Economic assessment of C-band re-allocation

A REPORT PREPARED FOR THE GSMA

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1 Introduction

The increasing consumer demand for mobile data services implies that mobile operators will be required to provide significantly greater capacity to consumers in future. Forecasts predict that, notwithstanding significant increases in the efficiency of spectrum usage, this will require large increases in spectrum allocation to mobile operators. The C-band spectrum (3.4-4.2GHz) is a frequency range that is suitable for mobile operators, in particular for providing additional capacity to networks in urban areas.

However, in the Asia Pacific (APAC) region C-band spectrum is currently mainly used by the satellite industry to deliver fixed satellite services, such as video distribution services for cable TV networks and for direct-to-home (DTH) television services and VSAT-based connectivity services for enterprises. The intensity of usage of the C-band varies by country – in some countries, such as Indonesia, it is more intensively used whereas in other countries, such as Australia, it is less intensively used.

Spectrum is a finite resource. From an economic perspective the objective of allocating spectrum is to maximise the efficiency with which it is used. This means maximising the difference between what users are willing to pay for it and the opportunity costs of supplying it, including the value of that spectrum to other users. Therefore, as the C-band spectrum is suitable for both satellite and mobile services a key question is, what is the most efficient way to allocate C-band spectrum?

Determining precisely the most efficient allocation is difficult given the uncertainties surrounding some of the key estimates of the costs and benefits of re-allocation of spectrum. However, this report seeks to take the debate further by considering the costs and benefits associated with re-allocating 400MHz of C-band spectrum (the 3.4GHz-3.8GHz range) to mobile operators whilst the use of the upper part of the C-band spectrum remains with satellite operators. We analyse, in particular, the costs and benefits for two case study countries, Australia and Indonesia, and use these case studies to estimate the net benefits for the wider APAC region.

There is limited information available about the current uses of the C-band spectrum, and the costs of shifting satellite usage to other frequency ranges. We have therefore had to make a number of assumptions to quantify the costs and the benefits, which are detailed below. Where possible we have relied on external sources for this information.

The rest of this report is structured as follows:

- In section 2 we provide a summary of our main results for the case study countries and for the wider APAC region; and

- In section 3 we explain in detail our approach and the key assumptions underlying our results.

2 Our results summary

Below, we summarise the main results of our high level analysis of net benefits of C-band re-allocation and discuss our indicative estimates.

Our modelling approach looks at the potential benefits to mobile operators of having access to 400MHz of C-band spectrum by 2025.[1] We then look at the cost such re-allocation would imply for satellite applications that currently use this frequency band. By estimating net benefits (benefits minus costs) of C-band re-allocation, we approximate the gross-value added (GVA) created in the economy.

Our approach relies on two key assumptions:

- C-band spectrum will be used in the future in a similar way that 2.6GHz is currently used by mobile operators, that is to build additional capacity networks in densely populated urban areas. We therefore assume that the access to 400MHz of C-band will help mobile operators to meet the future data demand in urban areas at lower costs than without this spectrum.

- The future demand for satellite services currently provided in C-band will be met after the re-allocation. This will be achieved through the remaining 400MHz of C-band and by shifting non-critical usage to other delivery means, such as other frequency bands assigned to satellite providers (Ku/Ka bands[2]) or migration to alternative platforms (fixed and terrestrial networks).

Our analysis focuses on estimating benefits and costs of C-band re-allocation in two 'case study' countries Australia and Indonesia. **Figure 1** and **Figure 2** show estimated benefits and costs in these countries under three separate benefits scenarios and three separate cost scenarios.

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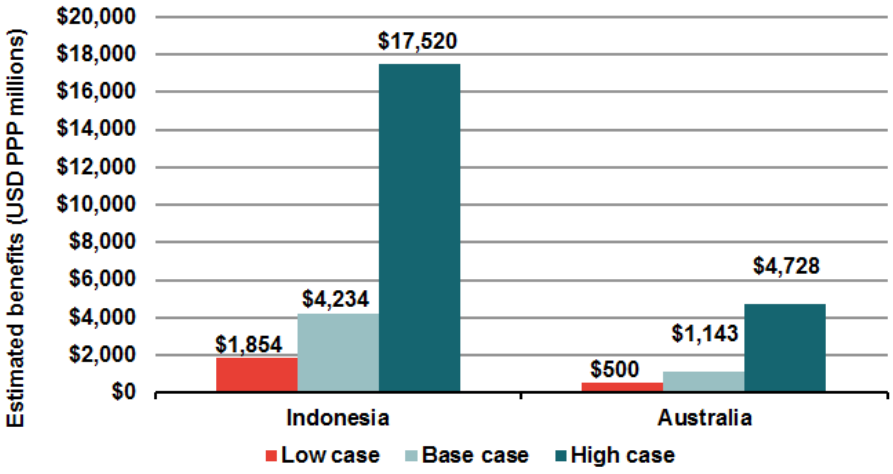
[1] In particular, we are considering lower part of C-band spectrum in the frequency range 3.4GHz to 3.8GHz. As our analysis is high level we do not explicitly consider the need to set aside spectrum for a protection band.

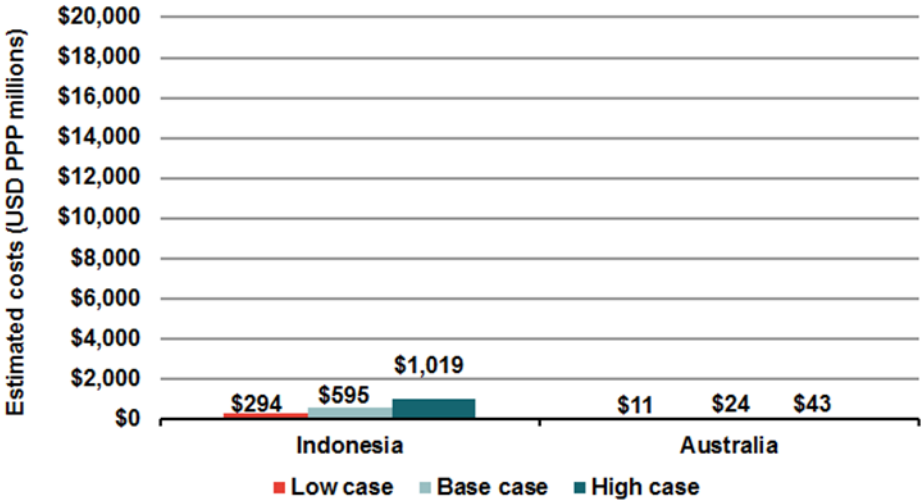
[2] In this report, we use Ku-band when referring to frequencies between 11GHz and 18GHz and Ka-band when referring to frequencies between 26.5GHz and 40GHz

Figure 1. Benefits of C-band re-allocation in Australia and Indonesia



Source: Frontier Economics

Figure 2. Cost of C-band re-allocation in Australia and Indonesia



Source: Frontier Economics

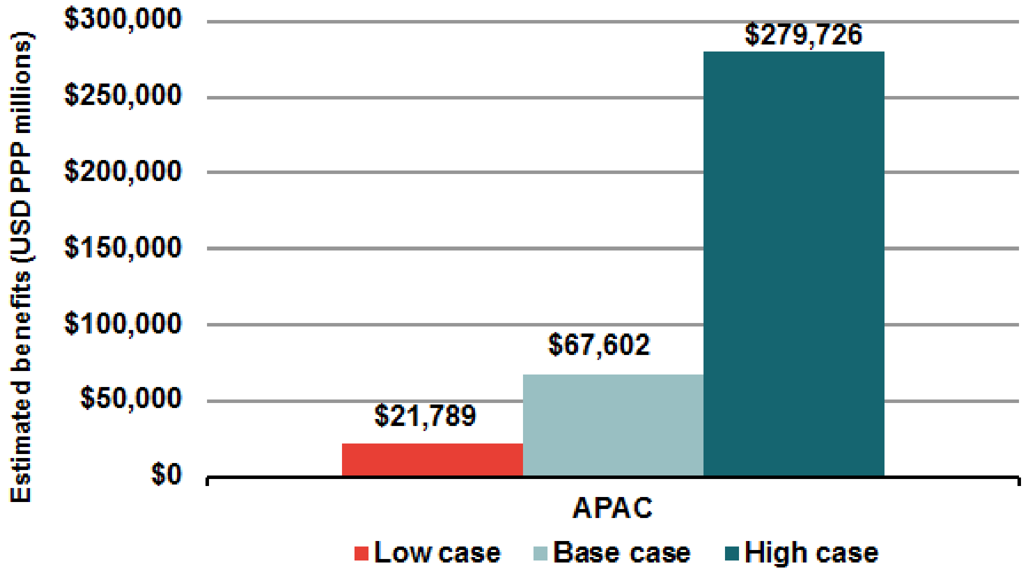
For Indonesia, the estimated benefits range from PPP $1.9 billion to PPP $17.5 billion, with estimated costs being between PPP $0.3 billion and PPP $1 billion. In our central 'base case' scenario, the benefits of C-band re-allocation exceed costs by approximately 7 times.

Our results summary

For Australia, the estimated benefits range from PPP $0.5 billion to PPP $4.7 billion, with estimated costs being between PPP $11 million and PPP $43 million. This implies that in our central 'base case' scenario, the benefits of C-band re-allocation exceed costs by approximately 47 times.

