Peru, is currently being used by 383 broadcasters[14], with 43% of these licenses concentrated in only five regions (Lima, Ica, Cusco, Puno and Junín), which means that reassignments could potentially be easier to conduct. Other licenses have been awarded or have been reserved for the State. Figure 3 shows the number of outstanding licenses in the capitals of all Peruvian regions. Of these, only 26% are digital transmissions.

The band is not heavily occupied. On average, occupation rates are 33% and 28% in the 500 and 600 MHz bands, respectively. Lima and Callao have the highest rates at 73%. Licenses are awarded for 10 years, with automatic renewal once legal conditions established by law have been fulfilled. The number of licenses up for renewal is evenly distributed over the next ten years.

Figure 3. Number of licenses in the capitals of Peruvian regions



Source: ConcorTV; TAS analysis

[14] Source: Consejo Consultivo de Radio y Televisión (ConcorTV).

Peru's digital switch-off is still a decade away. Lima and Callao already have simultaneous analog and digital transmissions; the switch-off is scheduled for 2020. The rest of the country was divided into three regions which will have full simultaneous transmissions starting in 2016, 2018 and 2024, with the switch-off scheduled for 2022 and 2024 for the first two, undefined for the rest of the country.

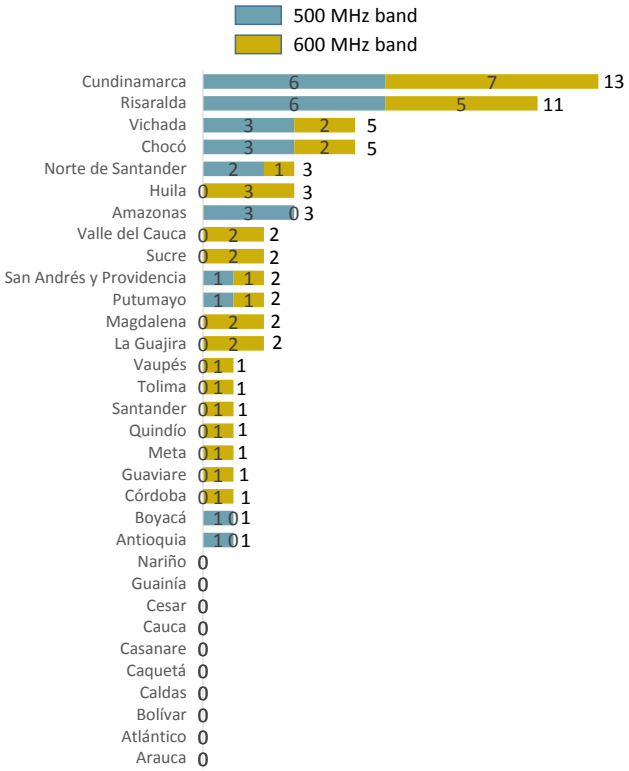
Peru has not made any public or official statements indicating whether they are considering exploring the possibility of changing the allocation of the lower part of the UHF to be used for IMT services.

2.1.4. Colombia:

Colombia has awarded more than 8,400 broadcasting licenses (analogue and digital), of which 1,521 are in the 500 MHz band and 372 in the 600 MHz band; many of these licenses cover small geographical areas. It has also reserved another 2,260 for two new national licenses and for local operators, of which 1,123 and 602 are in the 500 and 600 MHz bands respectively.

Figure 4 shows the number of licenses operating in the capitals of all Colombian departments. As can be observed, the lower UHF band is not heavily occupied. The average occupation for the 500 and 600 MHz bands is only 6% and 4%; it goes up to 13% and 5% if the reserve for future broadcasters is considered. The city of Bogota exhibits the highest occupation of the 500 MHz, reaching only 22%. The issue in Colombia in not how occupied the band at any given location, but the number of tenants it already has; this makes the process of relocation more complicated, as the number of broadcasters at the national level is large.

Figure 4. Number of licenses in the capitals of Colombian departments



Source: TAS analysis

In its Technical Plan for Television, which was published in July 18, 2014, the National Spectrum Agency (ANE – Agencia Nacional de Espectro) has reorganized its spectrum for the transition to digital television. It has considered a total of 12,970 licenses, of which 7,047 will be in the 500 MHz band and 1,087 in the 600 MHz band. It is already considering that new licenses will be awarded. The analog switch-off is scheduled for 2019.

2.1.5. Chile:

Chile has an average occupation of the 500 MHz, whilst the 600 MHz band is almost unused. There are 21 digital broadcasters, 19 of which use the 500 MHz band and only 1 in the 600 MHz. There are also 19 analog stations, 16 of which use the 500 MHz band and only one in the 600 MHz band. Concessions are awarded for 25 years. The oldest concessions date back to 1990, but most of them were granted in the period 1995-2003.

The Subtel has recently concluded (August 10, 2014) the public consultation for the new TV Broadcasting Plan, which includes a revised plan for the transition to digital television. It has reserved channels 21 to 51 (512-698 MHz) for digital broadcasting. It has also contemplated that analog concessions in the VHF band can submit an application for a new concession in the UHF band. The analog switch-off of broadcasters in the UHF band is scheduled to happen in two years after the publication of the law; for those using VHF spectrum, the plan allows for a 5-year transition.

