The Boston Consulting Group

The Economic Benefits of Early Harmonisation of the Digital Dividend Spectrum & the Cost of Fragmentation in Asia-Pacific

INTRODUCTION

In 2010, GSMA and The Boston Consulting Group released a report on the social and economic benefits of allocating the 700 MHz band to mobile broadband in the Asia-Pacific region. Based on a rigorous and conservative proprietary methodology, we identified a significant uplift in GDP, tax revenues, employment and entrepreneurship resulting from a harmonised mobile band plan relative to its most likely alternative, digital broadcasting.

Since then a number of important developments have been observed in the region. Most notably, an increasing number of countries are committing to the proposed Asia-Pacific technical harmonisation, or APT band plan, Long Term Evolution (LTE) technology is being introduced throughout the region and the 700 MHz band allocation is attracting interest from the EMEA region and Latin America. However, not all countries have committed to the band plan.

Building on the findings and methodology of the 2010 report, this report analyzes the economic implications of a harmonised APT band plan, and considers the impact of delay and non-harmonisation. It also recommends a way forward for countries that are in the process of determining their spectrum allocation policies.

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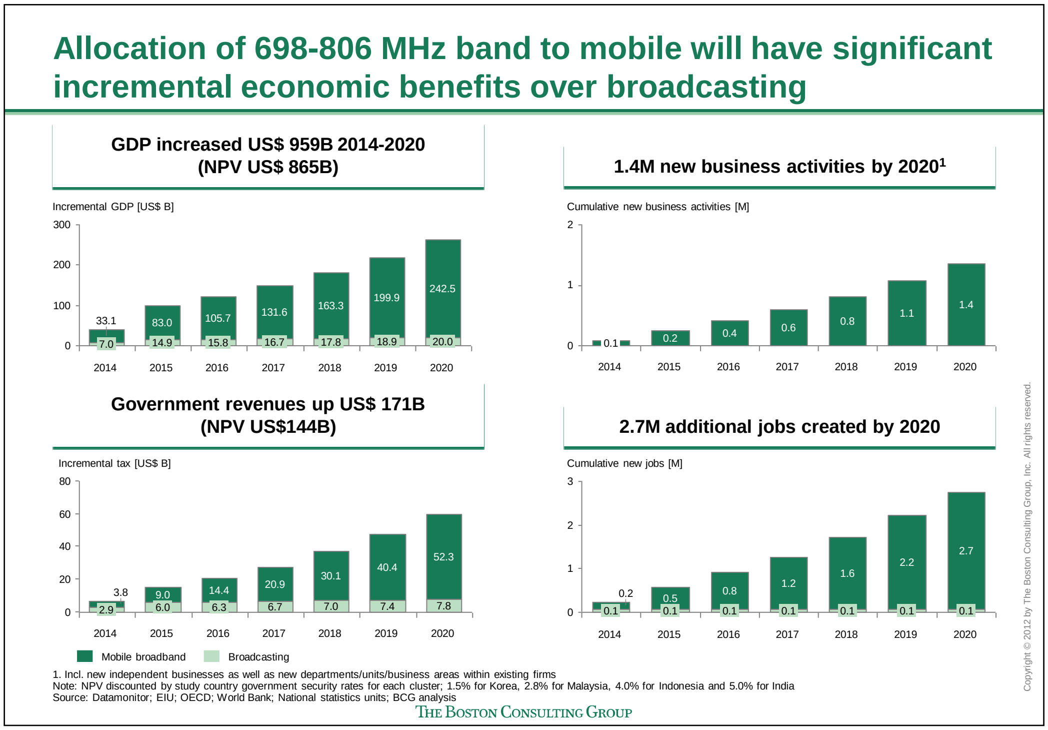
EXECUTIVE SUMMARY

As the switchover in Asia-Pacific from analogue to digital broadcasting approaches, a growing number of countries have committed to allocating the frequency band 698-806 MHz (the 700 MHz band) to mobile in accordance with the Asia-Pacific Telecommunity (APT) harmonised band plan. The Asia-Pacific region as a whole could take the lead in the implementation of a multi-regionally harmonised spectrum band, as there is also interest in the Middle East and Latin America. However, as of May 2012, not all countries in the Asia-Pacific region have committed to the harmonised plan.

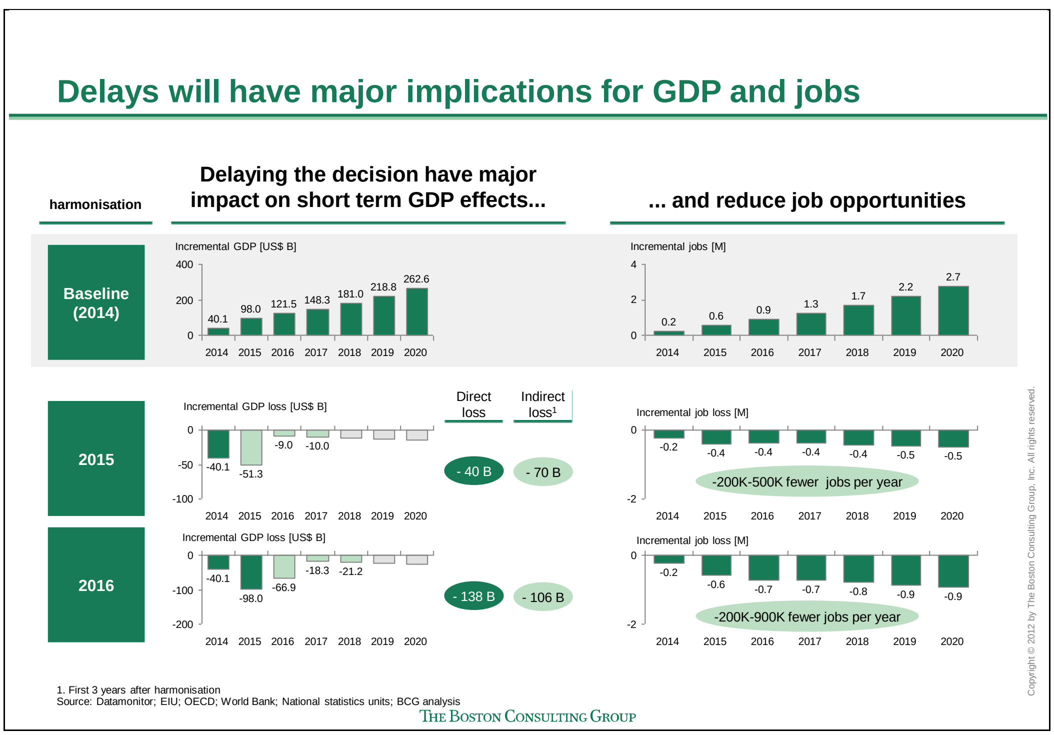
The socio-economic benefits of allocating the 700MHz band to mobile – including growth in GDP, employment, entrepreneurship and tax revenues – are significant. In fact, **by 2020, the digital dividend for the Asia-Pacific region could be worth almost US$1 trillion in additional GDP**. To achieve the full benefits, a harmonised solutions needs to be implemented as quickly as possible.

A delay in the allocation of the 700 MHz band by one year, to 2015, could result in a loss in incremental GDP growth of US$40 billion in the first year, and an indirect loss of US$70 billion in the three subsequent years. Between 200 and 500 thousand fewer jobs would be created in the region. Delaying by two years, to 2016, would have an even bigger negative impact. On the other hand, fragmentation will lead to cross-border interference and loss of economies of scale, reducing the socio-economic benefits associated with the switch. **Countries that implement a different allocation will see a reduction in benefits of up to 30% in the case of job creation.** Furthermore, they will also affect their neighbours along the borders. Neighbouring countries could lose up to 3% of digital dividend GDP, and up to 11% of new business activities.

To reap the benefits of the digital surplus, **countries should follow three steps** – identify the optimal band use through cost-benefit analysis and consult with stakeholders; select an appropriate switchover approach; and implement so as to minimise costs and disruptions. Failure to follow these steps could lead to delays, reduce benefits, or even necessitate additional costs to harmonise with other systems.



Impact of alternative allocations of 700 MHz band



Impact of delayed harmonisation

1 KEY RECENT DEVELOPMENTS

As countries across the Asia-Pacific region recognise the potential benefits to consumers and society, support is strong and growing to allocating the frequency band 698-806 MHz (the 700 MHz band) in accordance with the Asia-Pacific Telecommunity (APT) harmonised 2X45 MHz APT band plan.

The majority of countries in the region are committed to/have stated intention to implement the same technical specifications, the FDD option of the APT band plan: collectively, the populations of these countries number more than 2 billion.

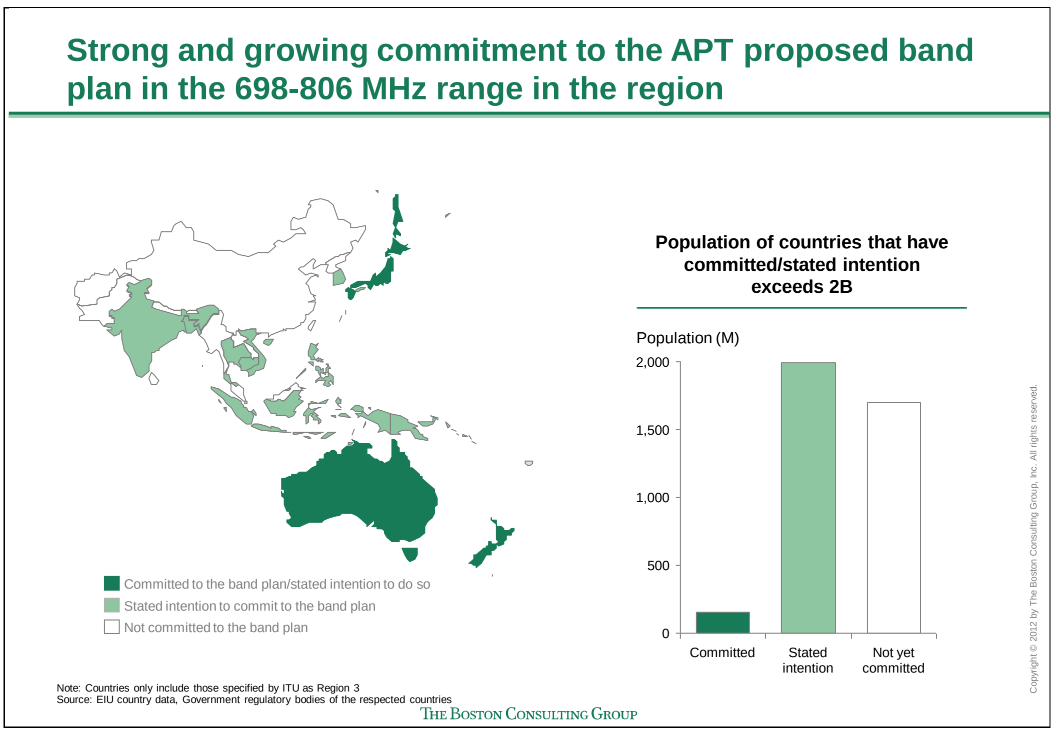


Exhibit 1.1 Commitment to APT band plan

China has proposed to adopt time division duplexing (TDD) in the 700 band. TDD uses the same spectrum for both uplink and downlink, with the network alternating between uplink and downlink on a time basis. Meanwhile, Malaysia is considering allocating the spectrum up to 742 MHz to broadcasting. Both situations would result in interference with neighbouring countries.

1.1 Regional commitments

Within Asia-Pacific, two countries – Australia and New Zealand – have recently announced clear commitments to implement the 700 MHz band plan.