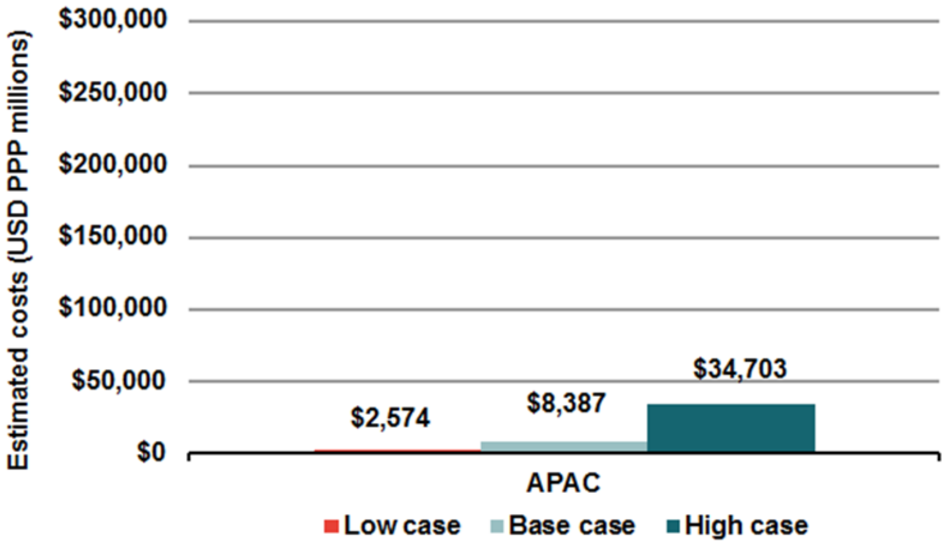
Based on the results for these case study countries, and using some simplifying assumptions, we then derive indicative results for the whole APAC region, and show our indicative estimates of benefits and costs for the whole APAC region. The estimated regional benefits range from PPP $22 billion to approximately PPP $280 billion, with estimated costs being between PPP $2.6 billion and PPP $34.7 billion. This implies that in our central 'base case' scenario, the benefits of C-band re-allocation exceed costs by approximately 8 times.

Figure 3. Benefits of C-band re-allocation in the APAC Region



Source: Frontier Economics

Figure 4. Costs of C-band re-allocation in the APAC Region



Source: Frontier Economics

It should be noted that the benefits presented above are equal to the cumulative value of economic benefits derived from C-band spectrum by mobile operators,[3] whereas the cost of re-allocation are mostly one-off in nature, as discussed in more detail below.

Based on the estimates of net-benefits of C-band re-allocation, we also provide a high level estimate of the impact on government income and employment. We estimate that in the base case the total government income in the APAC region from C-band spectrum licencing and taxation of additional economic activity will be PPP $52 billion, with an addition of 108,000 new jobs.

Our approach, as discussed below, relies on a number of assumptions due to limited availability of data, in particular on satellite usage and costs. Nevertheless, our approach could be considered conservative as we have not estimated additional benefits of higher quality of mobile services arising from the access to C-band spectrum. In addition, we have not explicitly modelled any indirect effects on the mobile supply chain and wider economy.

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[3] Operators benefit over time from having greater spectrum assigned to them (e.g. because they need less base stations) and they reflect this in the value they are willing to pay for that spectrum.

3 Our approach

This section describes in more detailed our approach and key assumptions underlying the results presented above.

- We first provide an overview of the methodology applied to estimate net benefits of re-allocating 400MHz of C-band spectrum.
- We then discuss in more detail how we estimated the direct benefits and costs of C-band re-allocation. We also present results for our case study countries and provide indicative estimates for the whole APAC region.
- Lastly, we discuss at a high level additional impacts of spectrum re-allocation on the wider economy, in particular on tax revenues and employment in the APAC region.

3.1 High level description of methodology

The mobile sector is an integral part of the economies in the APAC region and one of the significant drivers of economic growth. Demand for mobile services and mobile data in particular is rapidly increasing. To meet this demand, mobile operators are likely to need access to additional spectrum.[4]

Our approach assumes that access to 400MHz C-band spectrum will help mobile operators to meet the future demand for mobile data services. We consider mobile operators will primarily use C-band to increase capacity of their mobile networks in urban areas, where demand for mobile data is likely to be high. We therefore expect C-band spectrum to be used in future for similar purposes as 2.6GHz spectrum in the countries where it is currently in use, or will be soon used.

By having access to additional C-band spectrum we assume mobile operators will be able to meet mobile data demand and serve future mobile users more efficiently, i.e. at lower costs than in the case without access to C-band spectrum. This is expected to lead to economic benefits (an increase in social welfare) through the following two channels:

- An increase in 'producer surplus' implied by lower costs, i.e. mobile operators will need less resources to deliver the required services and meet

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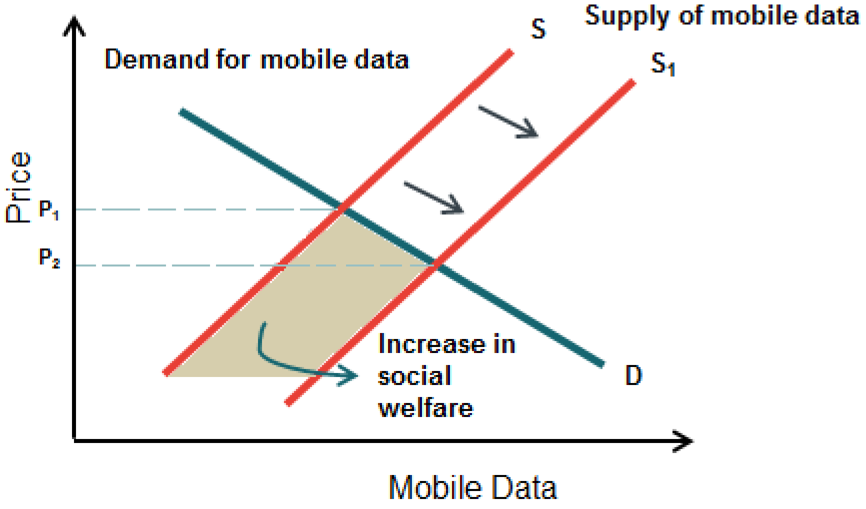
[4] This is widely accepted and has been a consistent finding by many regulators. See, for example, Ofcom (2012): "Securing long term benefits from scarce spectrum resources: A strategy for UHF bands IV and V", 29 March 2012.

the future demand for mobile data. It also implies that scarce capital and labour resources in the economy can be freed up and put to other more productive uses.

- If access to C-band spectrum lowers the marginal costs of mobile operators to some extent, in a competitive market, this would lead to lower prices and higher quantity or quality of services for end consumers, having further positive effects on social welfare.

Figure 5 below illustrates a shift in the supply curve, resulting from lower cost from C-band re-allocation, which leads to increases in both producer and consumer surplus and thus to an overall increase in social welfare. In addition, in this example the relationship between demand and supply would lead to lower prices for consumers and higher quantity of mobile data provided.[5]

Figure 5. Consumer and producer surplus from C-band re-allocation



Source: Frontier Economics

At the same time, there are costs that current C-band users would incur as a result of spectrum re-allocation. In particular, certain fixed satellite services currently relying on C-band spectrum would need to be shifted to alternative means of delivery, e.g. other frequency bands allocated to satellite or fixed/terrestrial infrastructure. For the satellite applications that will continue to

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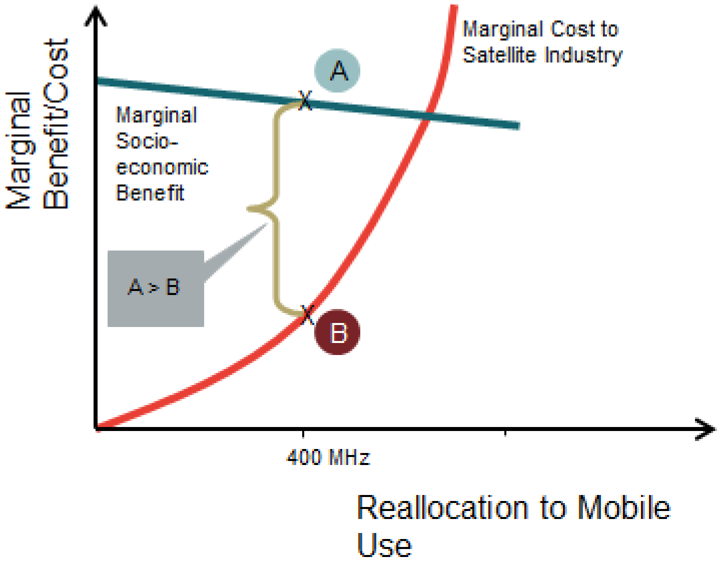
[5] Since the relative shift in costs and prices will be small, the primary welfare effect is an increase due to the lower costs for mobile operators, some of which will be passed on to consumers.

use C-band spectrum after re-allocation, there might be costs related to mitigating possible interference from mobile networks operating in C-band.[6]

Therefore, our aim is to estimate the incremental benefits of allocating 400MHz of C-band spectrum to mobile operators and compare that to the costs incurred by the satellite industry.[7] If the benefits are greater than the costs, this would imply that there is an economic rationale for re-allocating a share of C-band spectrum as this would lead to an increase in social welfare. **Figure 6** below, shows the situation where the marginal socio-economic benefit from allocating C-band spectrum to international mobile telecommunications (IMT) is greater than the marginal cost to the satellite industry.