2.2. Conclusion:

As the analysis of the situation in five countries of the region has shown, the lower part of the UHF band – from 470 to 698 MHz – is allocated, on a primary basis, to broadcasting services in all countries in Latin America. That said, some countries, such as Mexico and Colombia, are considering the future use of this band for IMT.

In this context, in order to provide some assessment of the potential impact of a policy change that could be gained from assigning the band to IMT, it is relevant to study the social and economic benefits of such a measure. This is being addressed in the following chapter.

3. SOCIAL AND ECONOMIC BENEFITS OF THE 470-698 MHz BAND IN LATIN AMERICA

Following the methodology initially implemented by Telecom Advisory Services for quantifying the benefits of the 700 MHz digital dividend (see Katz and Flores-Roux, 2011), social and economic benefits of allocating the 470-698 MHz band were estimated for the following effects:

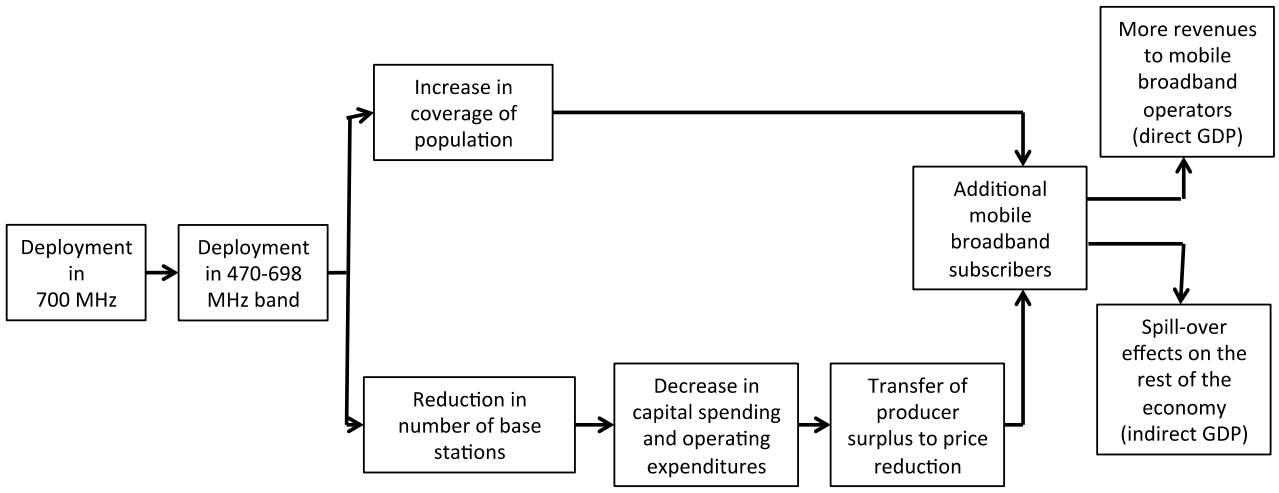
- Incremental contribution to GDP (direct, in terms of additional mobile broadband revenues, and indirect, in terms of economic spill-overs);
- Job creation (direct -within the industry- and indirect –suppliers to the mobile broadband industry);
- Additional tax contribution of the wireless sector to the treasuries of Latin American countries; and
- Increase in consumer surplus resulting from price declines.

To avoid any double counting, the estimation of the benefit of the 470-698 MHz band was done after isolating the effect from the 700 MHz band for IMT.

3.1. Contribution of the 470-698 MHz band to GDP in Latin America:

The quantification of the impact on the GDP of increased mobile broadband coverage resulting from allocating the 470-698 MHz band to IMT was conducted according to the following methodology (see figure 5):

Figure 5. Approach to estimating the impact of the 470-698 MHz band on GDP



Starting with the current mobile broadband coverage based on 3G technology, the increase in coverage of allocating and using the 700 MHz band (digital dividend) first, and the 470-698 MHz band subsequently, was estimated. Accordingly, the deployment of networks on 700 MHz and 470-698 MHz bands has two effects. On the one hand, due to better signal propagation, the new bands allow a better geographic coverage, reaching further in rural areas. On the other hand, better propagation and more capacity allows operators to reduce the number of base stations in urban areas while meeting the new capacity requirements. The reduction in the number of base stations has an economic impact: decrease in CAPEX and OPEX, which would allow operators to further reduce service pricing. A combination of increased coverage and price reduction yields an increase in the number of subscribers, located in rural areas and/or at the base of the socio-demographic pyramid. Finally, the gain of new subscribers has a net effect in service penetration, which results in an increase in service revenues for the operators (a direct contribution to GDP), combined with a spill-over impact on the rest of the economy (indirect contribution to the GDP).

3.1.1. Increase in mobile broadband coverage

As of the end of 2013, fixed wireline coverage in Latin America ranged between 41.37 % in Bolivia to 100 % in Uruguay, while wireless coverage spanned between 79.40 % in Peru and close to 100% in Colombia (see table 1).