In a June 2010 announcement, Australia's minister for Broadband, Communications, and the Digital Economy identified the size and frequency band (694-820 MHz) of the ultra-high-frequency (UHF) digital dividend[1]. A complete switch-off of analogue services is planned for December 2013 and work continues on the restacking process, including revising channel plans, to determine the channels to which digital television services will move, and implementing the channel changes.

In early 2011, New Zealand announced that the 700 MHz band would be allocated to mobile services. Restacking started in May that year and will be completed by June 2013. Meanwhile, in mid-2012, the country will release the auction design, rules and timing for consultation. A complete switch-off of analogue services and freeing-up of spectrum will take place by December 2013. Band management rights will be allocated for the period from December 1, 2013 to November 28, 2031.

In April 2012, Thailand and Japan also confirmed their commitments. Japan aims to allocate spectrum to different mobile operators by the end of June 2012. The Ministry of Internal Affairs and Communication has announced draft guidelines for allocation of 700 MHz spectrum in accordance with APT FDD band plan. Licence applications have been submitted and three pairs of 10 MHz x 2 will be awarded in July 2012. Thailand has announced the allocation of 698-806 MHz band to mobile, and is looking into the possibility of a digital TV broadcasting switch-on and analogue switch-off within four years.

[1] "Digital dividend" refers to the part of the radiofrequency spectrum that can be freed up following the switch from analogue to digital television

Additional comments on major countries in Asia-Pacific

Country	Status	Comments
Australia	✓	Auction date announced for April 2013 in full alignment with APT band plan
New Zealand	✓	Restacking between May 2011 – June 2013; 700 MHz band clear and available nationwide from Dec 2013 onwards
Indonesia	✓	Looking into allocating the 700MHz band (694-806MHz) for mobile broadband
Singapore	✓	Plans to commit, but concerned about potential interference with Malaysia
Malaysia	✗	Consider broadcasting on parts of the band
Thailand	✓	700 MHz band allocated to mobile services, effective April 2012
India	✓	Has shown intention to follow the APT band plan but Government yet to make a formal announcement on the 700MHz auction
China	✗	Agrees to use the 700Mhz band for mobile, but not committed to a frequency option
Japan	✓	Awarded 3 licenses totaling 2x30 MHz on 27 June, in partial alignment with the APT band plan
South Korea	✓	Will allocate 700MHz after switch over in Dec 2012 to LTE services
Papua New Guinea	✓	2x22.5 MHz (the lower block) allocated to Digicell PNG in April 2012
Tonga	✓	In the process of allocating one 2x15 MHz block to an operator.

✓ Committed ✗ Non-committed

Source: Press search, expert interviews

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Exhibit 1.2 Detailed regional update of APT band commitment

1.2 Incentives for Asia-Pacific

At the World Radiocommunications Conference in Geneva in early 2012 (WRC-12), it became clear that the 700 MHz band could be a viable model and that Asia-Pacific as a region could take the lead in its implementation. Telecoms leaders at WRC-12 discussed the incentives for Asia-Pacific regulators to develop a harmonised band plan. These incentives include:

- Demand for and willingness to support a 700 MHz band plan in Arab and African countries (a testament to the benefits of the plan);
- The possibility for the first time for the existence of a multi-regionally harmonised spectrum band that could provide a coherent ecosystem for Long Term Evolution (LTE) devices, with recommendations for the 700 MHz band plan extended to EMEA; and
- The fact that popular consumer goods are moving in support of the harmonised band plan

2 THE BENEFITS OF HARMONISATION

In looking at the impact of harmonisation on GDP growth, productivity, job creation, entrepreneurship, infrastructure investment, and taxation, we believe that the biggest socio-economic benefits are likely to arise by allocating the 700 MHz band to either mobile or broadcast services.

To estimate the incremental benefit of allocation of the 700 MHz to IMT[2] technologies, we simulated the benefits of two types of harmonisation – the harmonisation of mobile services (IMT) and the harmonisation of broadcasting services (DTT). Thereafter, we assessed the incremental benefit of allocating the 700 band to mobile services relative to broadcasting.

2.1 Analysis of benefits

The economic impact of the harmonisation of mobile services is likely to be seen in four areas – GDP growth, employment, entrepreneurship and tax revenues.

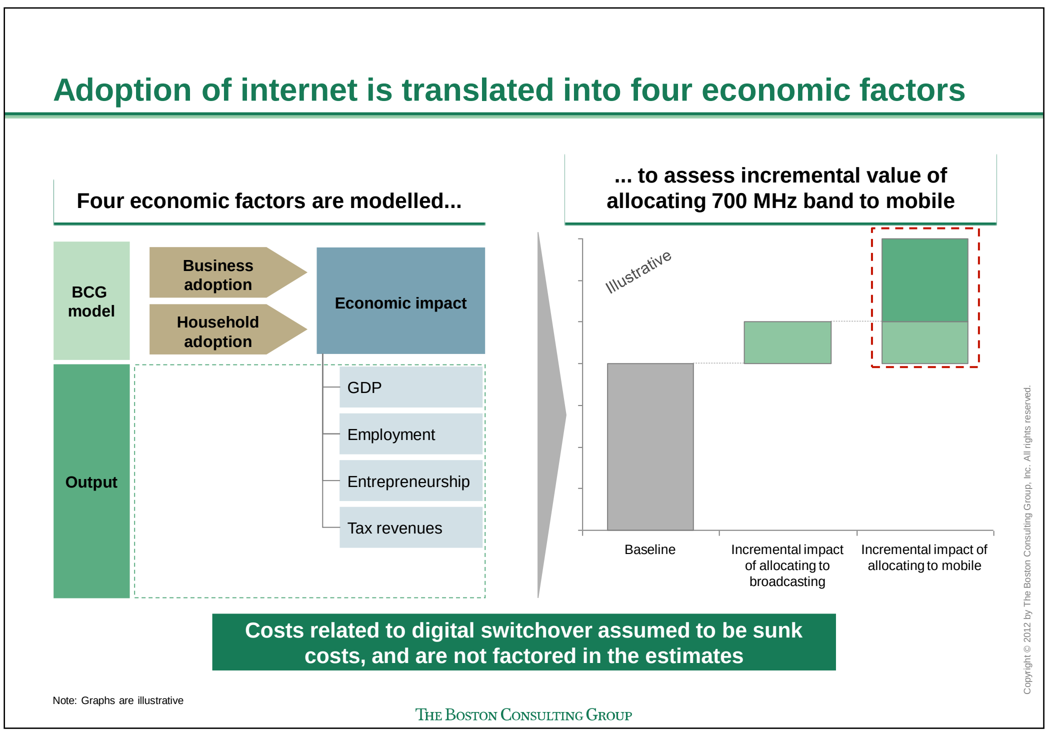


Exhibit 2.1 Methodology

[2] IMT (International Mobile Telecommunications) and IMT-Advanced are terms used to describe the capabilities of different generations of cellular mobile technologies

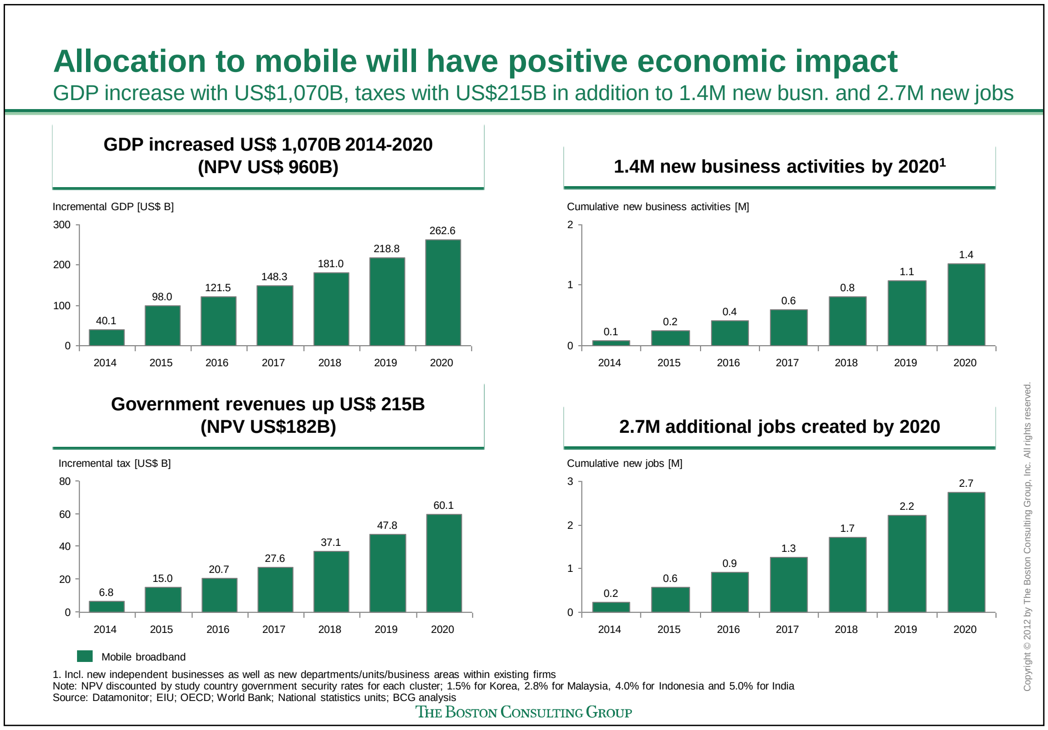


Exhibit 2.2 Impact of mobile allocation of 700 MHz band

In terms of economic impact, by 2020, the allocation of 700 MHz band to mobile could have a positive impact across the region, generating a GDP increase of more than US$1 trillion (NPV of $960 billion) and tax revenue growth of US$215 billion, along with the creation of an additional 1.4 million new businesses (including new departments or business units within existing firms) and 2.7 million new jobs.

When it comes to the harmonisation of broadcasting services, allocation of the 700 MHz band will accommodate more TV channels. In most countries, the addition of some 25 to 35 channels would be technically feasible (although channels that are not commercially viable might be deliberately excluded).

This would generate additional broadcast revenue across the television supply chain. However, the overall effect on the industry might be less evident, since additional channels could cannibalize existing offerings and marginal channels only cater to limited audiences. And the broader economy would see fewer spin-off effects since existing public service channels already provide a wide range of educational programmes and special interest groups are well served by cable and satellite TV.

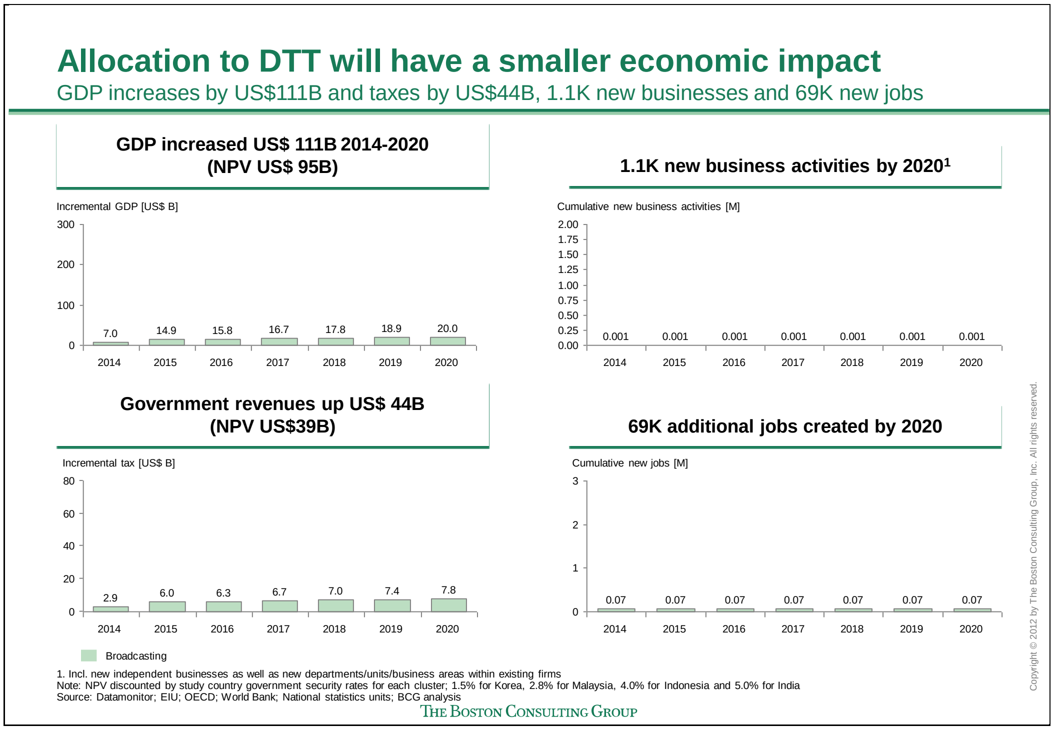


Exhibit 2.3 Impact of broadcasting allocation of 700 MHz band

By 2020, allocating 700 MHz band to broadcasting services could have a positive effect on economies in the region, with a possible GDP growth of US$111 billion, increased tax revenues of US$44 billion, as well as 1,100 new businesses or business units and 69 thousand new jobs. However, these benefits represent a smaller economic impact than would be generated by allocation to mobile.