Figure 6. Social welfare analysis of C-band re-allocation



Source: Frontier Economics

Our analysis focuses on estimating benefits and costs of C-band re-allocation in two ‘case study’ countries – Australia and Indonesia. We chose Australia as an example of a country where it would be relatively easier to free up C-band spectrum for mobile usage and at relatively lower costs to the satellite industry compared to countries where the C-band spectrum is more heavily used by

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[6] Also, there may be additional costs arising from a potential decrease in the quality of services and applications currently using C-band spectrum.

[7] Our methodology assumes that there is no impact on the consumer benefits derived from the satellite services currently using C-band, so the cost benefit analysis need consider only the costs incurred by satellite operators to reconfigure their services. .

satellite providers. This is because the current satellite usage of C-band can be relatively easily shifted to alternative means of provision.[8] On the other hand, we chose Indonesia as a country where there are a large number of satellite applications currently relying on C-band and where freeing up 400MHz of this spectrum is likely to be costly.

Based on the results for Australia and Indonesia, and using some simplifying assumptions, we also provide indicative results for the whole APAC region.

3.2 Estimating benefits of C-band re-allocation

3.2.1 Methodology and key assumptions

In order to estimate the benefits of re-allocating C-band, we start by considering what the supply and demand for mobile spectrum will look like in 2025. The two primary questions that arise out of this are:

- Would there be a need to allocate additional spectrum to the mobile sector?
- If yes, what would the benefits of the C-band spectrum re-allocation be to mobile operators?

In order to answer the first question, we assess the pressure on the spectrum that is currently available to mobile operators to meet future demand: the more scarce this spectrum, the greater the need to re-allocate C-band. The pressure on spectrum that is already allocated to mobile will be determined by demand and supply.

There is extensive evidence to suggest that there will be a shortfall in supply of spectrum to International Mobile Telecommunications (IMT) in the future. This shortage in supply arises primarily out of the increasing demand for video and data services on mobile devices (including smartphones, tables, laptops, etc.). For example, Cisco forecasts a 17-fold mobile data traffic growth in the APAC region between 2012 and 2017. The APAC region is expected to account for 47.1% of the global mobile traffic by 2017.

The ITU Working Party 5D has estimated a total spectrum requirement of between 1340-1960 MHz for IMT by 2020[9]. This is significantly more than

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[8] We understand that usage of C-band spectrum by the satellite industry in Australia is relatively limited, as local Australian satellite TV is delivered mostly via Ku-band (FTA and PayTV). We also understand that the satellite component of the National Broadband Network will be relying on Ku/Ka-band frequencies. . [WE NEED TO KEEP THE LAST SENTENCE]

[9] ITU (2013): Document 4-5-6-7/237-E, 17 July 2013

spectrum currently identified for IMT in Indonesia and Australia by 2020, which we understand will be approximately 900 MHz.

In light of there being plans for only limited release of spectrum, it appears that the availability of new spectrum (such as C-band) will likely become necessary to meet the needs of mobile data users.[10] There are different ways of meeting the increase in demand, in addition to having access to additional spectrum.

- **More efficient use of spectrum:** advances in technology allow for a more efficient use of spectrum by mobile. For example, the Australian regulator ACMA suggests that "*the move to 3G and 4G technologies provides significant improvements in spectral efficiency and frequency re-use, especially compared with 2G technologies*."[11] Similarly, Real Wireless estimated that technology developments associated with LTE deployment would provide between a three and ten times increase in mobile capacity for macro cells with three sector antennas by 2030.[12]

- **Increased network deployment:** higher traffic demand could be accommodated by increasing the number of sites, i.e. by reducing the cell radius. However, as emphasized by UK regulator Ofcom, "*there are practical limits on how closely cells can be packed together without causing interference with one another and in securing planning permission for new sites*". [13] In addition, increasing the number of sites in urban areas would imply significant deployment cost for operators.

- **Off-loading indoor mobile traffic onto fixed networks:** in the UK, Ofcom estimated that "over half of mobile data traffic could potentially be offloaded onto fixed networks by 2030 using WiFi and Femtocells."[14] The feasibility of this alternative, though, depends on a number of factors, including the availability of WiFi access points, the availability and capacity

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[10] The UK government, for instance, decided in 2011 to free up additional 500MHz of spectrum to meet increasing mobile demand, including C-band frequencies 3.4GHz-3.6GHz, see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/77460/Spectrum-Public-Update-December-2011.pdf

[11] ACMA (2011): "Towards 2020 – future spectrum requirements for mobile broadband", May 2011. Page 27.

[12] OFCOM (2012): "Securing long term benefits from scarce spectrum resources: a strategy for UHF bands IV and V", 29 march 2012. Paragraph 3.38.

[13] Op. Cit., paragraph 3.39.

[14] Op. Cit., paragraph 3.40.

of fixed networks[15] and the willingness of mobile users to off-load their mobile traffic.[16]

However, most studies conducted by national regulatory authorities and international organisations have concluded that these alternative methods will not be sufficient to accommodate the very significant increases in future demand.[17] It is further a question to what extent these alternative measures can be applied in a cost-effective manner, in particular in the relatively less developed APAC countries with a limited deployment of fixed networks. Consequently, additional spectrum would be needed to cope with this.

Given the likely value that mobile operators will place on C-band spectrum, and the assumption that this can be equated with the economic value generated using this frequency band, we can address the question on the economic benefits of re-allocation.

As it is envisioned that C-band spectrum will be used in a similar manner to the way the 2.6GHz is currently used by mobile operators, we use prices from the recent spectrum auctions of 2.6GHz FDD spectrum as a starting point for our estimates of economic value of C-band spectrum.[18] While we understand that C-band spectrum may primarily be used by technologies relying on unpaired spectrum (e.g. LTE-TDD), we assume that by 2025 these technologies will be widely applied and used by mobile operators in a similar way to how FDD services are currently used.

Thus, the economic value of C-band spectrum was estimated as follows:

- The economic value of 2.6GHz spectrum was estimated based on benchmarking of auction prices.

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[15] See WIK Consult (2012): "Study on Impact of traffic off-loading and related technological trends on the demand for wireless broadband spectrum", A study prepared for the European Commission DG Communications Networks, Content & Technology.

[16] For instance, a recent survey of UK Everything Everywhere shows that 43% of their 4G subscribers uses fewer or no public Wi-Fi hotspots since having 4G, see https://explore.ee.co.uk/our-company/newsroom/4gee-transforming-britain-into-nation-of-nomadic-sharers-streamers-and-shoppers

[17] For instance, "Study of Future Demand for Radio Spectrum in Canada 2011-2015" explicitly takes into account alternative measures to meet spectrum demand, concluding that a substantial increase in spectrum allocated to mobile operators would still be required to meet the expected mobile data demand http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10271.html

[18] We understand that both 2.6GHz and C bands can and will be used to add capacity at particular traffic hotspots. Also both bands would be useful for small cells (indoor and outdoor) with high throughput.

- These values were then adjusted to reflect the differences in the physical characteristics of C-band spectrum.

- Further adjustments were made to reflect country-specific factors, such as the degree of urbanisation and income levels.

- From this adjusted price, the economic value of C-band for Indonesia, Australia and the APAC region was derived.

Further details on the methodology are provided below.

Estimating value of high frequency spectrum based on auction benchmarking

The future demand for C-band spectrum is uncertain. However, as discussed above, it is expected that future demand for spectrum for IMT usage will exceed future supply. Rather than projecting forwards supply and demand, both of which are highly uncertain, our alternative proposition is that in 2025 (and beyond) mobile operators will use the C-band spectrum in the same way they are currently using, or planning to use, 2.6GHz spectrum. Effectively, we assume that the balance between future demand and supply of C-band can be approximated by the balance between the demand and supply for 2.6MHz. Thus, our starting point is auction benchmarking which gives a range of prices per MHz/population for 2.6GHz spectrum.

We have gathered publicly available data on auction outcomes to benchmark the value of different spectrum bands in the period 2009 to 2013.[19] We have also concentrated on auction outcomes for paired spectrum as there currently is less demand for unpaired spectrum, partly due to limited number of devices available for this spectrum. Nevertheless, we assume that this will change in the future and that by 2025 the availability of network equipment and mobile devices will imply wide use of unpaired spectrum.

In order to compare different spectrum auctions we have "normalised" each observation so that they are consistently expressed. In doing so we make a number of assumptions:

  - we express all auctions in a price per MHz per population;
  - we convert all prices to US dollars on a purchasing power parity basis;

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[19] Earlier periods may be less relevant for the purpose of current benchmarking as they pre-date the widespread penetration of smartphones so mobile operators may have different valuations of the spectrum, and the period since 2009 coincides with the adoption of LTE as a mobile standard.