Table 1. Latin America: Coverage in Wireline and Mobile Broadband (2013)

Country	Fixed Broadband Coverage (% of households)	Mobile Broadband (% of population)
Argentina	95.98 %	89.00 % (2)
Bolivia	41.37 %	90.00 %
Brazil	100.00 % (3)	91.30 %
Chile	98.66 %	95.00 %
Colombia	94.42 %	100.00 % (3)
Costa Rica	94.86 %	93,25 % (1)
Ecuador	86.83 %	87,47 % (2)
Mexico	75.00 %	91.00 %
Peru	…	79.40 %

Uruguay	100.00 %	96.08 % (1)

(1) 2011
(2) 2012
(3) In countries with the extension and topography of Latin Americas it is theoretically impossible to achieve 100% coverage.

Note: The definitions of coverage might not be consistent across sources, which is why these statistics should be considered as approximate indicators.

*Sources: **for fixed broadband**: Argentina (TAS, Ministerio de Planeamiento), Bolivia (TAS, Entel), Brazil (Teleco), Chile (TAS, Entel), Colombia (MINTIC), Costa Rica (Plan Nacional de Banda Ancha), Ecuador (Mintel), Mexico (COFETEL), Uruguay (EUTIC); **for wireless broadband**: Argentina (Personal), Bolivia (Entel), Brazil (Teleco), Chile (Subtel), Colombia (Deloitte), Costa Rica (UIT, MINAET), Ecuador (UIT), Mexico (Deloitte, SCT), Peru (UIT), Uruguay (TAS, Deloitte), Venezuela (TAS).*

As table 1 indicates, the deployment of mobile broadband based on 3G technology has been fairly efficient in terms of rapidly reaching and/or surpassing fixed broadband population coverage. Beyond relying on conventional spectrum bands (450, 800, 850, and 900 MHz, 1.8 and 1.9 GHz, 1.7/2.1 GHz, 2.5-2.6 GHz, and even 3.4 GHz), the allocation of the 700 MHz will have an important benefit in facilitating rural coverage because of its propagation conditions.

According to the 700 MHz benchmarks of table 2, mobile broadband coverage after allocation of this band to IMT services could have an important impact on countries that are lagging in 3G network deployment (such as Paraguay and Peru) (see table 2).

Table 2. Latin America: Mobile broadband coverage (% of population)

Country	3G services	3G & 4G (700 MHz)	Incremental coverage
Argentina	89.00 %	93.60 %	4.60 %
Bolivia	90.00 %	90.00 %	0 %
Brazil	91.30 % (*)	94.28 %	2.98 %
Chile	95.00 %	95.38 %	0.38 %
Colombia	100.00 %	100.00 %	0 %
Costa Rica	93.25 %	93.25 %	0 %
Ecuador	87.47 %	87.47 %	0 %
Mexico	91.00 %	91.00 %	0 %
Paraguay	70.00 %	83.97 %	13.97 %
Peru	79.40 %	88.32 %	8.92 %

Uruguay	81.00 %	85.48 %	4.48 %
Venezuela	96.06 %	97.40 %	1.34 %

(*) Municipalities covered
Note: The increase in 700 MHz mobile broadband coverage differs somewhat from the estimates in Katz and Flores-Roux (2011) because of changes in 3G coverage and the rate of urbanization since 2011.
Source: Analysis TAS

For the countries that achieved close to 100% coverage with 3G technology, the benefit of 700 MHz will materialize in terms of a reduction in the number of base stations (this point will be addressed below).

Beyond the benefit of allocating the 700 MHz band, the 470-698 MHz band would have an even better performance in terms of signal propagation. For purposes of estimation, the reach of 470-698 MHz band is 20% superior to the 700 MHz band[15]. By combining the allocation of 700 MHz and 470 -698 MHz bands, mobile broadband coverage would increase significantly (see table 3).

Table 3. Latin America: Mobile broadband coverage (% of population)

Country	3G services	Total coverage due to 700 MHz	Total coverage due to 700 MHz and 470-698 MHz bands
Argentina	89.00 %	93.60 %	94.40 %
Bolivia	90.00 %	90.00 %	90.00 %
Brazil	91.30 %	94.28 %	95.70 %
Chile	100.00 %	100.00 %	100.00 %
Colombia	95.00 %	95.38 %	96.53 %
Costa Rica	93.25 %	93.25 %	93.25 %
Ecuador	87.47 %	87.47 %	89.60 %
Mexico	91.00 %	91.00 %	93.07 %
Paraguay	70.00 %	83.97 %	87.96 %
Peru	79.40 %	88.32 %	91.22 %
Uruguay	81.00 %	85.48 %	86.26 %
Venezuela	96.06 %	97.40 %	98.05 %

Source: TAS analysis

The increase in coverage benefits primarily rural areas, which results in the growth of mobile broadband subscribers. In some countries (Bolivia, Costa Rica), however, 3G has already reached coverage of extremely low-density areas. Consequently, rather than enhancing coverage in rural areas, the contribution of the 700 MHz and the 470-698 MHz band will be achieved in terms of additional capacity throughout the network, as opposed to enhanced coverage.

Assuming that penetration in newly-covered rural areas will mirror that of the national scale, the incremental number of subscribers has been estimated (table 4).