2.1 Incremental benefit of mobile over broadcasting

Comparing the two scenarios, allocation of 700 MHz band to mobile services would lead to significant incremental economic benefits over the allocation to broadcasting services – namely an extra US$959 billion in GDP, by 2020, as well as additional tax revenues of US$171 billion, 1.4 million more business activities, and 2.6 million additional jobs.

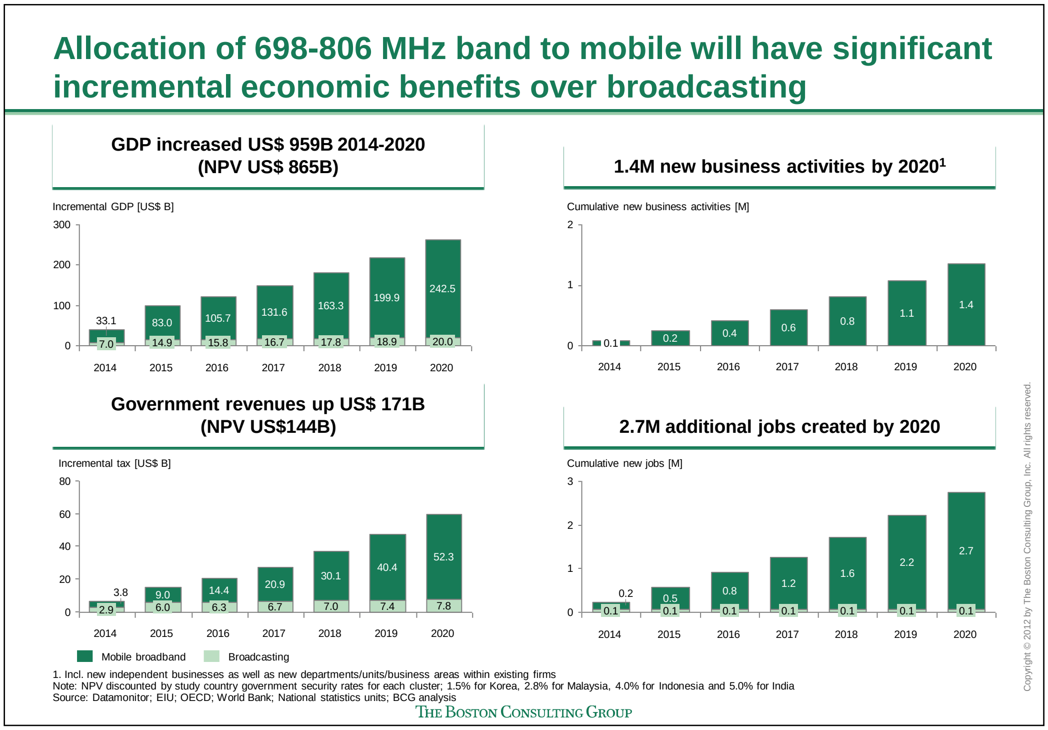


Exhibit 2.4 Impact of alternative allocations of 700 MHz band

3 BENEFITS OF EARLY HARMONISATION

For countries that delay the decision to allocate 700 MHz band, rollout would be affected and this could have an impact on the total socio-economic benefits of the technology. We assessed the potential opportunity cost of delaying harmonisation by one or more years relative to an early harmonisation baseline. We distinguish between the 'direct' loss up to the year of implementation, and the 'indirect' losses in the three subsequent years.

When we looked at the potential impact of delaying the decision on GDP and job creation, we found that delays could have a major impact on short-term GDP growth and employment opportunities when compared with the 2014 baseline.

Delaying by one year, to 2015, could lead to a direct loss in incremental GDP growth of US$40 billion and an indirect loss of US$70 billion, with the loss of 200 thousand to 500 thousand extra jobs. Delaying by two years, to 2016 could have an even bigger negative impact, with a direct loss of US$138 billion in incremental GDP growth and an indirect loss of US$106 billion, along with the loss of 200 thousand to 900 thousand extra jobs per year. The same logic applies to taxes and business creation, which would also be correspondingly lower.

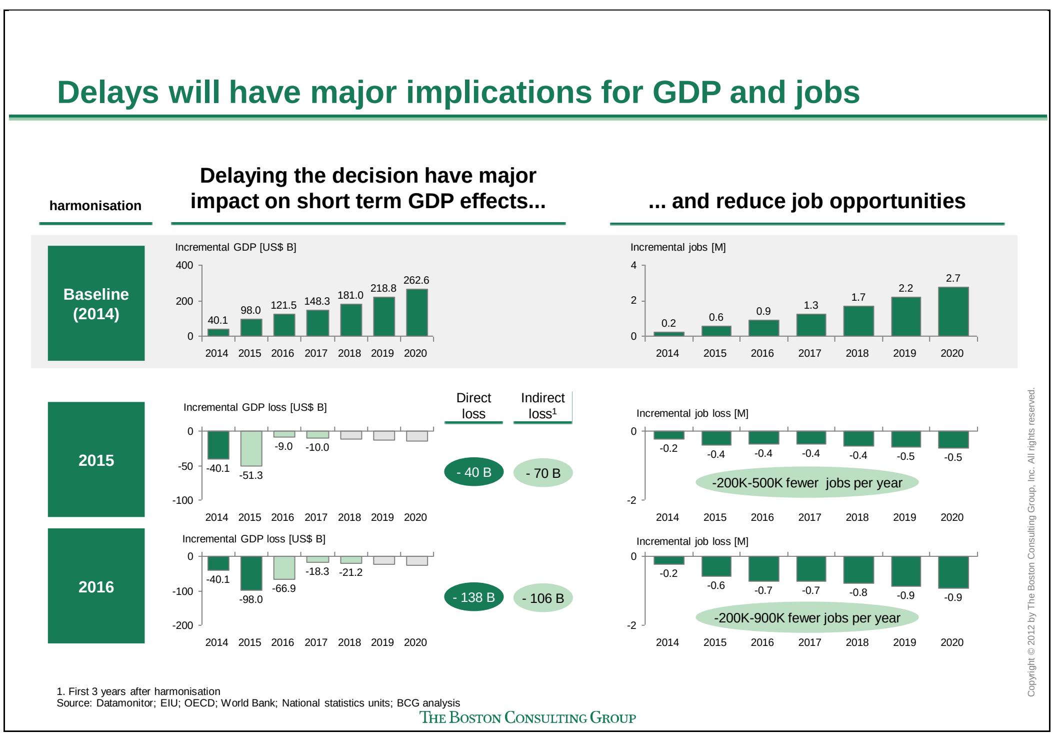


Exhibit 3.1 Impact of delayed harmonisation

4 THE IMPLICATIONS OF FRAGMENTATION

By definition, digital signals, being mobile, broadcasting or similar, are radio signals that are transferred from a transmitter to a receiver. This means signals using the same frequency directly interfere with each other, resulting in a reduction in the quality of service in affected areas, with direct interference potentially extending up to 200km. Fragmentation of different 700 MHz band allocations could therefore lead to cross-border interference in the region.

4.1 Possible scenarios

In Asia-Pacific, two scenarios could arise that could potentially cause cross-border interference.

First, interference occurs when FDD and TDD is used across borders. Frequency division duplexing (FDD) supports two-way radio communication by using two distinct channels for uploading and downloading information, while time division duplexing (TDD) uses a single frequency to transmit signals in both downstream and upstream directions at different times.

Second, cross-border interference also occurs when only a portion of the intended spectrum is allocated to IMT, whilst the rest is allocated to DTT services. If neighbouring countries were to allocate the whole spectrum to IMT, direct cross-border interference would occur in the portion of the spectrum that is allocated to DTT.

We modelled the potential implications of non-harmonisation for a representative country – a medium developed economy – that shares borders with three neighbouring countries – one developed, one medium and one emerging economy.

The representative country X might adopt a non-harmonised 700 MHz solution as a result of either a spectrum split between digital broadcasting (DTT) and mobile services (IMT) or because it has chosen to use TDD rather than FDD technology.

We assessed the implications of non-harmonisation for country X (in terms of interference mitigation costs, loss of 700 band mobile coverage and increased handset costs) as well as on the three countries it borders (which would all suffer from cross-border interference).

In all countries, interference would create a number of negative effects. First, the cost of service would be higher than in a harmonised scenario, due to higher rollout costs and mitigation costs. The benefits will also be lower due to a poorer quality of service and/or the exclusion of a certain portion of the population due to the implementation of an exclusion zone.

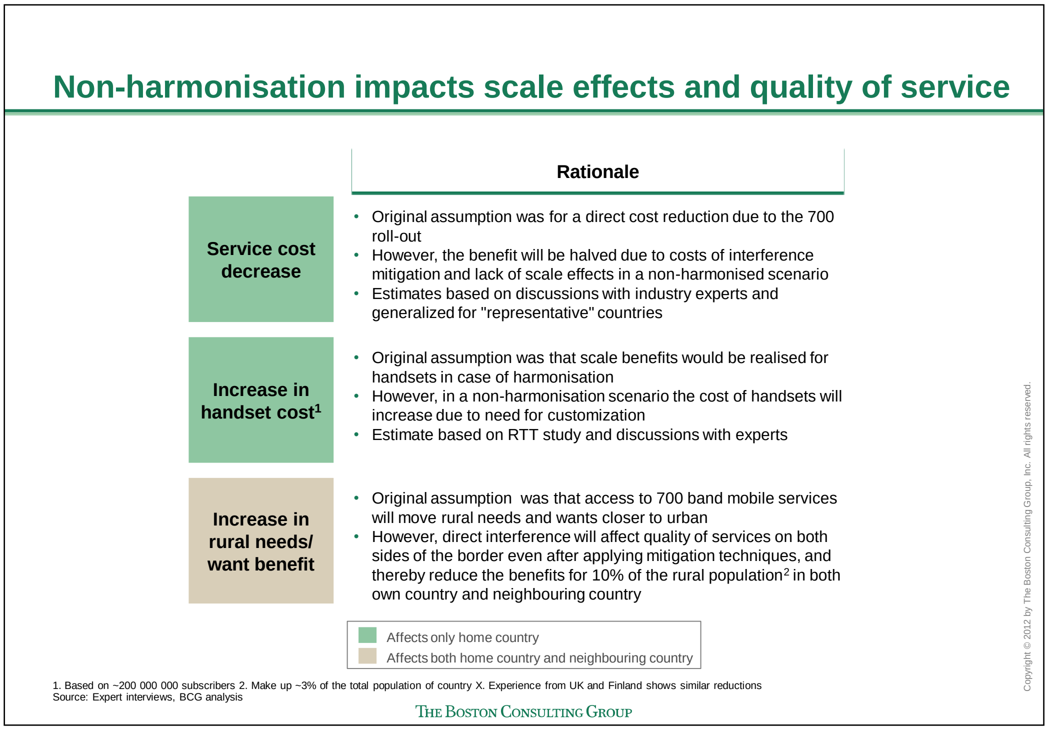


Exhibit 4.1 Impact of fragmentation on own country and neighbouring countries

In terms of overall impact, all four countries would experience reduced benefits as a result of technology fragmentation. For representative country X, the greatest loss would be in incremental growth of new business activities and job opportunities (both 30%) and tax revenue generation (18%), with a 5% loss in GDP growth. For the other countries, these losses would be less severe but significant nonetheless.