- we express prices as 2013 prices by adjusting for CPI inflation since the auction;[20] and
- we normalise all auctions to a common twenty year term using an assumed discount rate.[21]

We recognise there are a number of external factors influencing the spectrum prices that we do not control for explicitly, which is why we work with a relatively wide range of estimates in our scenario analysis discussed below. In addition, as there is uncertainty surrounding what the exact equilibrium between demand and supply will be in the future, we used this range to develop 3 scenarios under which to analyse the potential benefits of re-allocating C-band.

- **Base case:** we use the simple mean of prices paid in 2.6GHz auctions as our starting point. We believe this approximates the economic value mobile operators believe to be able to extract from 2.6GHz spectrum today, taking into account expectations of future demand for mobile data and availability of spectrum. We note that the mean price is higher than the median price in the auction sample. However, we consider the mean as an appropriate measure in this case, as the value is skewed upwards by the auction results in countries in the APAC region (albeit by the countries which are currently the most developed), and thus may be more representative of the value of spectrum in the region.

- **Low case:** the median price was used as the input for the low case scenario. This case was used to model the scenario where demand for data is not as high as expected and the spectrum available is more likely to, at least partly, meet the mobile data demand in 2025. Thus, higher frequency spectrum would have a lower value for mobile operators.

- **High case:** the prices from recent auctions in Hong Kong and Korea were used to model the spectrum value in the high case.[22] Hong Kong placed the highest value on the 2.6GHz spectrum and prices in Korea were also well above the average. This case thus modelled the scenario where the shortage of spectrum for countries like Hong Kong and Korea today are representative of the APAC region in 2025.

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[20] Please note that throughout this report, all our results are presented in US dollar PPP prices for 2013.

[21] We estimate prices of a notional twenty year licence assuming that operators would be indifferent between choosing the twenty year licence term and the observed licence term given an assumed discount rate.

[22] These were adjusted to take account of the high GDP per capita and urbanisation in these countries.

As shown in table below, these scenarios allow for a wide range of prices in our modelling, with a significant difference between low and high case scenario. This helps ensure that our results reflect the significant uncertainties involved

Table 1. 2600 value per MHz Pop

Low Case	Base Case	High Case
0.05	0.11	0.46

In $PPP per MHz per population Source: Frontier Economics benchmarking analysis

However, it is important to note that the prices from the auction do not give us the full estimate of economic value that mobile operators are able to generate as a result of using the spectrum. The auction prices are more likely to approximate the willingness to pay of the second-most efficient operator participating in the auction, which is directly related to the expected cost savings this operator can generate from having access to additional spectrum. Therefore, to estimate the full economic value of spectrum, we assumed the total economic value derived is approximately 50% above the price paid in the auction.[23]

Adjusting for physical characteristics of C-band spectrum

C-band is in a higher frequency band than the 2.6GHz spectrum and has different propagation characteristics, offering lower coverage (both outdoors and in building).

The higher the frequency of the spectrum, the more the number of cell sites needed to meet a given level of demand. It is estimated that C-band will need approximately twice as many cell sites as 2.6GHz to cover a similar area, which means that the costs of network rollout will be higher for C-band than for the 2.6GHz spectrum.[24] We therefore need to take these differences in physical characteristics into account when estimating the value of C-band spectrum. For the purposes of our modelling, we rely on a GSMA estimate that the C-band will be valued at approximately 50% of 2.6GHz spectrum.

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[23] The winner's actual willingness to pay could be more. For instance, bid data released by Ofcom on a recent auction revealed that the winner's willingness to pay was more than twice the amount actually paid, see http://www.bbc.co.uk/news/business-22165797

[24] According to ITU (2011): Exploring the Value and Economic Valuation of Spectrum: "*This is because the service area covered by a base station is proportionate to the square of the frequency. For example, the minimum provision of service over a low population density region will require twice the number of base stations at 1 GHz than at 700 MHz, eight times more at 2 GHz and 14 times more at 2.6 GHz, and the cost of deploying a mobile network in such a region will rise in proportion.*" http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR11/documents/BBreports_Economic-Valuation-of-Spectrum.pdf

Adjusting for urbanisation and GDP levels

We considered Australia and Indonesia as example countries. To derive the benefits for the APAC region, we divided it into two cohorts - "High" and "Low". The "High" cohort consists of the more developed countries, such as Australia and Japan, with high GDP and urbanisation levels and the "Low" cohort consists of all the other countries in the APAC region.

As C-band will primarily be used to provide capacity in densely populated urban areas C-band spectrum is likely to have higher value in countries with higher levels of urban population.

However, our estimates of C-band value were derived from auctions for 2.6GHz spectrum that took place primarily in developed countries in Western Europe with high urbanisation and GDP.

We adjusted for this by assuming a linear relationship between income/urbanisation and spectrum value, placing equal weight on both factors[25]. We adjusted for the country/region by first calculating the country/region's urbanisation and GDP per capita as a percentage of the auction sample's average urbanisation and GDP per capita respectively. A simple average of these two proportions then gives us the adjustment factor.

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[25] Our methodology is broadly consistent to that applied by various spectrum benchmarking studies, which assumed a linear and cumulative relationship between income/population density (urbanisation) and the value of spectrum. See for instance DotEcon study for the Irish regulator available at http://www.comreg.ie/_fileupload/publications/ComReg1071b.pdf

Table 2. Adjusting for GDP and urbanisation levels

Country/Region	GDP/capita as a percentage of auction sample average	Urbanisation as a % of auction sample average	Adjustment factor (simple average)
Indonesia	23%	70%	47%
Australia	158%	115%	137%
APAC (high cohort)	140%	116%	128%
APAC (low cohort)	31%	59%	45%

Note: GDP per capita and Urbanisation levels in the APAC countries (projections for 2020) compared to the average of the countries the auction sample (as of 2012).

Source: Frontier Economics

Calculating benefits for Australia, Indonesia and the APAC region

We multiplied the price per MHz/population of C-band spectrum after the above adjustments were made with 400MHz, which is the assumed amount of spectrum which will be made available, and the population of the country/region.

This gave us the economic benefits of C-band spectrum for the country/region.

Table 3. Economic Benefits

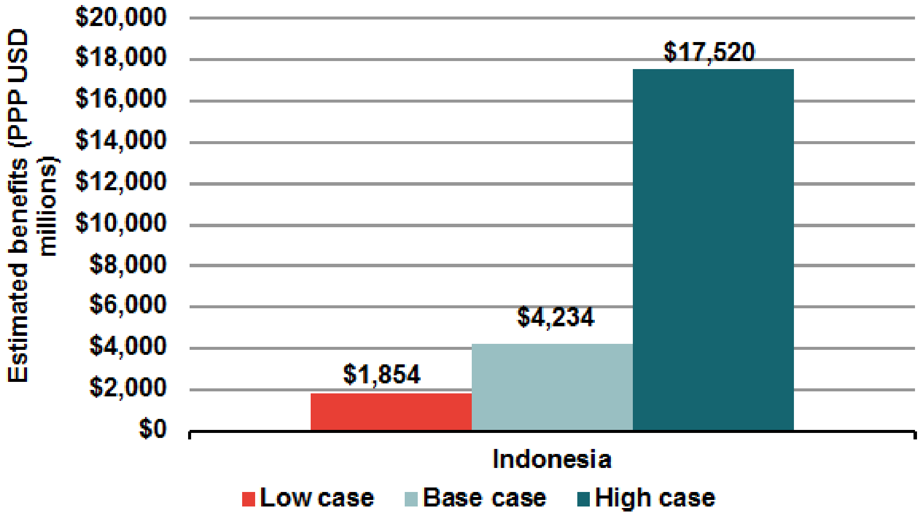
Country/Region	Low Case	Base Case	High Case
Indonesia	$1,854	$4,234	$17,520
Australia	$471	$1,076	$4,453
APAC	$21,789	$60,602	$279,726

In PPP $million. Source: Frontier Economics

3.2.2 Results

Based on our calculations, we estimate that the benefits to Indonesia range from $1.9 billion to $17.5 billion, with the base case being $4.2 billion.

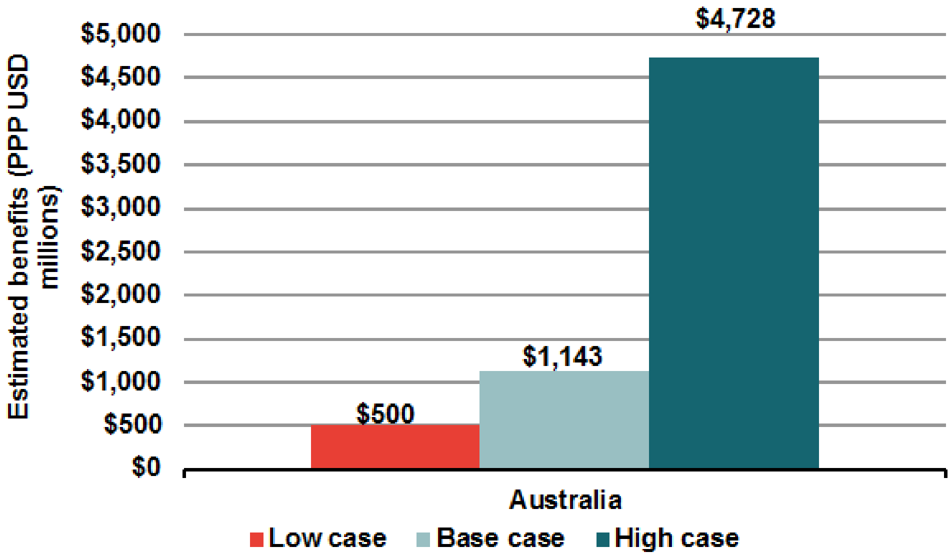
Figure 7. Benefits to Indonesia from re-allocating C-band spectrum



Source: Frontier Economics

Australia's lower population implies lower benefits from re-allocating C-band, but even the most conservative scenario, the low case, gives estimated benefits of PPP $500 million. The base case benefits are estimated at around PPP $1.1 billion.