Table 4. New mobile broadband subscribers resulting from coverage increase (in million)

Country	Incremental subscribers	Incremental subscribers resulting	Incremental subscribers

[15] It was assumed that dB loss for the 470-698 MHz would be similar to the PCS band for 5 km, which, by relying on the central frequency of lower UHF band, yields a distance of 15.8 km, which is equivalent to a 22% gain relative to the 700 MHz band.

	resulting from 700 MHz	from 700 MHz and 470-698 MHz bands	resulting from 470-698 MHz band
Argentina	0.957	1.123	0.165
Brazil	3.631	5.368	1.737
Chile	0.023	0.093	0.070
Colombia	-	-	-
Mexico	-	0.717	0.717
Peru	0.766	1.016	0.250
Rest Latam[16]	1.475	2.282	0.806
TOTAL	6.852	10.599	3.746

Source: TAS analysis

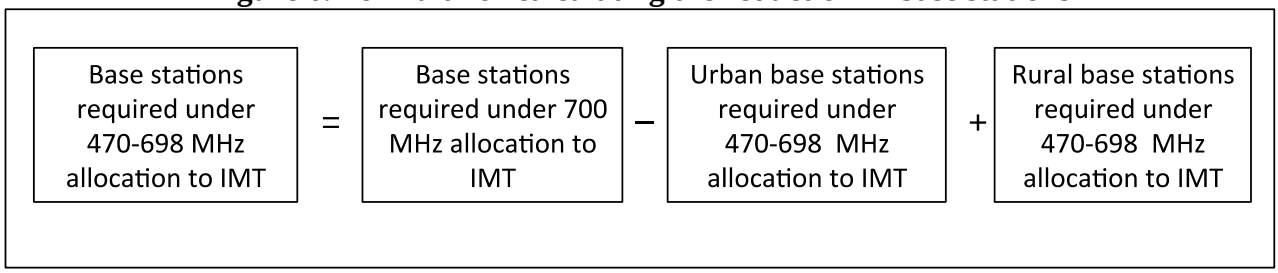
The increase of 3.7 million subscribers is a result of increasing coverage at current price points. The next section will assess the effect of gaining additional subscribers as a result of a decline in pricing resulting from savings in network capital spending.

3.1.2. Reduction in the number of base stations

To estimate the reduction in the number of base stations, we started considering the approximate number of base stations being required today country-by-country on the basis of utilizing a combination of the 900 MHz, 1.9 GHz; 1.7/2.1 GHz and 2.6 GHz bands. This estimate was generated from sources such as GSMA Intelligence and ITU, which in many cases required interpolation, or extension of data of a single operator to the total market.

As a next step, replicating the analysis conducted by Telecom Advisory Services for estimating the effects of the digital dividend (Katz and Flores-Roux, 2011), updated coverage and demographic statistics were relied upon to calculate the number of base stations required under the 700 MHz allocation scenario. Finally, considering an allocation of the 470-698 MHz band, the number of base stations was estimated. **This number needs to account for an additional number of base stations to ensure coverage of additional rural areas** (see figure 6).

Figure 6. Formula for calculating the reduction in base stations



The allocation of the 470-698 MHz band would result in a reduction of 5% of the total number of base stations (see table 5).

[16] The impact on the rest of the region is estimated in relation to the proportion of the population living in the six countries covered in the study (78.71%), and the population of the rest of the region (21.29%).

Table 5. Latin America: Reduction in the number of base stations

Country	Current number of base stations	Reduction in the number of base stations under 470-698 MHz
Argentina	15,731	881
Brazil	73,111	3,977
Chile	4,892	271
Colombia	14,019	749
Mexico	37,943	1,998
Peru	9,335	513
Rest Latam	41,931	2,269
TOTAL	196,962	10,659

Source: TAS analysis

The reduction in the number of base stations is estimated to represent a net present value of US$ 897 million[17]. It is considered that this reduction will allow mobile operators to reduce their prices by around 0.95% (in addition to the 10% resulting from the utilization of the 700 MHz, which also results in significant economies). By considering the price of the most economical mobile broadband product in the region, the net impact of transferring a portion of the producer surplus to prices (see table 6) can be considered.

Table 6. Latin America: Monthly price of 500 MB cap mobile broadband plan (in US$)

Country	Price (as of January 2014)	Estimated price (with 700 MHz)	Estimated price (with 700 MHz and 470-698 MHz)
Argentina	11.02	9.92	9.81
Bolivia	7.09	6.38	6.31
Brazil	15.21	13.69	13.54
Chile	34.18	30.77	30.44
Colombia	13.86	12.47	12.34
Costa Rica	17.90	16.11	15.94
Dominican Rep.	19.66	17.70	17.51

[17] Cost per base station ranges between US$ 84,000 in Argentina, Colombia, and Peru and US$ 91,000 in Brazil. Discount rate is 10%

Ecuador	16.79	15.11	14.95
El Salvador	32.50	29.25	28.94
Guatemala	12.77	11.49	11.37
Honduras	15.38	13.84	13.70
Mexico	15.11	13.60	13.46
Nicaragua	12.20	10.98	10.86
Panama	9.99	8.99	8.90
Paraguay	7.91	7,12	7.04
Peru	15.17	13.65	13.51
Uruguay	6.58	5.92	5.86
Venezuela	27.98	25.18	24.91

Sources: TAS survey price plans; TAS analysis

These price declines are reasonable in light of the tendencies identified so far in many of the Latin America markets. According to Galperin (2014), the average price reduction of broadband products between 2010 and 2014 in the region was 28%, while the average reduction of the most economical plan within the same period is 6%.