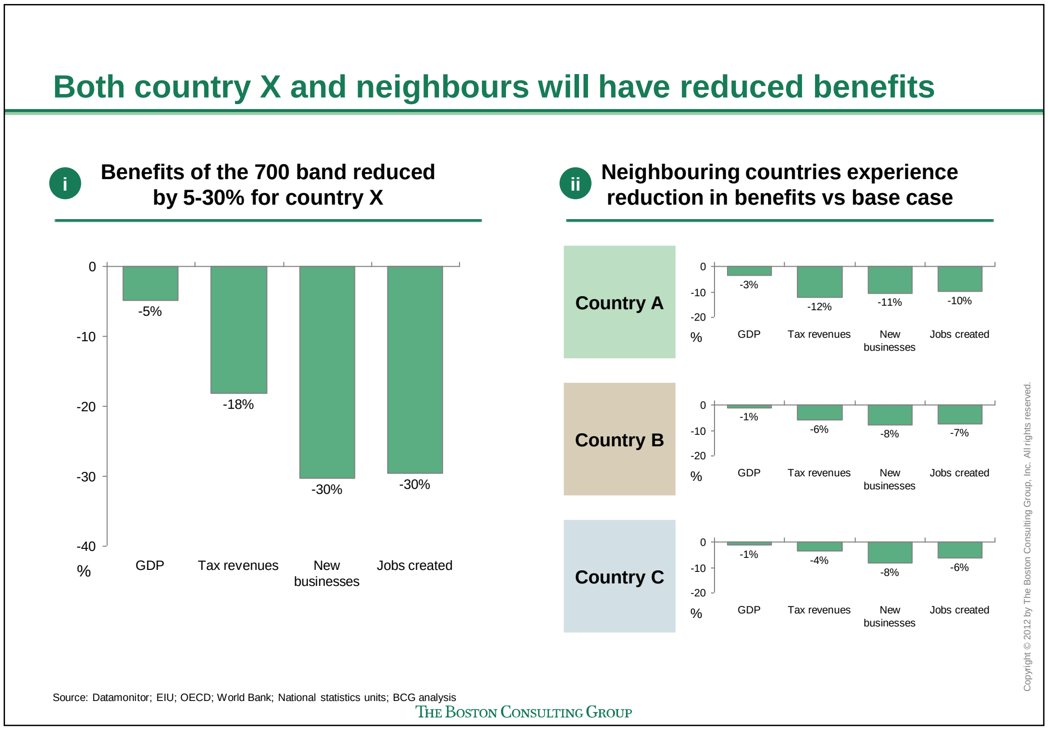


Exhibit 4.2 Impact on country X and neighbouring countries

Case study: Finland and Russia
Mitigating cross-border interference for those living near the border

To prevent cross-border interference with the Russian air navigation services (ARNS) and TV broadcasting, Finnish authorities agreed to limit the construction of the LTE-networks in the range of 800 MHz in the border area with Russia.

The agreement sets out overall limits of the LTE rollout density to approximately 100km from the Russian-Finnish border. It also imposes limits on the location of LTE base stations in different areas along the border, depending on the type of potential interference (12-20km from the borderline for mobile communications; 75km if there could be interference with television; and 100km if there could be possible interference with radio navigation).

The neutral zone covers almost one-third of Finland, with such concessions to Russia causing disagreement among the public, which has experienced reduced quality of service as a result. However, the interference mitigation is only temporary as Russia plans to allocate the 800 MHz band to LTE services from next year (with 2-5 years required to allocate the full spectrum band to LTE services).

5 Recommendations for implementation

Based on observations from countries that are in the process of implementing LTE technology, or that have already completed it, releasing the digital dividend, we have identified three steps – assess and consult, select, implement—that are essential to ensuring a smooth switchover and reaping the full benefit of the digital surplus.

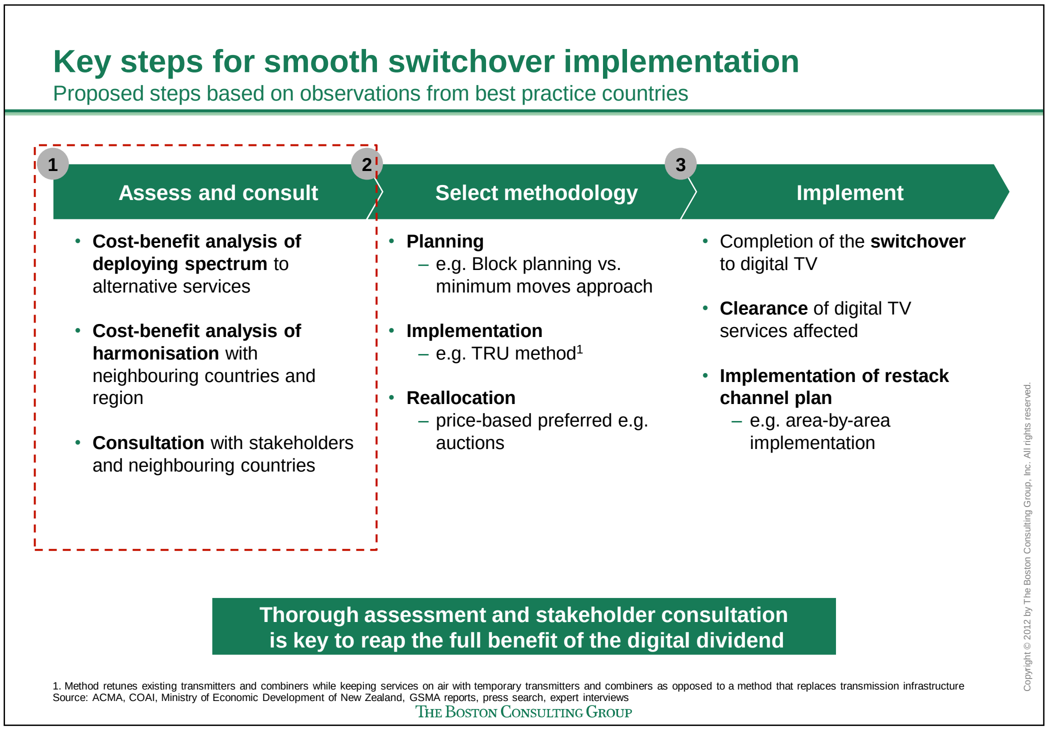


Exhibit 5.1 Key steps for mobile spectrum implementation

Assess and consult: in this process, countries need to assess the alternative uses of the digital dividend through cost-benefit analysis, including potential benefits of harmonising spectrum allocation and technology with neighbouring countries, and with the region as a whole. Countries should consult both internal and external stakeholders to ensure a transparent process and to increase the likelihood of a harmonised band plan.

Select: in the planning stage, countries need to select an appropriate approach to execute the switchover. Similarly, when it comes to implementation, they might choose the TRU method (which retunes existing transmitters and combiners while keeping services on air with temporary transmitters and combiners) as opposed to replacing the whole transmission infrastructure. Finally, they need to choose a method by which to reallocate the spectrum, for example, on a price basis, through auctions.

Implement: countries then need to complete the switchover to digital television, clearing digital TV services that will be affected and carrying out the transition in a smooth way that minimises costs and disruptions.

To maximise the benefits of the digital dividend the most critical is to choose the band plan that yields the largest estimated benefit, and to ensure harmonisation of spectrum allocation with neighbouring countries through dialogue and coordination. Failure to assess and consult might lead to suboptimal band plans reducing benefits for both own as well as neighbouring countries, or may even need to subsequently incur the cost of redeploying spectrum in order to harmonise with other systems.

5.1 Assessment and consultation:

5.1.1 The benefits of engaging

Australia and New Zealand were early adopters of the APT band plan. While, due to location, neither country faces interference issues, both see mobile internet as the best allocation choice, providing the potential to reach remote rural populations. Both countries have also seen harmonisation as important, particularly in the ability to reduce the cost of infrastructure and equipment, and to avoid being isolated. Throughout this process, both countries have emphasised rigorous cost-benefit assessments of alternative spectrum allocations and entered into extensive consultation dialogue with local and international stakeholders.

Case studies: Australia and New Zealand

For Australia—which will complete its analogue switchover by end of 2013—one of the drivers of the decision to choose mobile spectrum allocation was the ability to achieve coverage for its large rural population and penetrate buildings more effectively than with the higher frequency band. The economic benefits of the 700 MHz band allocation was estimated to be between US$7 billion and US$10 billion. The APT band plan and its potential for large-scale adoption also offered Australia the opportunity to drive economies of scale in the development of mobile infrastructure, equipment and handsets.

At every stage of the selection and implementation process, Australia kept its progress open, with a focus on regular consultation and transparency – including the publication in 2010 of a consultation paper on the digital dividend as well as the gathering of responses and recommendations from various stakeholders, such as the GSMA.

In the case of New Zealand – where spectrum is scheduled to be freed up by December 2013 – mobile spectrum allocation was seen as the best way to maximise the potential of the digital dividend, with analysis revealing that the economic benefit of APT harmonisation would be between US$1.1 billion and $2.4 billion in present value. As in Australia, the lower frequency band was ideal for New Zealand's rural coverage, as well as minimising "black spots" in its current urban coverage. New Zealand, with its 4.3 million inhabitants, also recognised the risk of isolation if it adopted a non-harmonised solution, including the limits this would place on the equipment market, which would remain small with no economies of scale.

New Zealand also engaged in open consultation, launching a discussion paper on the digital dividend in August 2011, followed by public workshops.

5.1.2 The cost of not engaging

For some countries that are in the process of reallocating the digital dividend spectrum, failure to assess different alternatives and consult with key stakeholders ahead of implementation have proven costly. Spain and the UK were early movers in terms of digitising their broadcast signals in order to free up the 800 MHz band digital dividend. But due to lack of coordination and assessment of different spectrum allocations, including benefits of regional harmonisation, both needed to redeploy to harmonise with rest of Europe. In both cases, the benefit of harmonisation clearly outweighed the cost of redeployment. However, the redeployment process has not only proven costly, but has also considerably delayed the implementation process.

Case studies: the UK and Spain

In 2003, the UK ran its own process of allocating some of the digital dividend to mobile services. It selected channels 63 to 68 for mobile services, with studies that showed economic benefit of between £15 billion and £20 billion could be realised. In 2007, the UK initiated DTT rollout in parts of the 800 MHz band.

At the 2007 World Radio Communication conference (WRC-07) however, European countries were broadly aligned in deciding to allocate the full 800 MHz band to mobile services. Channels 61 to 69 were planned for mobile services.

The country therefore needed to redeploy spectrum in order to harmonise with European allocations, requiring additional investment. This included £115-250 million on redeploying channel 61 and 62 to facilitate harmonisation. The UK spent a further £100 million on interference mitigating measures such as deployment of filters in households and at mobile base stations, reorientation of aerials and migration of users from DTT to alternative platforms such as satellite and cable.