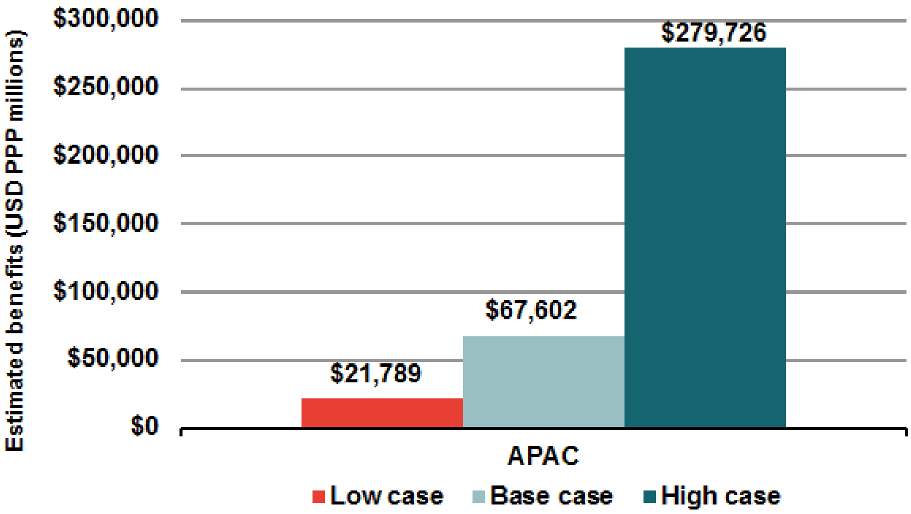
Figure 8. Benefits to Australia from re-allocating C-band spectrum



Source: Frontier Economics

When estimating the benefits for the APAC region, the results range from $22 billion to around PPP $280 billion, with the base case benefits being estimated at PPP $67.6 billion.

Figure 9. Benefits to the APAC region from re-allocating C-band spectrum



Source: Frontier Economics

The above presented results may be conservative, as we have not explicitly considered additional benefits for consumers from higher quality of mobile services arising from the access to C-band spectrum. In addition, we have not explicitly modelled any indirect positive effects on the mobile supply chain and wider economy.

3.3 Estimating costs of C-band re-allocation

Freeing up 400MHz of C-band spectrum will imply costs for the satellite industry. Below, we describe at a high level our methodology for estimating these costs and discuss in more detail our key assumptions. We then present our estimates of total costs that would need to be incurred by the satellite industries in Australia and Indonesia, also showing our results for the whole APAC region.

3.3.1 Methodology and key assumptions

The starting point of our analysis is to identify the main applications or forms of usage of C-band spectrum by the satellite industry.[26] Based on the information

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[26] We note there are a number of non-satellite uses of C-band spectrum, such as fixed point-to-point and fixed point-to-multipoint services. We do not have information about the costs of moving these services to other delivery mechanisms. However, we understand that usage of these services is not intensive and therefore the costs are not expected to be significant.

from Northern Sky Research (NSR)[27], we identify four broad categories of applications relying on C-band:

- receive only consumer applications (e.g. satellite TV broadcasting);
- receive only commercial applications (e.g. cable head ends);
- two-way Very Small Aperture Terminals (VSAT) (e.g. banking terminals and ATM networks); and
- two-way large dishes (e.g. trunk telephony).

There are a wide range of applications that fall into these four categories, including direct-to-home (DTH) broadcasting, satellite broadband internet services, military and government satellite use, corporate connectivity, as well as traditional telephony and carrier services.

We then considered the cost of re-allocating 400MHz of C-band related to the individual applications. Our key assumption is that the ITU WRC decision will be passed in 2015, but the effective re-allocation of the lower part of C-band may not happen until 2025, We further assume that this will give the satellite industry enough time to gradually migrate non-critical applications, i.e. applications that can be delivered cost-efficiently using alternative methods.

We understand that it would not be possible to shift some of the applications currently relying on C-band to other satellite frequencies (e.g. Ku/Ka band) or deliver them via alternative communication channels (e.g. over fixed networks). This is because some applications require high availability of service (e.g. VSAT terminals used for banking services, disaster relief etc.), and in certain countries they would still need to use the upper part of the C-band after 2025, since C-band satellite services can provide the high availability required.

This is particularly relevant for countries like Indonesia, where high rain attenuation is an important factor influencing of the availability of satellite services.[28] Broadly speaking, high rain attenuation limits the extent to which satellite services in higher frequencies (Ku/Ka band) can be used to deliver services that require high levels of availability. This is known as the 'rain fade' issue and its importance in Indonesia is illustrated in **Figure 10** below. It shows that countries with high rain attenuation like Indonesia need a higher fading

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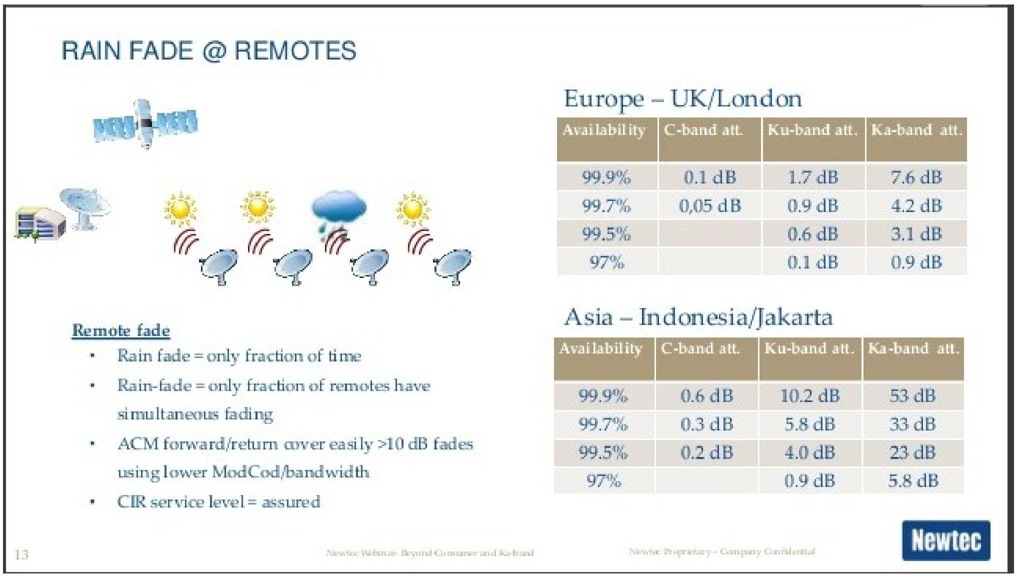
[27] See Northern Sky Research (2013): Global Assessment of Satellite Supply & Demand, 10th Edition

[28] Also the archipelago nature of Indonesia with 17,000 islands restricts the feasibility to deploy fibre infrastructure everywhere given the relatively high cost of sub-marine fibre optic deployments to connect smaller population centres on islands.

margin[29] (expressed in dB's) to achieve the same level of availability than countries with lower rain attenuation (e.g. UK).

In addition, the figure shows that providing services with high availability in higher frequency bands (e.g. Ku/Ka bands) requires significantly higher fading margins, compared with providing the same services in C-band. In other words, in countries like Indonesia rain fade implies lower quality of services provided in higher Ku/Ka bands in comparison to an equivalent service provided in C-band, unless other factors are varied to increase the resistance of the system to signal degradation, such as using bigger dishes. However the importance of this depends on the required availability of the service and the reaction of consumers to this. For example it may be that DTH will not require the same availability as some two way satellite services. As can be seen from **Figure 10** a small reduction in required availability such as from 99.9% to 99.7% may have an impact on the link budget.[30]

Figure 10. Rain fade issue in Indonesia



RAIN FADE @ REMOTES

Europe – UK/London

Availability	C-band att.	Ku-band att.	Ka-band att.
99.9%	0.1 dB	1.7 dB	7.6 dB
99.7%	0,05 dB	0.9 dB	4.2 dB
99.5%		0.6 dB	3.1 dB
97%		0.1 dB	0.9 dB

Asia – Indonesia/Jakarta

Availability	C-band att.	Ku-band att.	Ka-band att.
99.9%	0.6 dB	10.2 dB	53 dB
99.7%	0.3 dB	5.8 dB	33 dB
99.5%	0.2 dB	4.0 dB	23 dB
97%		0.9 dB	5.8 dB

Remote fade

- Rain fade = only fraction of time
- Rain-fade = only fraction of remotes have simultaneous fading
- ACM forward/return cover easily >10 dB fades using lower ModCod/bandwidth
- CIR service level = assured

13 Newtec Webinar- Beyond Consumer and Ka-band Newtec Proprietary – Company Confidential

Source: Newtec Webinar June 2013, Beyond Consumer and Ka-Band: The Future of Traditional VSAT (www.slideshare.net/newtec_satcom/the-future-of-traditional-vsat)

Therefore, for the purposes of our modelling exercise, we assume that for applications that require high availability of services, and can't be moved cost

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[29] Fading margin is a measure of the amount by which a received signal level may be reduced without causing the signal availability to fall below the specified value.