Based on a demand elasticity of 0.6 estimated by Katz et al. (2014), the price decline and the increase in coverage resulting from using the 470-698 MHz band for IMT will result in an increase in the number of subscribers of 19.35 million beyond the market projections [18].

Table 7. Latin America: Mobile broadband connections subscribers (baseline estimate and additional subscribers under the 470-698 MHz band, 2014-2020) (in thousands)

Country		2014	2015	2016	2017	2018	2019	2020
Argentina	Baseline	20,678	26,153	32,398	38,194	43,510	48,487	53,202
	470-698 MHz	0	1,308	1,492	1,525	1,555	1,583	1,610
Brazil	Baseline	122,974	163,325	191,778	222,707	251,170	278,045	303,231
	470-698 MHz	0	5,170	6,261	6,437	6,598	6,751	6,894
Chile	Baseline	6,117	8,660	11,478	14,053	16,307	18,235	19,903
	470-698 MHz	0	247	313	327	340	351	360
Colombia	Baseline	8,986	12,700	17,770	24,043	29,829	35,259	40,481
	470-698 MHz	0	0	101	137	170	200	230
	Baseline	35,757	46,491	56,560	66,873	76,841	86,373	95,354

[18] All estimates of economic benefits in the paper use 2015 as a starting point. The authors are cognisant, however, that a resolution of the allocation of spectrum will require more time to be completed. In that sense, the estimates have to be considered as an assessment of value to become effective once the allocation and assignment of spectrum is completed.

Mexico	470-698 MHz	0	2,475	2,797	2,856	2,912	2,966	3,018
Peru	Baseline	8,391	12,312	16,138	19,834	23,472	27,076	30,303
	470-698 MHz	0	2,948	3,040	3,061	3,082	3,102	3,121
Rest Latam	Baseline	28,967	43,799	56,161	71,159	86,208	100,189	112,879
	470-698 MHz	0	3,286	3,787	3,879	3,964	4,045	4,120
Total	**Baseline**	**231,871**	**313,441**	**382,284**	**456,863**	**527,337**	**593,663**	**655,351**
	470-698 MHz	**0**	**15,435**	**17,791**	**18,221**	**18,622**	**19,000**	**19,354**

Source: Baseline from GSMA Intelligence; TAS analysis

This estimate is also reasonable from an affordability perspective. An analysis completed by Katz and Callorda (2013) on mobile broadband affordability indicated that, even for its most economical price plans, mobile broadband could not be acquired by significant portions of the population in the five most important Latin American countries (see table 8).

Table 8. Latin America: Population that cannot purchase the basic mobile broadband plan

Country	Deciles that cannot acquire the basic broadband plan	Population (millions)
Argentina	1,2	11.89
Brazil	1, 2, 3, 4	95.88
Colombia	1, 2, 3, 4, 5	26.43
Ecuador	1, 2, 3, 4, 5, 6	9.84
Mexico	1, 2	24.43

Source: Katz and Callorda (2013)

As a result, the introduction of mobile broadband services based on the 470-698 MHz band would result in an incremental subscriber base of 19.35 million (which represents an increase of 8% over current base of 231,871,000 subscribers for the whole region).

3.1.3. Contribution to GDP

The increase in subscribers contributes to national GDP at two levels. On the one hand, new subscribers represent additional revenues to operators, which should be considered a direct contribution to the national product. On the other hand, the increased penetration of mobile broadband has a spill-over impact on the economy by enhancing market reach for new products, improving efficiency in businesses, and ultimately promoting innovation. Numerous studies have quantified this effect, including those conducted by Telecom Advisory Services (Katz et al, 2013).

The direct contribution to GDP is estimated on the basis of the revenues for mobile broadband operators resulting from the additional number of connections subscribers yielded by the additional rural coverage and a reduction of prices benefitting primarily the basis of the socio-demographic pyramid. The incremental subscriber base (23.1 million) was multiplied by the most economical mobile broadband plan presented in table 6. This yields a net present value of revenues for mobile operators of US$ 12 billion (see table 9).

Table 9. Latin America: Net present value of additional revenues resulting from the 470-698 MHz band allocation to IMT (2015-2020) (in US$ million)

	2015	2016	2017	2018	2019	2020	NPV TOTAL[19]
Argentina	153	172	176	179	182	184	752
Brazil	834	991	1,017	1,040	1,062	1,083	4,322
Chile	90	111	116	120	124	127	492
Colombia	0	13	18	22	26	30	73
Mexico	400	446	454	462	470	477	1,950
Peru	477	490	493	496	499	501	2,139
Rest Latam	528	601	615	627	639	650	2,631
Total	**2,482**	**2,825**	**2,888**	**2,947**	**3,002**	**3,053**	**12,360**

Fuente: Análisis TAS

Beyond this direct contribution, one has to factor in the indirect contribution driven by spill-overs. The assumption, based on prior research, is in this case that a percentage point increase in broadband penetration yields an increase in 0.022 percentage points of GDP (Katz & Koutroumpis, 2013)[20]. Based on this multiplier, the estimated future increase in GDP resulting from spill-over effects is shown below (see table 10).