The UK estimated an additional incremental value of £2-£3 billion of the redeployment. However, the lack of initial assessment, consultation and co-ordination meant that the UK went from being a first mover to a latecomer, and had to bear additional, avoidable costs.

In 2005, Spain (along with Portugal) announced its allocation plan, stating that the 800 MHz band would be allocated to additional broadcast channels. At the end of the year, it announced the allocation of channels and its switchover schedule, which was due to start in 2009. The country started licensing out the 800 MHz band to broadcasters.

Like the UK, Spain also needed to redeploy spectrum to harmonise with European allocations after rest of Europe and WRC decided to allocate the whole 800 MHz band to mobile services because of the greater estimated benefit of mobile services relative to broadcasting services.

This required Spain to commit to new investment. However, in response to recommendations from the European Commission, policymakers deemed the investment worthwhile because of the economic benefits that would accrue to the country as a result of mobile allocation.

However, the process was criticised for its lack of assessment and consultation. No formal cost-benefit analysis was conducted before the allocation of services and the agreement for mobile usage was reached only four days before the analogue switch-off was completed. Meanwhile, the European Commission is currently investigating a Spanish plan that compensates DTT broadcasters for the extra cost of parallel broadcasting.

APPENDIX - METHODOLOGY

The core methodology for estimating the socioeconomic impact of broadband penetration comprises four key components, as depicted below in Exhibit A.1.

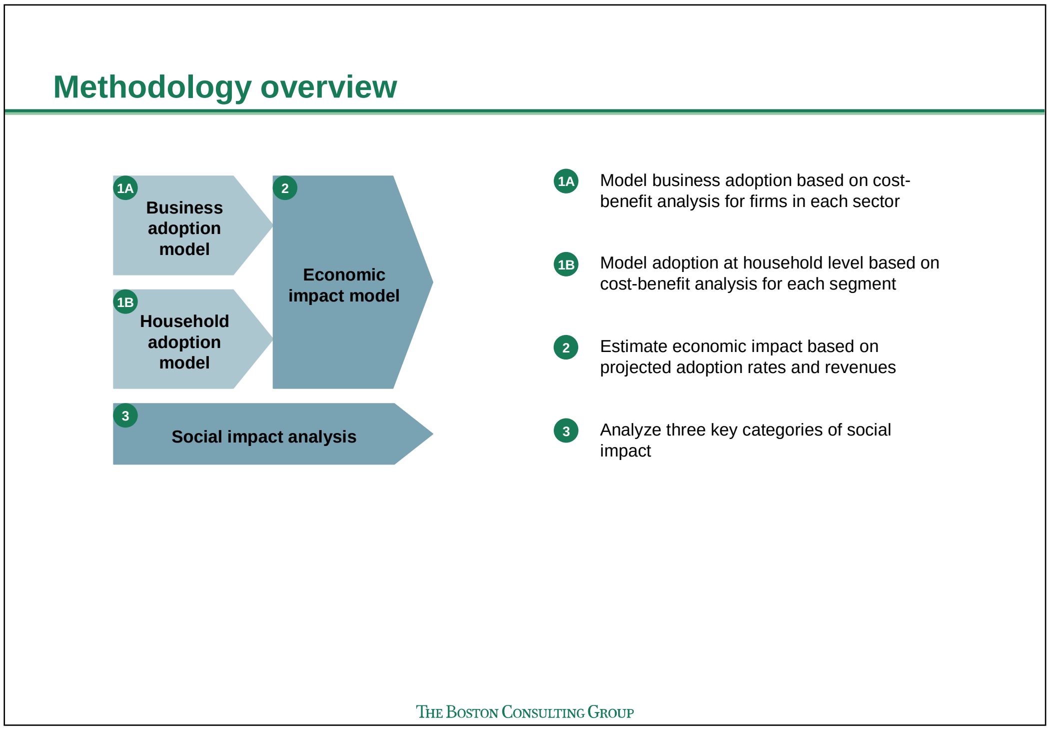


Exhibit A.1 Methodology overview

The general approach to modeling adoption is to do a bottom-up cost-benefit analysis to estimate of the number of subscribers in each segment for each year. Adoption is modeled separately for businesses and households. The methodology for business adoption, household adoption and economic impact are described in more detail below, as outlined in Exhibit A.2

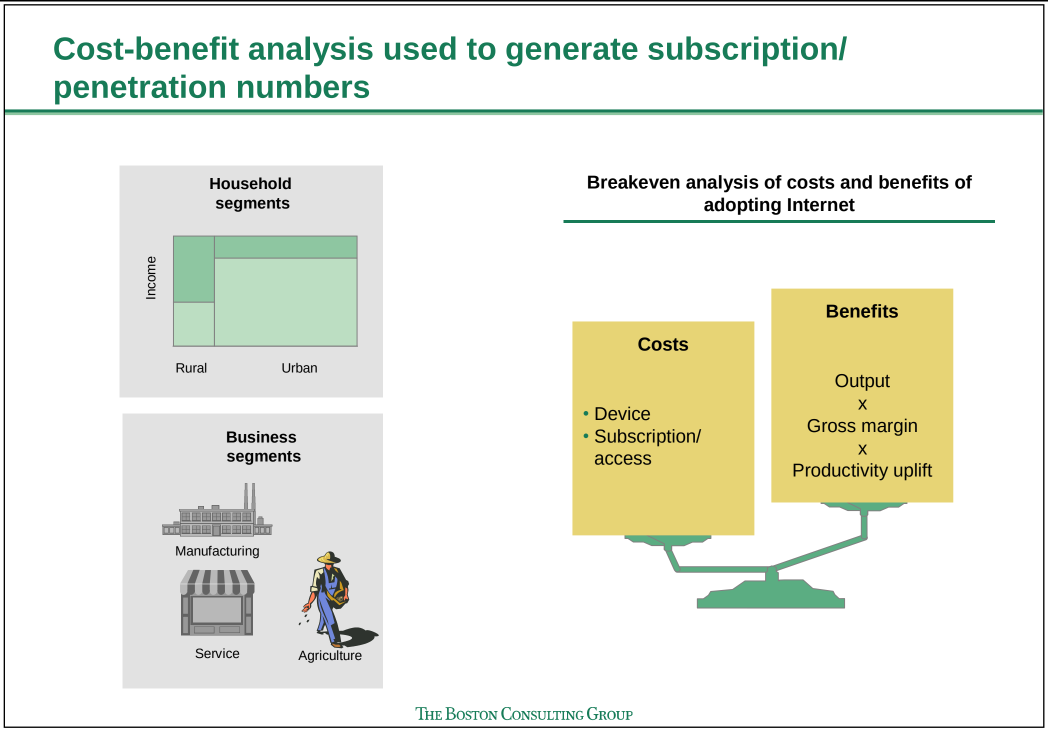


Exhibit A.2 Cost-benefit analysis

In addition, three extensions to the core model will be discussed:

- Impact of assigning the 700 MHz band to mobile broadband mobile and the consequences of non-harmonization of the 700 MHz band
- Impact of assigning the 700 MHz band to digital broadcasting (an alternative use)
- Extrapolation of results from study countries to the Asia-Pacific region

A.1.A Business adoption model

Estimating business adoption involves three steps:

- Segmentation of firms by size and industry
- Defining the addressable market
- Estimating adoption based on a cost-benefit analysis.

Segmentation Business adoption analysis begins by segmenting firms into agriculture, services and manufacturing sectors as each have distinct drivers of benefit from broadband adoption. Firms in each sector are further divided into large and small firms based on number of employees, as firm size is observed to drive penetration as well as the type of package required.

Defining addressable market In some markets, some businesses are not computer-capable, and these have been excluded from the addressable market. This is done based on data from the local statistical office.

Estimating adoption Adoption is estimated by analyzing the costs and benefits of Internet adoption for firms within each segment. Firms will adopt if the increased gross profit from Internet usage exceed the total costs of ownership.

The primary driver of benefit is the increased productivity that accrues to the firm because of the Internet. Productivity in this case is defined as gross value added per worker, or in accounting terms, gross profit per employee. We have leveraged existing research to estimate the productivity impact of the Internet on industry, both services and manufacturing, and, in line with those studies, have assumed an increase in labour productivity of up to 10% for services, and 5% for manufacturing.

Within that range, the exact benefit depends on e-business intensity, that is, the extent to which the Internet is integrated into processes within the company. For example, a firm could initially use the Internet for internal emails, then for third party services such as e-banking or e-government, all the way up to a website with an online store. The model assumes that productivity increases linearly as e-business intensity increases, reaching 10% in service and 5% in manufacturing when intensity reaches 100%.

We have cross-referenced a number of studies to estimate the starting level and rate of change of e-business intensity in the study countries.

Starting e-business intensity An EU study from 2008 measured the level of e-business intensity in European countries in 2006, providing a benchmark for determining productivity uplift. To extend this measure to the study countries, which were not covered in the original EU report, an independent e-business adoption measure (the

Economist Intelligence Unit e-Readiness ranking), which did cover both Europe and the Asia-Pacific, was used. A relation between the two measures was found through linear regression, yielding e-business intensities for the study countries in the year 2006.

Rate of change of e-business intensity The EU report found that countries differed in growth rate of e-business intensity depending on their categories (such as “large industrial countries” or “less developed knowledge societies”). The study countries were assigned to these categories, and their associated growth rates, based on measures such as their demographic and economic structures.

We have assumed that these growth rates will remain linear over the timeframe of the study. It is possible that in reality, intensity growth will accelerate due to increasing network externalities as more companies in the economy adopt the Internet. However, we have chosen not to make additional assumptions around the rate of change in intensity, and prefer linear growth rates as they are more conservative.

From these e-business intensities, we derived the projected productivity increases for the study countries as shown in Exhibit A.3.

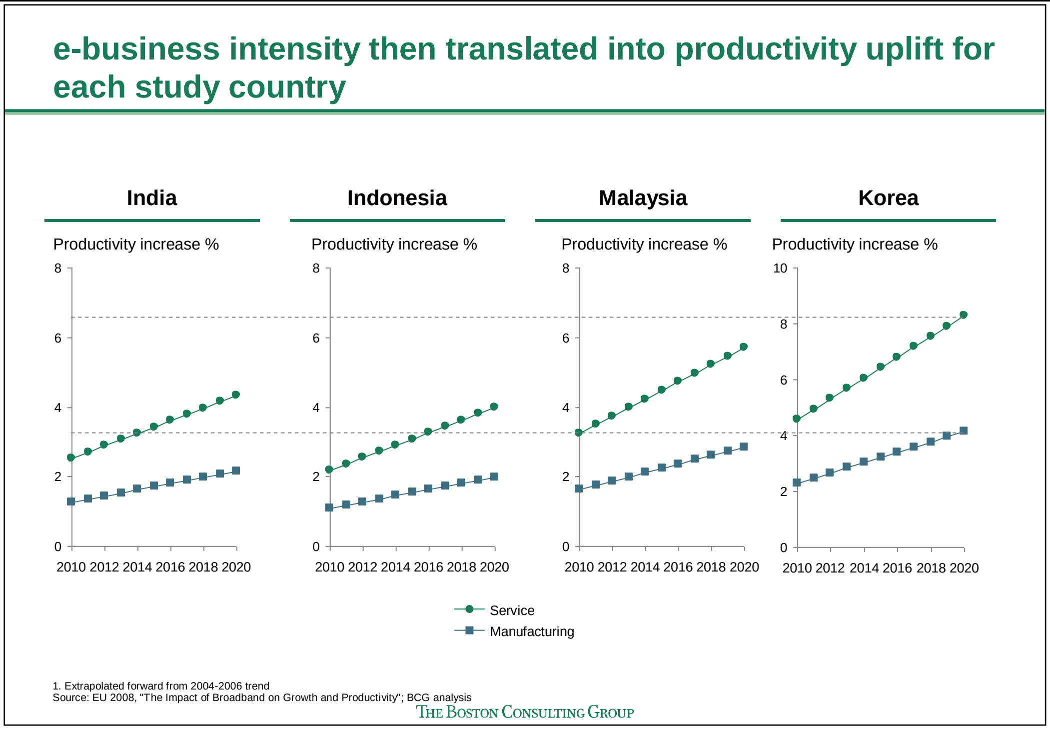


Exhibit A.3 Productivity impact

Agriculture The productivity uplift accruing to agriculture from ICT has been more difficult to estimate, with anecdotal reports varying widely in estimated impact. For example, in Senegal, the Internet was reported to have helped farmers to make better decisions about the choice of priority crops, optimal use of fertilizers and product diversification, leading to a productivity increase of 5%. In contrast, the Bangladeshi "e-krishak" scheme was reported to have increased yields by 65% for some farmers by providing online information solutions. To be conservative, BCG has assumed a 5% productivity uplift for small agricultural companies as a result of Internet adoption.