[30] A link budget counts all the gains and losses through a telecommunication system.

effectively to higher frequency bands, the 400MHz of C-band will be sufficient to fully meet the demand of these applications in the future. This is based on the assumptions that:

- C-band spectrum will be used more efficiently in the future, through technological advancement (e.g. use MPEG-4 and potentially HEVC or DVB-S2); and
- applications that do not require C-band will be shifted to other bands or to fixed/terrestrial infrastructure, thus freeing up additional spectrum in the C-band.

Given the limited availability of data on satellite usage, we focus on two main groups of applications that are likely to require significant amount of C-band spectrum in the future, in particular in the areas where rain fade may be a constraint to C-band re-allocation.

- direct-to-home satellite TV broadcasting (DTH) and video distribution to cable head ends; and
- various forms of two-way satellite connectivity with high service availability requirements.

For these applications, we explicitly modelled the costs of partial migration (where possible) to other frequency bands and additional costs related to dealing with potential interference from mobile services operating in the lower part of C-band.

In addition, we took into account the expected costs of making some satellite equipment redundant as a result of freeing up the lower part of C-band in 2025.[31] We also considered additional costs related to moving earth stations using C-band out of urban areas to areas where there is likely to be lower interference.

This allows us to derive indicative estimates of the net cost of re-allocating 400MHz to mobile use. We also applied a number of sensitivity checks on individual cost drivers to make sure that we have provided a sufficiently wide range of cost estimates.

We recognise that this is not an exhaustive list of applications that would incur costs as a result of C-band re-allocation. Nevertheless, based on the information available to us, we believe that these applications are likely to represent the major

---

[31] Clearly this is a backward looking approach. Arguably, these costs are sunk and should not be taken into account in a cost-benefit analysis. However, we use this approach as indicative of the future additional costs that would need to be incurred to provide new satellite equipment earlier than otherwise would have been necessary without C-band reallocation.

cost of C-band re-allocation. For instance, NSR estimates that video distribution[32] and corporate connectivity services will account for almost 80% of C-band satellite capacity in South East Asia by 2022.

We also note that according to NSR's data the overall demand for C-band satellite capacity in the region will decline gradually, which is in contrast to forecasted growth of usage in both Ku and Ka band. This is consistent with our assumption that a share of applications currently using C-band will, in any case, gradually migrate to more cost-effective higher frequency bands.

Below, we discuss in more detail our approach to estimating the costs of re-allocation for the key applications described above.

Cost of DTH TV and video distribution

We assumed a proportion of DTH TV households would continue to use C-band, in particular in countries where rain fade is a significant issue. However, since our scenario considers mobile operators using the lower part of the C-band spectrum in urban areas, this would imply that filters would need to be installed to the satellite dishes of these customers.[33]

We modelled this explicitly for Indonesia, assuming that there will be approximately 10 million DTH TV households close to urban areas relying on C-band satellite signal in 2025.

We assumed that a proportion of these households (20% in our base case) would have chosen to switch to DTH TV services provided over Ku band by 2025. These would be users willing to accept somewhat lower availability of TV service due to rain fade, because they would have access to a potentially cheaper and wider range of services since the capacity for SD and HD channels is much larger in Ku band.

The remaining 8 million of DTH TV household that are assumed to continue to use C-band will require filters to prevent signal interference from mobile networks operating in lower parts of the C-band. We assumed the cost of LNB filters to be $10 in our base case, and that 20% of households would be able to self-install these filters. For the remaining 80%, a home visit by an engineer

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[32] According to NSR methodology, video distribution includes also DTH free-view broadcasting services

[33] This is because the DTH satellite dishes have been designed to pick up signals across the C-band and would need to be adjusted so that they did not pick up the high power mobile signals in this range.

would be required, with an assumed cost of $25 per visit. This implies a one-off cost of C-band DTH filtering of approximately PPP $405 m[34].

In addition, we assumed that cable head ends operating in urban areas would need to be equipped with filters at $200 per piece. Assuming a total number of 500 head ends in Indonesia and 30 pieces per head end, this implies a one-off cost of head end filtering of approximately PPP $5m.

In total, we estimate the cost of DTH TV and video distribution for Indonesia to be approximately PPP $410m in our base case.

We note that due to the decreased spectrum available for C-band video distribution by satellite in urban areas, the DTH proposition would be somewhat restricted. We do not have sufficient information to model the impact on consumer welfare of a somewhat lower range and quality of channels available for these users. However, we note that subscribers that place a high value on the wider range of channels would be those that would be more likely to switch to the new Ku-band satellite services, in any case. Therefore, this limits the welfare impact on the C-band subscribers.

With regards to Australia, we understand that DTH TV in C-band is significantly less important than in Indonesia and is effectively limited to households capturing C-band satellite signal from foreign satellites (Indonesian, Indian, Chinese, Korean, Vietnamese, Thai, Arabic, etc and some International TV channels), that are aimed at cable head ends, for the purpose of further distribution or aimed at foreign DTH consumers. The main Australian Free-to-Air and Pay TV packages are offered on Ku-band satellites.[35] Moreover, as rain fade is unlikely to be a significant issue in Australia, we assume cable head ends currently relying on C-band would be able to switch to other frequencies in the 10 year period between 2015 and 2025 at no additional (significant) cost. Therefore, for the purposes of our modelling, we assume that total costs of accommodating DTH TV usage in C-band in Australia are likely to be insignificant.[36]

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[34] For the purposes of these cost calculations, we work with PPP exchange rate of 1.69 for Indonesia. This implies that one $ in nominal terms is converted into PPP $1.69. For Australia, we use PPP exchange rate of 0.73. For simplicity we apply PPP adjustment to all cost items.

[35] The key Australian TV satellites such as Optus C1, Optus D1, Optus D2 and Optus D3 carry mainly Ku-band transponders, see https://www.optus.com.au/network/satellite/fleet

[36] With regards to the cost of video distribution in Australia, we cover this in the section below where we discuss moving large earth stations outside urban areas.

Table 4. Costs associated with DTH TV and video distribution

Scenario	Potential costs for Indonesia (PPP $ mn)
Low Case	198
Base Case	410
High Case	712

Source: Frontier Economics

Cost of VSAT usage

For the purposes of our modelling, we assumed that it would be feasible to shift 50% of corporate VSAT usage to alternative frequency uses (e.g. reconfiguring VSAT terminals on Ka/Ku frequencies or using fixed lines). We further assumed that this could be done gradually, over a 10 year period, at no effective additional cost, as this migration would take place anyway. This is because we assume that for applications not requiring high service availability it would be cost efficient to use Ka/Ku band, in line with the forecasted increases in Ku/Ka band usage, according to NSR data.

In particular broadband internet services require a lot of capacity and therefore a lower price per MByte. Ka-band offers more bandwidth per transponder resulting in a lower bandwidth cost, though at the expense of a lower availability due to rain fading.. Some solutions even propose dual-band Ku/Ka to benefit from both more cost-effective bandwidth at Ka-band and better availability at Ku-band. We understand that broadband applications will, for bandwidth cost reasons, try to make more use of the higher satellite frequency band, as long as the reduced availability is acceptable for the customer (a typical example would be consumer satellite broadband).

The remaining VSAT terminals would then need to be equipped with appropriate filters, at a cost of $200 per terminal. We assumed that there will be approximately 30,000 affected terminals in Indonesia and 5,000 in Australia. This would imply one-off costs of approximately PPP $10m and PPP $0.7 million respectively.

Table 5. Estimated costs for VSAT users

Scenario	Indonesia (PPP $ mn)	Australia (PPP $ mn)
Low Case	5.1	0.4
Base Case	10.1	0.7
High Case	16.9	1.2

Source: Frontier Economics

Cost of redundant satellite equipment

By 2025, there will still be a number of 'old' satellites (released before 2015) carrying C-band transponders configured for 3.4-3.8GHz range. As these transponders will not be well utilised after 2025, we consider their remaining asset lifetime to estimate the total cost of satellite equipment stranded as a result of C-band re-allocation.

We assumed that there are currently around 50 satellites carrying C-band transmitters that are targeting the APAC region. We also assumed that C-band capacity of these satellites is 50% on average. We further assumed an average satellite lifetime of 15 years. Assuming that the satellites had been launched at the same rate over time, this implies that by 2025, there will be approximately 17 of these satellites still in operation, with a remaining asset lifetime of 2.5 years that would be stranded.[37] Assuming the cost of satellite capacity of approximately $250m per satellite, we estimate the total cost of C-band satellite equipment for the APAC region to be around $347m.

We then approximately allocated this cost to Indonesia and Australia on the basis of population shares in the APAC region.[38] This implied a cost of satellite equipment in our base case of approximately PPP $48m and PPP $2m respectively.

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[37] We recognise that this is a very simplified approach relying on a number of assumptions, but we believe it should provide a reasonable estimate of the order of magnitude of the costs related to satellite assets. At the same time, this approach is conservative as these costs could be considered sunk.