Table 10. Indirect impact on GDP resulting from increase in mobile broadband penetration (in US$ million)

Country	2015	2016	2017	2018	2019	2020	GDP (NPV)
Argentina	371	425	439	445	453	461	1,864
Brazil	1,349	1,798	2,014	2,250	2,508	2,564	8,762
Chile	160	227	264	304	348	358	1,157
Colombia	-	97	140	187	238	273	615
Mexico	1,740	2,113	2,308	2,512	2,691	2,738	9,994
Peru	1,302	1,488	1,654	1,836	2,035	2,047	7,329
Rest Latam	1,331	1,663	1,844	2,038	2,237	2,283	8,039
TOTAL	6,252	7,811	8,664	9,573	10,509	10,722	37,764

Source: TAS analysis

[19] Discount rate 10%

[20] The coefficient estimated by Katz and Koutroumpis (2013) for Senegal is that every 1% increase in mobile broadband penetration yields 0.022% growth in GDP. A similar coefficient was estimated for Australia (Center for International Economics, 2014). For that country the mobile broadband generated an additional 0.29 per cent increase in GDP in 2013. In the same period the mobile broadband penetration growth 15.5%, which implies a 0.019% growth in GDP for a 1% increase in mobile broadband penetration.

As indicated in table 10, the cumulative indirect GDP impact between 2015 and 2020 for the region would reach $ 37.7 billion. This estimate represents a total economic spillover and, therefore, should be considered beyond the direct effect resulting from incremental revenues to mobile broadband operators.

3.2. Job creation

The increase in the number of mobile broadband connections will require the hiring of new employees. This estimate was calculated by relying on the current relationship (4Q13) of mobile broadband users per employee, as reported in the GSMA Intelligence database (see table 11).

Table 11. Latin America: Employees in mobile sector (4Q13)

Country	Current number of employees	Mobile broadband users	Users/Employees
Argentina	16,150	19.16	1,186
Brazil	64,088	122.97	1,919
Chile	5,864	4.30	733
TOTAL	86,101	146.43	1,700

Source: TAS analysis based on GSMA Intelligence

By relying on these ratios, the number of incremental direct jobs resulting from an increase in subscribers was calculated (see table 12).

Table 12. Latin America: Direct jobs resulting from the increase in mobile broadband subscribers yielded by the 470-698 MHz band allocation to IMT (2015-2020)

Country	2015	2016	2017	2018	2019	2020	Average per year
Argentina	1,102	1,257	1,285	1,311	1,335	1,357	1,275
Brazil	2,694	3,263	3,354	3,439	3,518	3.593	3,310
Chile	338	427	447	464	479	492	441
Colombia	-	59	80	100	118	135	82
Mexico	1,455	1,645	1,679	1,712	1,744	1,774	1,668
Peru	1,734	1,788	1,800	1,812	1,824	1,835	1,799
Rest Latam	1,981	2,282	2,338	2,390	2,439	2,485	2,319
TOTAL	9,304	10,721	10,984	11,228	11,458	11,672	10,894

Source: TAS analysis

In some countries (Chile, Colombia), since the industry is already operating at scale, the increase in direct employees to support the additional subscribers is marginal. However, all in all, the average yearly incremental employee base reaches approximately 11,000.

By applying the ratio of direct to indirect employees calculated by Convergencia Research for 2007, the number of job/years was estimated between 2015 and 2020 (see table 13).

Table 13. Latin America: Indirect Jobs resulting from the increase in mobile broadband subscribers yielded by the 470-698 MHz band allocation to IMT (2015-2020)

Country	2015	2016	2017	2018	2019	2020	Average per year
Argentina	3,215	3,667	3,749	3,823	3,892	3,958	3,717
Brazil	11,666	14,127	14,524	14,889	15,234	15,557	14,333
Chile	1,173	1,483	1,552	1,613	1,665	1,710	1,533
Colombia	-	508	688	853	1,008	1,158	8433
Mexico	2,778	3,139	3,205	3,269	3,329	3,387	3,185
Peru	4,760	4,908	4,942	4,975	5,008	5,038	4,939
Rest Latam	6,381	7,528	7,751	7,958	8,151	8,333	7,684
TOTAL	29,973	37.980	36,411	37,380	38,289	39,141	36,092

Source: TAS analysis

In total, the increase in the number of direct and indirect jobs as a result of allocating the 470-698 MHz band will amount to an average of 47,000 per year.

3.3. Tax contribution

The increase in revenues to be generated by mobile broadband service providers will result in an increase in tax contribution. To calculate this effect, service revenues from table 9 were multiplied by the sales tax rate of each country (see table 14).