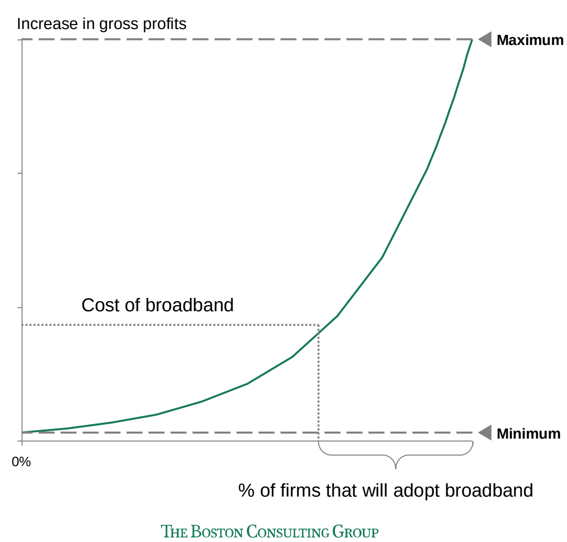
For large commercial farms, the value added from these holdings is assumed to be 20% of the manufacturing gain for that country at that time. This is based on relative benchmarks[3], and fits well with expected outcomes. The majority of the increase in value added in family farms is attributable to moving them towards the efficient

[3] *See ICT and productivity – an economic analysis of Australian industry* (Department of Broadband, Communications and Digital Economy, Australia) 2008

production frontier, through better information on seed varieties, planting times, fertilizer, disease treatment, as well as through better prices. Large farms should already have access to these, and be operating close to the efficient frontier, benefiting from their larger scale. Therefore, it should not be surprising that the benefit of Internet adoption is relatively low for such farms.

To estimate the breakeven percentile for adoption, we need to estimate the costs as well as the benefits. We determine the cost by defining the type of package that firms in each segment (large vs small firms) are likely to adopt, and estimate the price of such packages at each point in time. We then estimate the distribution of firm revenues within each segment, starting from the lowest. The applicable productivity increase is multiplied against the estimated revenues of the firms within each segment[4] for each year to derive the benefit of Internet adoption. The lowest level of firm revenues for which the benefits equal the cost is the breakeven percentile, and all firms with revenues above that are assumed to adopt. This process is illustrated in Exhibit A.4.

Graphical illustration for adoption by firms



[4] Revenues of firms within each segment are assumed to be distributed exponentially, with a small number of high revenue firms and a large tail of low revenue firms. This assumption is supported by the available data

Exhibit A.4 Adoption by firms

Additional assumptions

Device costs have been excluded from the total cost of ownership for large firms, which typically already have a 100% computer penetration rates in the study countries.

The number of firms and the revenue of firms are assumed to each constitute 50% of real GDP growth. From a value added perspective, GDP is equal to the sum of value add for all firms, and hence, in aggregate, the number of firms and their revenue should track real GDP over time.

A.1.B Household adoption

The methodology for household adoption is broadly similar to business adoption.

Defining addressable market Households which are below the poverty line, or whose communities do not have adequate physical infrastructure for Internet access, are excluded from the addressable market.

Segmentation Households are segmented according to location and income. Consumer research suggests that location (urban vs rural) is a primary driver of likely adoption behavior as IT literacy, availability of services and awareness are driven by the rural/urban environment. For each location, the population is divided into "high" and "low" income based on their potential to be early adopters. A household is defined as "high" income if its expenditure on communications/IT, as reported in the local household expenditure survey, is higher than the average for that population.

Estimating adoption Adoption is estimated by analyzing the costs and benefits of Internet adoption for households within each segment. Households for whom the benefits from Internet usage exceed the total costs of ownership are assumed to adopt.

Estimation of benefits for households
Benefits for households are divided into two categories: "Needs", which are expressed as a percentage of household income, and "wants", which have a fixed dollar value for each segment.

"Needs" comprise the following

- Productivity gains from household businesses, calculated by multiplying the applicable productivity gain for the country against the proportion of household income derived from entrepreneurship and self-employment
- Productivity gains from agriculture. Studies suggest that households can increase their income by ~15% from better information and better prices, and

this is multiplied against the proportion of income from agriculture for rural households

- Cost savings from online procurement/shopping are estimated based on an analysis of household expenditure. Elements of expenditure which could be spent online are identified, and multiplied against the possible savings based on available benchmarks.
- Time savings for urban segments are also factored in. Time savings can be generated through email access on-the-go, search functions to locate destinations, etc. Studies support the view that leisure time is valued at more than or equal to the hourly wage rate, and this 'perceived' value of time is included in the needs estimate

"Wants" benefits capture the perceived benefits of Internet use, e.g.,

- Information search, e.g., news, websites of interest
- Entertainment, e.g., games, sports scores
- Social networking, e.g., instant messaging, online communities
- "Sophistication", keeping up with global trends

Recognizing that these elements are inherently difficult to quantify, the approach taken in this report is to express consumer's willingness to pay as a multiple of Average Revenue Per User (ARPU) for mobile voice. The argument is that mobile voice can provide many similar functions, and provides us with a starting point for estimating what consumers *might* be willing to pay. Each consumer segment is assessed based on the value they are likely to place on each of the elements. In general, urban high income segments are assumed to have the highest want benefits, and rural low income segments the lowest. The "wants" estimates are also cross-checked against expenditure on relevant categories (e.g., entertainment and recreation) as a further sanity check.

Estimation of costs for households

The total cost of ownership for households comprises the cost of access device and the cost of subscription.

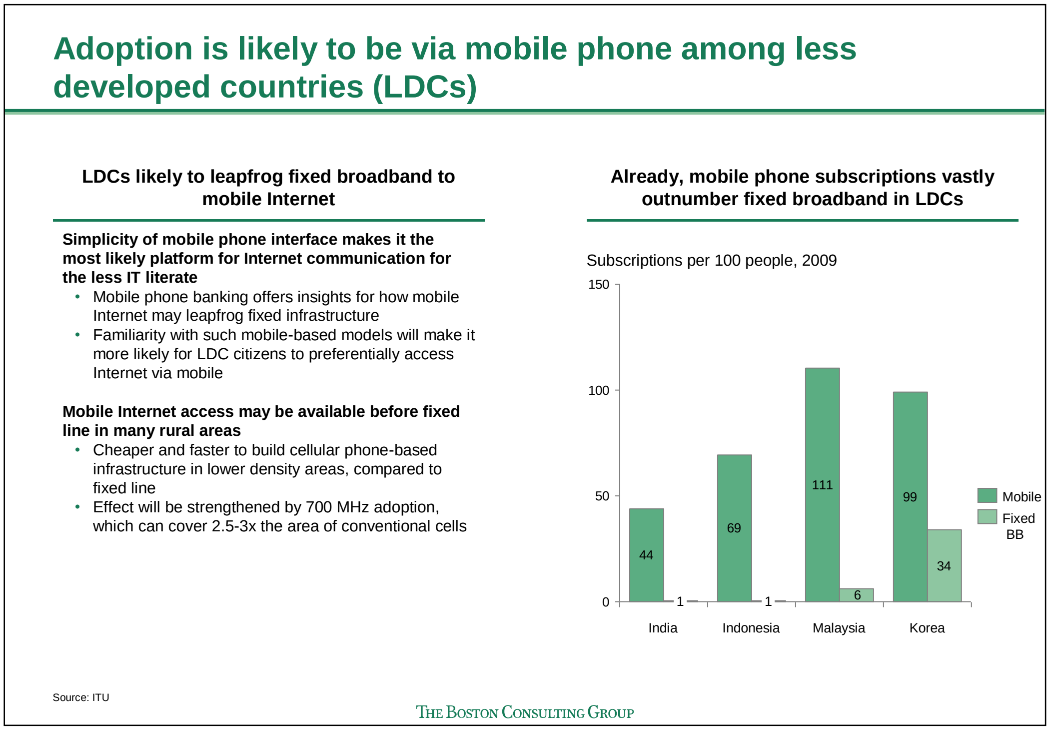


Exhibit A.5 Adoption platform for study countries

Choice of access platform varied between countries. In countries such as India or Indonesia, where fixed broadband penetration was <1% but mobile penetration was high and still rapidly growing, phones with basic Internet connections were assumed to be the primary device for potential Internet connections (see Exhibit A.5). In contrast, Korea and Malaysia have higher PC and fixed broadband penetrations. Thus, in these countries, the PC was assumed to be the primary access device for high income households.

Subscription and device costs were then estimated for these assumed access platforms, based on market data and expert interviews. The costs were typically of the lowest category of device and subscription that could fulfil the associated “needs” and “wants” benefits. Projections were also made on the rate of decline in costs over time, in line with experiences in developed countries.

Estimation of adoption

With the above information, the breakeven percentile for household adoption can now be calculated. The distribution of households by income can be estimated from data from the national statistics offices[5]. The breakeven percentile is defined as the percentile for which the total benefits ("needs" as % of income, plus "wants") equals the total cost of ownership. Households at or above that level of income are assumed to adopt.

Additional subscriptions within the household

The possibility that households could adopt more than one connection is also addressed within the model. This could represent a family supplementing the main fixed household connection with a Blackberry subscription for the businessman father, or perhaps a mobile broadband subscription for an undergraduate child. Households are assumed to adopt subsequent subscriptions if the total "need" and "want" benefit is sufficient to cover the total cost of ownership (service and device) of multiple subscriptions. To be conservative, no incremental benefit has been assumed from the fact that the subsequent subscription is mobile. The number of subscriptions has also been capped to 3 subscriptions for urban high-income households, to reflect the average household size in these segments.

A.2 Economic impact model

The economic impact model uses the Internet adoption figures from the adoption models to calculate their effect on 5 key economic parameters: productivity improvement, new business activity, jobs created, GDP impact and tax revenues. These are accounted for with respect to the telco supply chain, as well as the economy at large. The productivity impact and new business activity parameters , in particular, are more applicable to the general economy than to the telco industry specifically.