[38] We don't include China's population in this estimate, due to negligible share of DTH TV usage in C-band in China. This implies the adjusted population share of Indonesia is around 8% and about 1% for Australia.

Cost of earth stations

We further assumed there would be a number of earth stations, many of which would be TV receive dishes, operating in urban areas that would be affected by potential mobile interference. For that reason, we assumed these earth stations would need to be moved to more suitable areas (e.g. valleys in remote locations). In our base case, we assumed the cost of moving a single teleport to be approximately $0.8m in Indonesia and $2m in Australia. We further assumed that there will be significant cost savings arising from using shared facilities.

In our base case, we assumed it would be possible to achieve 75% saving in Indonesia as a result of facility sharing and 50% saving in Australia. Assuming total number of C-band earth stations in Indonesia to be 500 and in Australia 40, and assuming 75% of these stations would need to be relocated, this implied total cost of moving earth stations of approximately PPP $127m for Indonesia and PPP $22m for Australia.[39]

Table 6. Costs associated with Earth stations

Scenario	Indonesia ($ PPP mn)	Australia ($ PPP mn)
Low Case	53	9
Base Case	127	22
High Case	232	40

Source: Frontier Economics

Sensitivity analysis

We recognise that our estimates rely on a number of assumptions, due to limited availability of data on the actual satellite usage and costs in C-band.

We therefore identify the key cost drivers underlying the estimate for each of the key applications discussed above.

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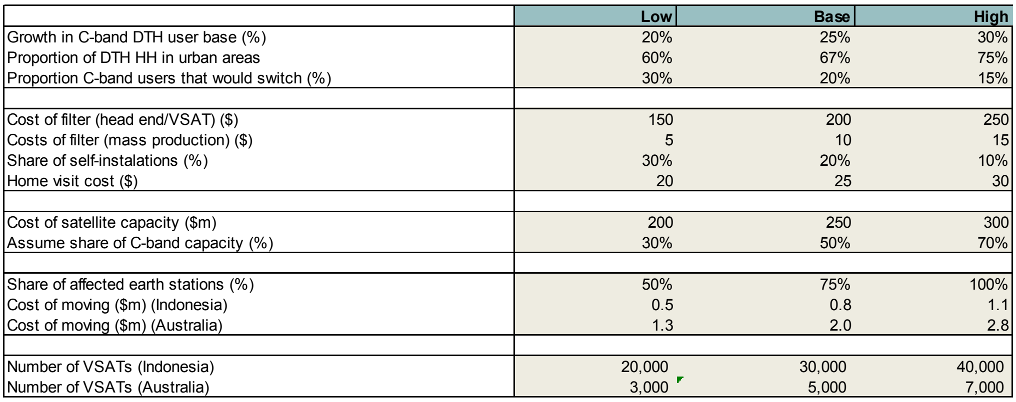
[39] We understand that there are only about 12 C-band earth stations that would need to be relocated in Australia, see Appendix 5 here http://www.acma.gov.au/webwr/_assets/main/lib410042/ifc27-2011_earth_station_siting.pdf. We also understand that some head ends will disappear as it becomes more cost-effective to distribute the TV signals over the fibre optic backbone (NBN) instead of building/maintaining cable head-ends all over Australia. Therefore, our assumption that 40 earth stations in Australia will be relocated appears highly conservative.

For each of these, we have assumed a range of values to model low, base and high cost scenarios.

The range of value for each of the key cost drivers in our calculation is illustrated in **Figure 11** below.

Figure 11. Sensitivity analysis - key cost drivers



	Low	Base	High
Growth in C-band DTH user base (%)	20%	25%	30%
Proportion of DTH HH in urban areas	60%	67%	75%
Proportion C-band users that would switch (%)	30%	20%	15%
Cost of filter (head end/VSAT) ($)	150	200	250
Costs of filter (mass production) ($)	5	10	15
Share of self-instalations (%)	30%	20%	10%
Home visit cost ($)	20	25	30
Cost of satellite capacity ($m)	200	250	300
Assume share of C-band capacity (%)	30%	50%	70%
Share of affected earth stations (%)	50%	75%	100%
Cost of moving ($m) (Indonesia)	0.5	0.8	1.1
Cost of moving ($m) (Australia)	1.3	2.0	2.8
Number of VSATs (Indonesia)	20,000	30,000	40,000
Number of VSATs (Australia)	3,000	5,000	7,000

Source: Frontier Economics

3.3.2 Results

Table 7 below summarises our cost estimates for Australia and Indonesia under different scenarios. The cost estimates for Indonesia range from PPP $0.3 billion to PPP $1 billion. The cost estimates for Australia range from PPP $11 million to PPP $43 million.

Table 7. Total costs of C-band migration for Indonesia and Australia

Scenario	Indonesia ($ PPP mn)	Australia ($ PPP mn)
Low Case	294	6
Base Case	595	11
High Case	1,019	19

Source: Frontier Economics

We then extrapolated our cost estimates to the whole APAC region. We calculated the share of cost on benefits for Indonesia and Australia and apply this share to similar countries in the APAC region.[40] We use the relative share of costs on benefits for each country based on the Base Case scenario. The results are shown in **Table 8** below.

Table 8. Total costs of C-band migration for the APAC region

Scenario	Low cohort	High cohort	APAC total
Cost to benefits ratio	14%	2%	
To be applied to the following benefits by cohort to get costs			
Low Case	2,486	88	2,574
Base Case	8,187	200	8,387
High Case	33,874	829	34,703

Source: Frontier Economics

3.4 Estimating indirect effects of C-band re-allocation

Besides the direct net benefits from the re-allocation of C-band spectrum to the mobile sector estimated above, the additional value added generated will also have a number of indirect effects over the economy. These include: government income, new job creation, an impact on the wider economy and the promotion of new business creation.

While our study estimates the impact on government income and employment, the impact on the wider economy is addressed only from a qualitative point of view. Hence, our estimates provide a lower bound on the potential benefits that the re-allocation of C-band spectrum to the mobile sector can bring to the economy.

3.4.1 Impact on government income and employment

The re-allocation of additional C-band spectrum to the mobile industry will allow mobile operators to be more productive. This is because an additional amount

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[40] The High Cohort consists of Australia, Japan, Hong Kong, Korea, New Zealand and Singapore. The Low Cohort consists of Brunei Darussalam, China, Indonesia, Vietnam, Philippines, Thailand, Malaysia, Sri Lanka, Fiji, Samoa, Vanuatu, Tonga, India, Bangladesh, Pakistan, Nepal, Cambodia, Lao, Myanmar, Papua New Guinea, Bhutan, and the Solomon Islands.

of spectrum will allow operators to serve a higher level of demand with the given resources. Alternatively, an additional amount of spectrum will allow mobile operators to meet the increasing demand for mobile data services more efficiently. This higher efficiency implies freeing up of scarce resources from the mobile sector to other sectors, which will lead to increasing economic activity and additional gross value added (GVA) in the economy. As a high level approximation, we assume GVA is broadly comparable with our estimates of net benefits for mobile industry generated by re-allocation of C-band spectrum.

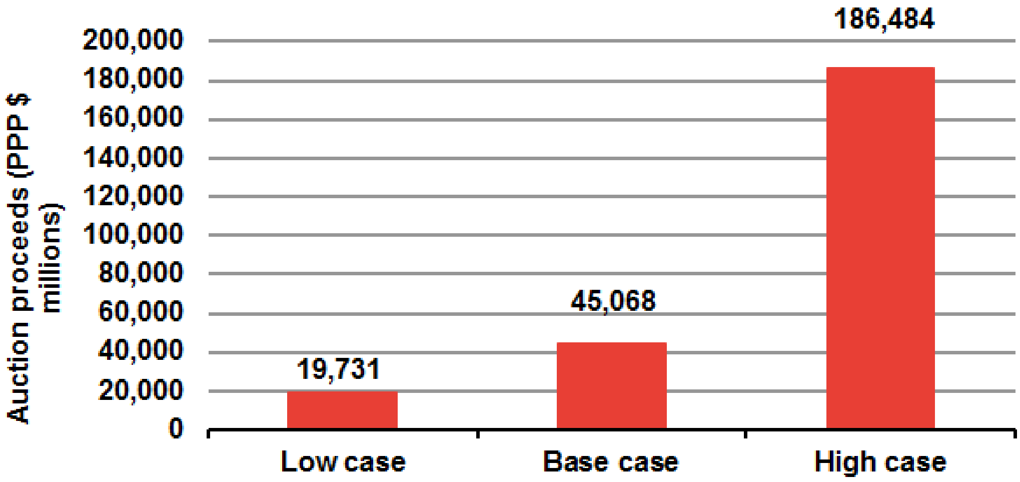
The extra GVA generated via the re-allocation of C-band spectrum will lead to additional government revenues and job creation, as discussed in more detail below.

Government income

There are two main sources of government income arising from the C-band re-allocation. First, there is direct income arising from selling spectrum licences proceedings. Second there is additional tax income from increased economic activity.

We estimate the overall government proceeding from spectrum licensing by simply multiplying the assumed price of C-band spectrum (per MHz/population) by 400MHz available and the total population in the APAC region. The results are summarised in **Figure 12** below.