Table 14. Latin America: Sales tax rate and contribution by mobile broadband service providers (in million US $)

Country	Sales Tax Rate	2015	2016	2017	2018	2019	2020	Net Present Value
Argentina	21,00 %	32	36	37	38	38	39	158
Brazil	27,50 %	229	273	280	286	292	298	1,189
Chile	19,00 %	17	21	22	23	24	24	94
Colombia	20,00 %	-	1	1	1	1	1	2
Mexico	16,00 %	64	71	73	74	75	76	312
Peru	20,00 %	95	98	99	99	100	100	428
Rest Latam	Varies	118	136	139	142	144	147	594
TOTAL		556	638	652	666	678	690	2,788

Source: TAS analysis

The resulting contribution to the treasuries of Latin American countries will reach a net present value of US$ 2.788 billion.

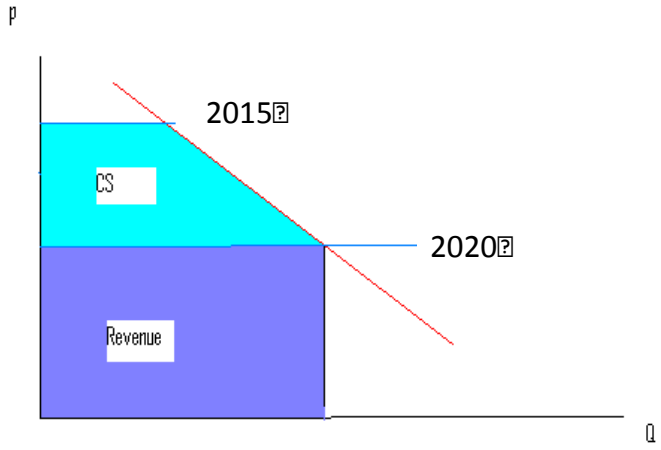
3.4. Consumer surplus

The last quantifiable benefit derived from allocating the 470-698 MHz band to IMT is consumer surplus. According to the classical definition, consumer surplus (a metric not captured in GDP statistics) represents the difference between a consumers' willingness to pay (as a measure of value) and actual price. The study of broadband consumer surplus is a bit more complex than GDP contribution insofar that it needs to be based on an understanding of the value attributed to broadband by consumers (a metric usually captured through survey research[21]).

For this study, the approach implemented by Greenstein and McDewitt (2011) for countries with no survey research data was used, which relies on price declines to "trace out" the demand curve for broadband: as the real price falls, the demand for broadband rises (see figure 7).

Figure 7. Gains in consumer surplus from decline in prices between 2015 and 2020

[21] For example, to estimate broadband consumer surplus in the United States, Greenstein and McDewitt (2009) relied on Savage and Waldman (2004) who conducted an extensive survey of dial-up and broadband users in 2002.



This methodology assumes that constant/falling nominal prices explain growing use of households and presumes a stable demand. It is somewhat conservative because it tends to ignore early adopters, which are less price sensitive and attribute enormous value (and therefore exhibit high willingness to pay) to broadband. The methodology computes consumer surplus indexed to the starting year of the time series, by multiplying the number of subscribers by the price decline in real terms.

Following this methodology, the consumer surplus is calculated for the existing mobile broadband subscribers benefitting from the price decline mentioned above[22] (see table 15).

Table 15. Latin America: Consumer surplus for subscribers benefitting from price decline resulting from the allocation of the 470-698 MHz band (in US$ million)

Country	2015	2016	2017	2018	2019	2020	Net present value
Argentina	32.8	40.6	47.9	54.5	60.8	66.7	211.9
Brazil	282.5	331.7	385.2	434.4	480.4	524.4	1,711.6
Chile	33.7	44.6	54.6	63.4	70.9	77.4	239.5
Colombia	20.0	28.0	37.9	47.0	55.6	63.8	172.4
Mexico	79.9	97.2	114.9	132.0	148.4	163.9	514.2
Peru	21.2	27.8	34.2	40.5	46.7	52.3	154.2
Rest Latam	127.1	154.2	182.5	208.8	233.5	256.5	812.4
TOTAL	597.2	724.1	857.2	980.6	1,096.7	1,204.9	3,816.3

Source: TAS analysis

As presented in table 15, the consumer surplus resulting from price declines affecting the totality of the mobile broadband subscriber base would reach US$ 3.8 billion.

[22] This estimate excludes all new subscribers gained as a result of extended coverage and those accessing the service for the first time as a result of lower costs.

4. Conclusion

Given the explosive growth in mobile traffic in Latin America, the 700 MHz band will probably not be enough to support future growth of mobile broadband. Even though other bands are still partially available (mostly, AWS and 2.6 GHz), Latin America will need to identify, allocate, and later assign, further spectrum bands for IMT services. The sub-700 MHz band (470-698 MHz), sometimes referred to as the "second digital dividend," is ideal for such services. As the analysis of the situation in five countries of the region has shown, the lower part of the UHF band is allocated, on a primary basis, to broadcasting services in all countries in Latin America. That said, some countries, such as Mexico, are considering the future use of this band for IMT. In this context, in order to provide some assessment of the potential impact of a policy change that would allocate the band to IMT, it is relevant to study the social and economic benefits of such a measure.

Mobile broadband coverage with the use of the 470-698 MHz band would reach an estimated total of 98.05 % of the population of Latin America, increasing the reach of networks by an average of 1.32 percentage points beyond 700 MHz, and 4.38 points beyond 3G. With an average mobile broadband penetration of 43% at the end of 2013 in the continent (Katz, 2014), the additional mobile broadband coverage and capacity would result in a significant increase in broadband adoption, which is a fundamental public policy objective of the majority of governments of the region.