[5] . This is typically reported in deciles, but was converted into percentiles through interpolation

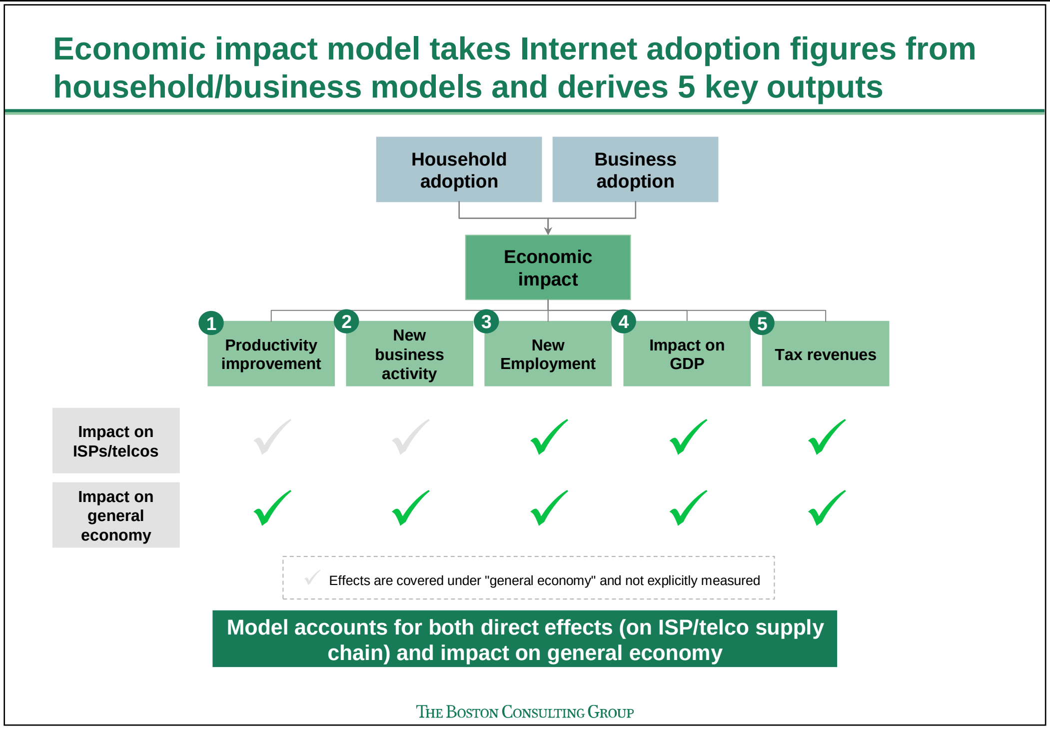


Exhibit A.6 Parameters of economic impact model

Productivity impact

We have already argued that Internet adoption will improve the productivity (gross value added per employee, or gross profit per employee) of firms that integrate it into their operations. Exhibit A.7 shows how productivity gains at the individual firm level are ultimately translated into GDP impact at the economy level. This is done by multiplying the productivity gain at the firm level by the Internet adoption rate and the total GDP contribution for each of the 6 segments in the business adoption model. The productivity impact by sector is then summed to arrive at an economy-wide productivity uplift figure.

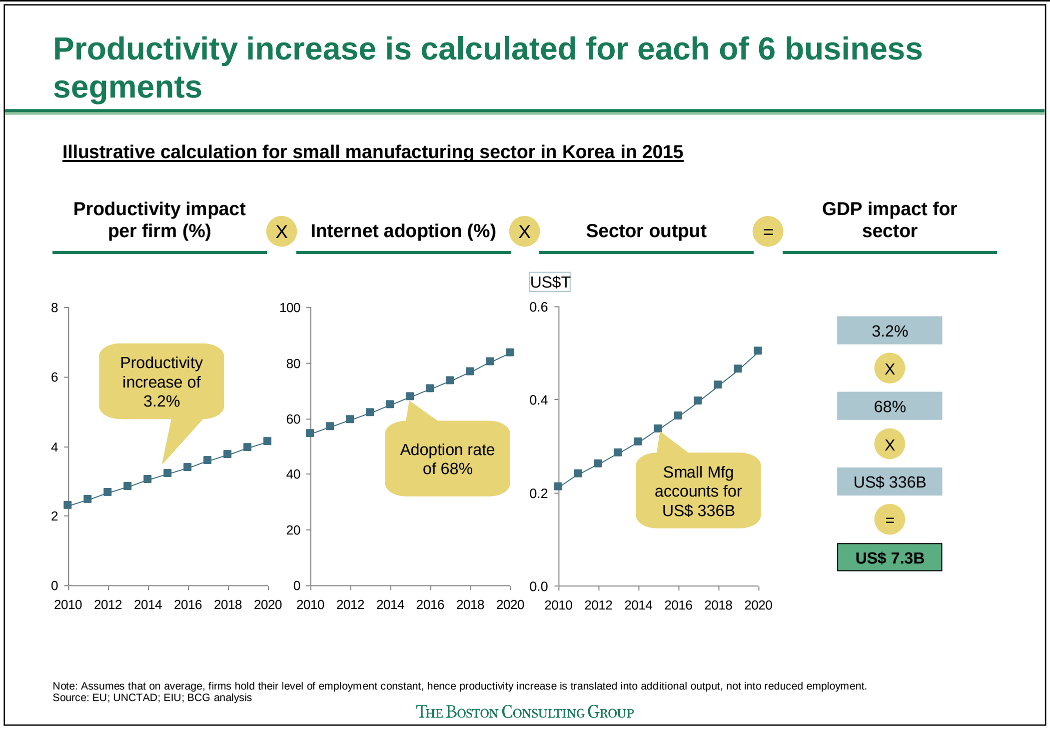


Exhibit A.7 Productivity impact calculations

New business activity

The Internet creates multiple opportunities for entrepreneurs to exploit. These include, but are not limited to:

- Businesses based on offering Internet access and its benefits to first-time or low-income users, such as Internet cafes, digital studios
- Leveraging the Internet as a sales channel for goods or services
- Using the Internet as an information aggregator to bring together buyers and sellers, such as with an online auction site or job search services
- Providing services to other Internet businesses, such as website design, e-commerce platforms, server and storage

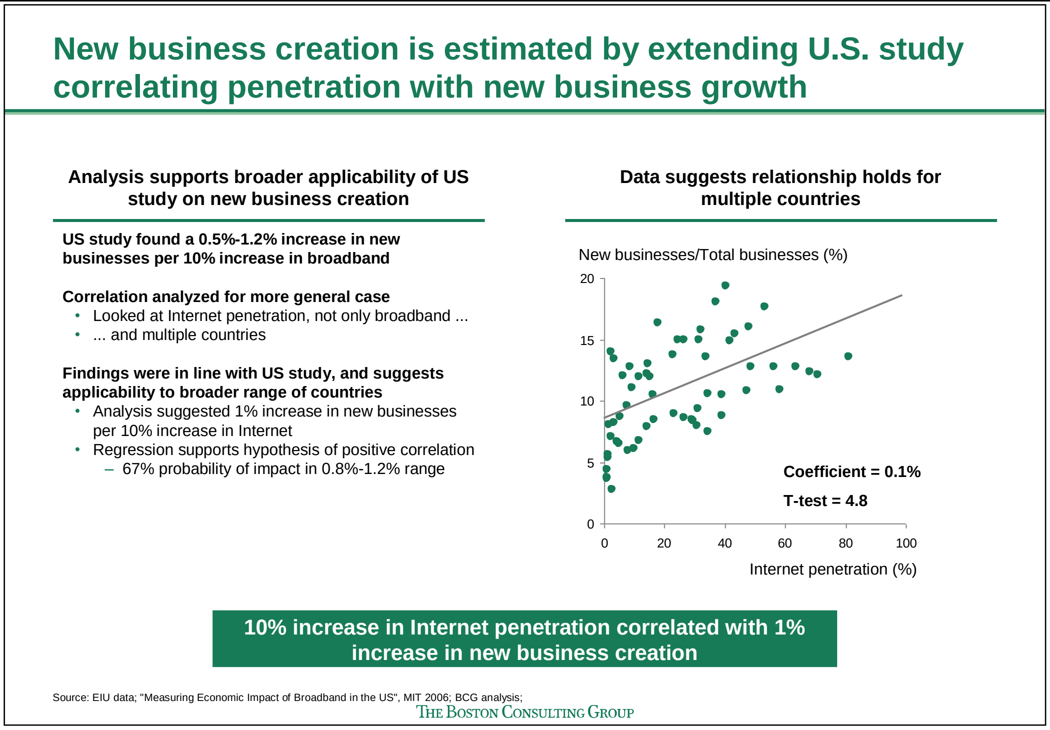


Exhibit A.8 New business creation

The study assumes that a 10 percentage point (pp) increase in overall Internet penetration will increase the rate of new business formation by 1%. This means that, if there are 1 million companies in the economy, ten thousand additional new businesses will be formed each year for every 10 pp of penetration. This relationship was reported in a study in the US, and supported by an analysis of a broader dataset of countries, as can be seen in Exhibit A.8.

These additional business activities are assumed to have the average revenues, profits and number of employees as the average small firm in the economy, thereby contributing to GDP as well as job creation.

GDP impact, employment and tax revenues

The last 3 parameters can be estimated by combining new business/productivity results with the direct impact of increased broadband adoption on the ISP supply chain.

- Incremental employment is estimated as the sum of employment resulting from additional jobs in the ISP supply chain, and new business employment. The latter is derived by multiplying new business creation with employment per new firm, from historical statistics. The former is estimated using the ISP job/profit ratio – that is, the number of employees the ISP needs to hire in order to generate $1 of value add. When multiplied by ISP broadband revenues (which is the sum of value adds across its supply chain), this ratio yields the total number of jobs created within the industry.
- GDP impact is calculated for the ISP supply chain as the sum of the following components: infrastructure spending as a result of 700 MHz band rollout; regulatory fees; additional wages paid to employees; and profits. In keeping with the principle of conservative estimation, care is taken to account for payments that may be made to foreign entities and thus have no GDP impact in the study country. Specifically, infrastructure spending and profit have been multiplied by their "% domestic share" in order to account for foreign outflows and avoid overestimating GDP impact.
- Although not a component of GDP, contribution to government revenues, in the form of taxes and regulatory fees, is an area of keen interest, and is therefore reported alongside the other economic metrics. The main components are: Value Added Taxes and corporate taxes accruing from new businesses, productivity increase as well as the ISP incremental revenues; income taxes from incremental employment; and regulatory fees and other industry-specific taxation.

A.3 Impact of the 700 MHz band and technical harmonization

Having built up a core model that translates price, income and industry data into broadband adoption and economic impact figures, we are now in a position to model the impact of the 700 MHz band by considering the different scenarios.

As statistics on Internet adoption frequently use different terms and definitions, the BCG methodology refers to Active Subscriptions, being the number of fixed and mobile Internet subscriptions actually being used, and taking part in the estimated socio-economic benefits, as shown in Exhibit A.9. For fixed line Internet, typically the number of users reported is higher than number of subscriptions, as people may use the Internet at cafés, or several share one household connection. For mobile Internet on the other hand, typically the number of subscriptions is higher than the number of actual users, as subscriptions are counted as Internet enabled devices – including dongles – in areas with 2.5G or better coverage, regardless of whether they are used.