Figure 12. Auction proceeds for the APAC region



Source: Frontier Economics

The additional taxation revenues will come via direct taxes (such as corporate taxes or income taxes) and indirect taxes (such as value added taxes – VAT). In this study we have taken a simple approach to estimating the impact on tax revenues. Hence, our results are only indicative.

For the sample of countries considered in the study, we have estimated the proportion of tax revenues over GDP and estimated the weighted average tax rate, as shown in **Table 9** below.

Table 9. % Tax revenues over GDP

Country	% Tax revenue	GDP (US$ billion)
Australia	21%	1,541.8
Hong Kong SAR, China	14%	263.0
Japan	10%	5,964.0
Korea, Rep.	16%	1,155.9
Singapore	14%	276.5
New Zealand	28%	169.7
Weighted average (High Cohort)	**13%**	
China	10%	8,227.0
Indonesia	12%	878.2
Malaysia	15%	303.5
India	10%	1,824.8
Pakistan	9%	231.9
Thailand	18%	365.6
Vietnam	30%	138.1
Weighted average (Low Cohort)	**11%**	

Source: Frontier Economics based on information from the World Bank

We note that the weighted average tax rates look rather low when compared with other regions.[41] Potential reasons identified to explain the low tax-to-GDP ratio observed in India include[42] (i) a low per capita income; (ii) a large proportion of small and medium enterprises which benefit from a variety of exemptions and, in some cases, may not comply with their tax duties; and, (iii) the lack of policy

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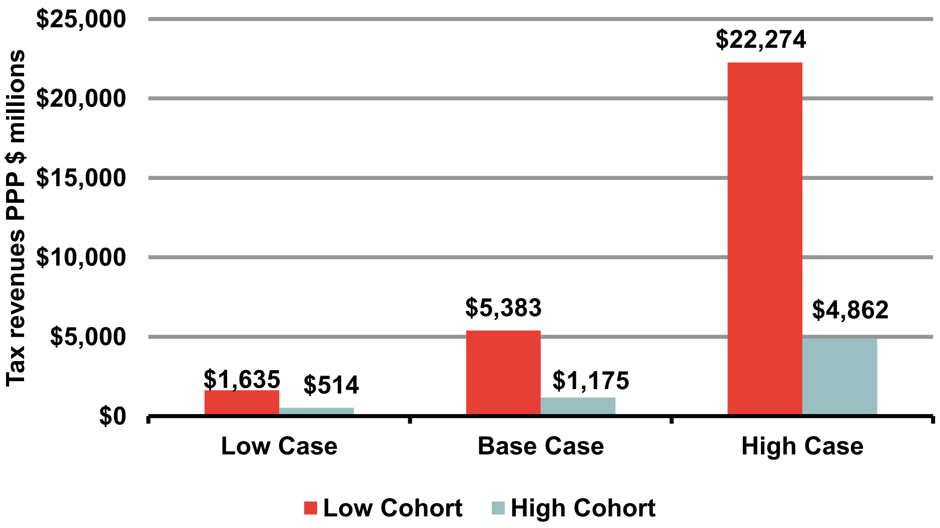
[41] The OECD average 33.8% in 2010.

[42] See http://www.firstpost.com/economy/why-is-indias-tax-to-gdp-ratio-so-low-239152.html

initiatives to increase tax revenues. These reasons are likely to be applicable to the other countries in the region that present a low tax-to-GDP ratio.

In order to estimate the additional tax revenues generated by the re-allocation of C-band we have applied the weighted average tax rate over the additional GVA generated in each cohort. The results are shown in **Figure 13** below.

Figure 13. Tax effects per cohort of countries



Source: Frontier Economics

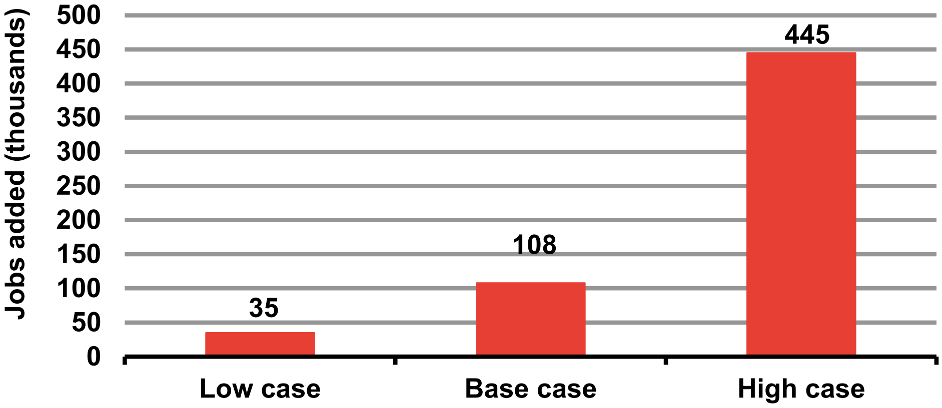
Employment

Similarly, we have simply estimated the impact on employment based on the average employment in each country compared to the total GVA. If we assume that this relationship stays constant, which may be a reasonable first order approximation, this implies an increase in employment which is proportional to the increase in the GVA generated by the re-allocation of C-band spectrum.

The above assumption is reasonable in this context. This is because the additional GVA generated by the re-allocation of C-band spectrum will come via the additional activity generated in the economy by freeing up resources that would otherwise be used to provide mobile services.

Figure 14 below shows the effect on employment associated with the re-allocation of C-band spectrum per country-cohort.

Figure 14. Employment effects for APAC countries (thousand jobs)



Source: Frontier Economics

3.4.2 Impact on wider economy

The re-allocation of C-band spectrum to mobile services is likely to exert two additional effects.

First, the additional economic activity generated by the freeing up of resources from the mobile sector to other sectors in the economy (via the higher productivity attained from the re-allocation of C-band spectrum) will exert a multiplier effect over the whole economy.

Second, the re-allocation of C-band spectrum to the mobile industry will likely result in a higher quality of service for mobile broadband services. By facilitating information flows, a higher quality for mobile broadband services may enhance the creation of new businesses.

While we recognize the potential importance of these effects, we do not provide a quantitative estimation in our analysis. Hence, our estimation of the benefits from re-allocating additional C-band spectrum in the mobile sector should, in this regard, be considered a conservative estimate.

Multiplier effect

The multiplier effect created by an increase in economic activity, in this case via freeing up resources by the mobile sector, refers to the subsequent spending rounds induced by the extra income generated. In other words, it captures the fact that a proportion of the wages paid to the direct and indirect employees in the new economic activity, will be spent on domestically produced goods, thus stimulating further economic activity within other sectors.

The multiplier effect is usually considered when assessing the impact assessment of a policy intervention or when estimating the economic contribution of a sector on the economy.

In the context of mobile communications, existing studies estimating the contribution of the sector on the economy, have considered a multiplier effect in the range 1.1-1.7.[43] A recent study by AT Kearney[44] considers a multiplier of 1.5 for the Asia-Pacific region.

By not accounting for a multiplier effect, our estimates represent a lower threshold of the potential benefits that the re-allocation of the C-spectrum band will generate in the APAC region.

New business creation

The potential increase in the quality of the mobile broadband service, due to the re-allocation of C-band spectrum for mobile services, is expected to enhance economic activity for different reasons. These include, among others, the following:

- An increased usage of mobile data services may also lead to lower input costs, for instance by promoting online shopping or by facilitating outsourcing to areas with lower labour costs.

- Higher quality mobile data services may facilitate a more efficient use of time and increase productivity of workers, by promoting telecommuting and while working while travelling.

The literature on the impact of mobile services on new business creation is still new and scarce. With exceptions, most studies focus on developed countries and estimate the link between the availability and/or penetration of Internet services on new business creation.

While the studies differ in the approach undertaken, they coincide on the existence of strong positive effects of the internet on new businesses and entrepreneurship. For example, Garcia-Murillo et al. (2013)[45] have found, for México, that a 10% increase in fixed broadband penetration is associated to a 0.09% increase in new businesses density (new businesses per 100 people).

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[43] Deloitte (2008): "Economic Impact of Mobile Communications in Serbia, Ukraine, Malaysia, Thailand, Bangladesh and Pakistan", A report prepared for Telenor ASA, January 2008.

[44] AT Kearney (2011): "Asia Pacific Mobile Observatory 2011: Driving Economic and Social Development through Mobile Broadband", A report for the GSMA.

[45] Garcia-Murillo, M., J.A. Velez-Ospina and P. Vargas-Leon (2013): "The techno-institutional leap and the formation of new firms", working paper version.

Similarly, Kim and Orazem (2012),[46] estimate that a 10% increase in broadband availability raises firm entry by 1.6% in urban areas, but only 0.2% in rural counties not adjacent to a metropolitan areas.

While this literature is not directly applicable to the current case, in areas where the availability of fixed broadband services is low, the impact of mobile broadband services may be of a similar magnitude. Further, the finding by Kim and Orazem that broadband availability may have a stronger impact on urban areas could well be relevant for the current case. This is because the availability of C-band spectrum will mainly benefit urban areas.

We therefore conclude that access to C-band spectrum might have positive effect on new business creation, in particular in countries where the availability of fixed broadband is low

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[46] Kim, Y., Orazem, P. (2012): "Broadband Internet and Firm Entry: Evidence from Rural Iowa", Iowa State University working paper.

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