More importantly, the use of the 470-698 MHz band for mobile services will allow access to broadband services via mobile to approximately 8.6 million people in Latin America living today in isolated areas. This would be achieved with savings of more than US$ 897 million in net present value of investment in the deployment of new networks. This represents a second "digital dividend" value from the perspective of infrastructure deployment.

When it comes to evaluating the economic and social impact, the results again support the use of spectrum for mobile broadband. First, the utilization of the 470-698 MHz band to offer mobile broadband services contributes directly and indirectly to GDP, in the amount of US$ 50 billion. In the case of the direct contribution, the study estimates the amount generated by increasing the subscriber base by 19.35 million as a result of gaining access to the 470-698 MHz band. This amount comprises additional mobile broadband adoption resulting from a reduction of prices of 10.95% (a transfer of a portion of the savings mentioned above), assuming a demand elasticity of 0.6 (in areas already covered) (19.4 million), and new areas to be covered as a result of gaining access to the 470-698 MHz band (3.7 million).

In the case of the indirect contribution of mobile broadband to GDP, the study estimates the externalities (or spill-over effects on other sectors of the economy); conservatively, only the economic impact derived from additional mobile broadband connections resulting from the use of the 470-698 MHz band is considered. This is estimated to reach US$ 38[23] billion in net present value between 2015 and 2020.

Secondly, by assigning the 470-698 MHz band to the development of mobile broadband, the industry could contribute significantly to job creation. In the case of direct employment (which includes the employees of the telecommunications service providers, as well as those selling services to the

[23] US$ 49 billion of total impact, less 12 billion of direct impact.

carriers) the number of jobs will reach 11,000 per year. In the area of indirect jobs, it will reach 36,000.

Thirdly, the utilization of the 470-698 MHz spectrum for mobile broadband contributes to the collection of taxes in Latin America in the amount of US $2.8 billion.

Finally, by using the 470-698 MHz band to provide mobile broadband services, important benefits can be generated in terms of consumer surplus. This is measured in terms of the difference between willingness to pay (as a measure of user benefit) and the price paid for a good or service. When measuring this benefit in terms of the cumulative decrease in tariffs over the total user base during eight years, we can estimate a total surplus of US $3.8 billion. This consumer surplus contributes in turn to GDP growth insofar that it can lead to more consumption.

Beyond the quantifiable economic benefits, the allocation of the 470-698 MHz band to mobile broadband in Latin America will have a positive social contribution in several areas. For example, the expansion of wireless broadband to unserved zones will allow the population without current coverage to gain access to more educational resources, improved health services, and financial services. At the same time, wireless broadband to be introduced in rural areas will enable the efficient provision of public services at a greater speed of access, improving the interrelationship between civil society and governments.

Thus, the results of the study indicate the benefits to be generated as a result of using the 470-698 MHz band to provide mobile broadband services in Latin America:

- An increase in broadband coverage resulting from increased availability of mobile broadband, a fundamental variable to ensure economic growth in Latin America;
- More optimal deployment and operation of new networks, resulting in a reduction of capital investment of US $ 897 million compared to deployment of infrastructure in higher frequency bands, while achieving better coverage;
- Direct (additional revenues to the industry) and indirect contribution (positive externalities) to GDP reaching US$ 49 billion;
- Creation of more than 47,000 direct and indirect additional jobs;
- Additional tax contribution in excess of US $ 2.8 billion;
- A consumer surplus of US $3.816 billion.

BIBLIOGRAPHY

Convergencia Research (2007). *Contribución de la telefonía móvil a las economías de Latinoamérica y el Caribe*. GSMA Latin America.

Federal Communications Commission (2010). *The broadband availability gap*. OBI Technical Paper No.1. Washington, DC

Galperin, H. (2014). *Benchmarking y tendencias de la oferta de banda ancha fija en América Latina*. Presentación al 1er Foro de Conectividad Regional de las Américas en Asunción.

Greenstein, S. and McDewitt, R. (2011). "The global broadband bonus: Broadband' Internet's impact on seven countries", Van Ark, B. (ed.) *The Linked World: How ICT is transforming societies, cultures and economies*. The Conference Board.

Holma, H. and Toskala, A. *WCDMA for UMTS: HSPA Evolution and LTE*. New York: Wiley

Katz, R. and Flores-Roux, E. (2011). *Economic benefits of the digital dividend in Latin America*. London: GSMA.

Katz, R. and Berry, T. (2014). *Driving demand for broadband networks and services*. London: Springer.

Katz, R. and Callorda, F. (2013). *Mobile broadband at the bottom of the pyramid in Latin America*. London: GSMA.

Katz, R. and Koutroumpis, P. (2013). "Assessment of the economic impact of telecommunications in Senegal", O'Neill, J., Noam, E., and Gerbarg, D. (eds.) *Broadband as a video platform*. London: Springer.

Katz, R. (2014). *2013-14: Avances en el desarrollo del sector de telecomunicaciones en América Latina*. Caracas: CAF