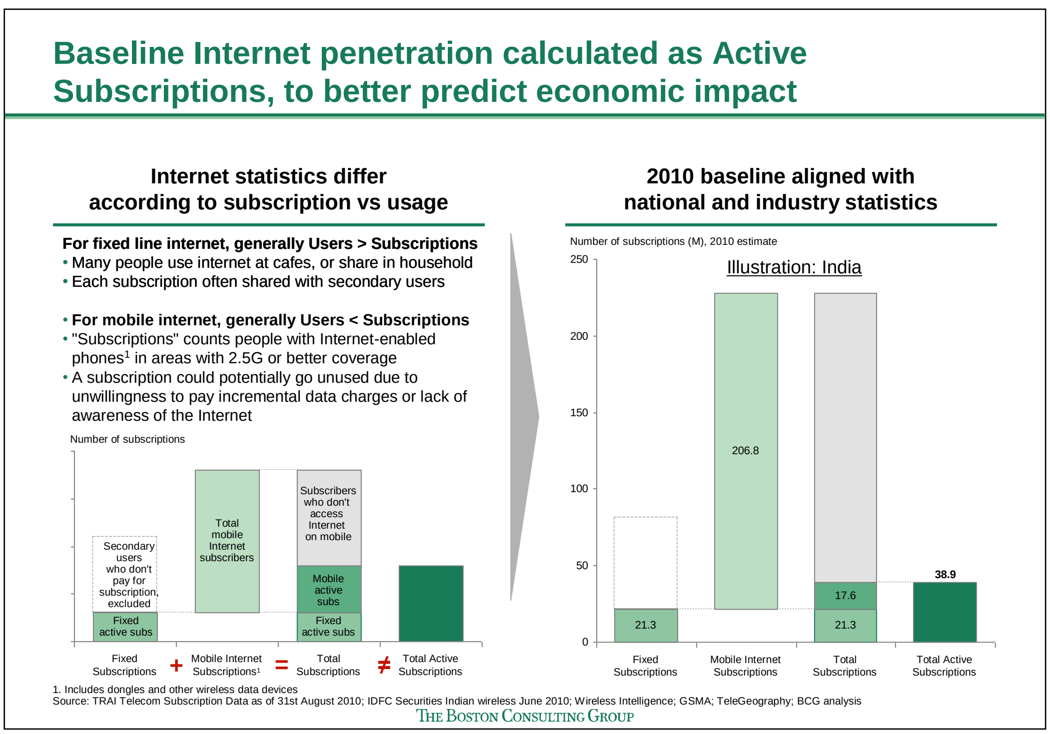


Exhibit A.9 Active Subscriptions

Scenario 1: Allocation of harmonized 700 MHz band to mobile broadband

We assume that the 700 MHz band based mobile broadband is rolled out 2014-2015, and measure the effect to 2020. The key changes in the scenario are:

- **Subscription price decrease of 6-10% to consumers as a result of service cost reduction**

  The 700 MHz band will primarily impact infrastructure roll-out costs in rural areas, as it has a much greater range than the 1800 MHz band, 2100 MHz band or 2600 MHz band based transmissions. Differences in propagation characteristics of the various frequency bands implies that utilizing the 700 MHz band in comparison will require fewer towers to serve a particular area. We assume that these savings, as a percentage of overall ISP costs, are passed on to the consumers, with the caveat that this may require a competitive telco market or government regulations on the use of the 700 MHz band to drive adoption through lower prices. With a conservative infrastructure cost reduction of 50% (dependent on network topology and degree of pre-existing infrastructure in rural areas), the most conservative estimate for savings is 6% based on BCG's benchmarks on telco cost structures, although experts believe the number could be significantly higher. Based on discussions with industry experts, a 10% cost decrease is applied for Malaysia, Indonesia and India, while 6% is applied to account for Korea's more mature network.

- **Increase in rural household benefits by 10-20%**

  This assumption accounts for the network externalities created by the projected increase in mobile broadband penetration in the rural areas. As rural penetration increases, more applications and services will be developed to service the rural areas, in turn increasing the benefit of mobile broadband subscription. Therefore, "needs" benefits are assumed to increase by 10%, and "wants" by 20%, which is typically sufficient to close the existing gap between rural and urban benefits.

- **Increase in rate of productivity growth**

  As productivity gain from Internet adoption is modeled on e-business intensity in the business adoption model, allocating the 700 MHz band to mobile broadband is expected to increase the rate of e-business intensity growth. This reflects both a network externality as more rural firms come online, and also the increasing value of the Internet to all firms as Internet penetration increases.

Additionally, to simulate the lag time required for the economy to build awareness and fully realize the potential of deploying mobile broadband in the 700 MHz band, the above assumptions are phased in over two years.

Scenario 2: Allocation of 700 MHz band to mobile broadband, but non-harmonized bandplan

- **Increase in device cost by $1.5 - $15**
  Non-harmonized bandplan forces handset manufacturers to customize handsets specifically for the non-harmonized countries. This raises the R&D and production cost of the handset, due to the need for circuit board redesign and additional RF components. A study by RTT on the cost effects of non-harmonization further argues that such a niche market would benefit less from product development efforts due to its lack of scale, leading to cost as well as value inefficiency compared to harmonized country. As shown in Exhibit A.10, this implies a per-handset price increase of US$1.5 in a market like China with 80M sold handsets per year, up to US$15 for markets with 8M handsets.

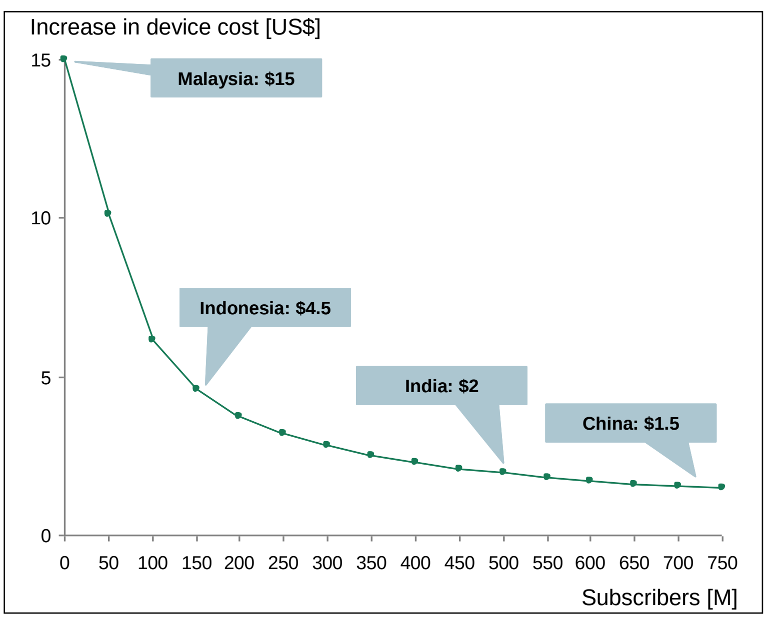


Exhibit A.10 Device cost increase due to non-harmonization

A.4 Impact of allocating 700 MHz band to broadcasting

As digital broadcasting has been identified as the most likely alternative use for the 700 MHz band, it is necessary to compare the effect of allocating the band to Digital Terrestrial Television (DTT) rather than to mobile broadband. These effects are calculated by considering the effects of incremental DTT channels on GDP impact, new jobs, new businesses and taxes – thus allowing comparability with the core model.

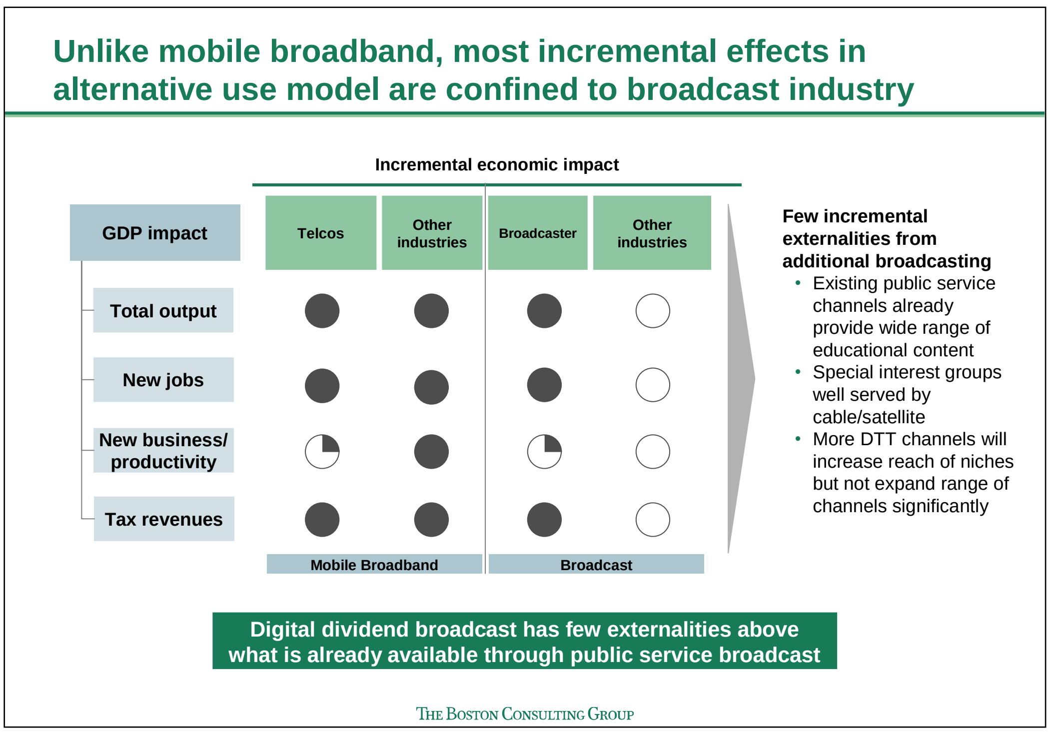


Exhibit A.11 Economic impact of broadcast vs. broadband

However, unlike mobile broadband, 700 MHz band based broadcast is not likely to have many incremental externalities on the general economy (see Exhibit A.11). While it is true that broadcast plays a crucial role in disseminating of social messages and educational material, most of these externalities can be captured by existing public service TV channels. Special interest groups are also well served by cable, satellite or IPTV in most markets, especially since the number of channels can be increased from the current baseline even without the 108 MHz bandwidth of the 700 MHz band being allocated to broadcasting. Therefore, the broadcast model focuses on the economic effects of the broadcast industry rather than the general economy.

Estimation of socioeconomic impact of incremental DTT channels

The broadcast model estimates the number of additional DTT channels that 700 MHz band can hold, and combines that with per-channel revenue and employment in order to arrive at GDP output and job creation. Government taxes are then derived from these figures.

The key assumptions in the broadcast model were:

- **Incremental number of TV channels**
  We assumed that the maximum technically feasible number of TV channels will be added to the study countries' broadcast offerings. This was determined by estimating the number of multiplexes that could fit in the 698-806 MHz band, and assuming 10 digital TV channels to each multiplex. The 10:1 compression is based on DVB-T/MPEG4 standards, which is optimistic as the MPEG2 to MPEG4 upgrade has not been applied yet in most countries. DVB-T2 compression, which further offers 30-50% spectrum savings, was not assumed as it has been used in most countries to implement High Definition TV, which would not result in more TV channels overall.

- **Revenue per incremental TV channel**
  Additional TV channels create incremental value add across the broadcast supply chain, from production houses to content aggregation and distribution. To measure this incremental effect, we consider the additional revenue earned by broadcasters as a result of the additional TV channels, which is the sum of these value add components. In theory, the revenue of each marginal TV channel should be approximately equal to the lowest-revenue TV channel in each study country, since a popular TV channel would tend to replace less popular offerings. However, in the interest of conservativeness, BCG has estimated incremental TV

channel revenue as the average TV channel revenue within the broadcast industry.

- **Employment per incremental TV channel**
  From interviews with experts in the broadcast industry, BCG estimates that each additional syndicated TV channel creates only a small number of jobs since they only need to package and distribute local content, while TV channels which produce content will have more employees. The TV channel mix was assumed to be 50-75% local, depending on the nature of the film and broadcast industry in each industry. Channels subsidized with public funds were excluded from the analysis because they utilize government funds which could have been used in other job creation/economic stimulus measures.

In general, the broadcast model was calculated based on best-case estimates in order to deliberately overstate the effect of allocating 700 MHz band to broadcast. However, evidence from countries that have made the DTT transition suggests that incremental revenues and number of TV channels may be lower than expected due to issues of commercial (rather than technical) feasibility. In Exhibit A.12, the average number of digital terrestrial TV channels in Europe is 32, compared to the 25-35 incremental TV channels used in the broadcast model. Also, in a market with hundreds of TV channels, each incremental TV channel is unlikely to gain significant market share without cannibalizing existing TV offerings, reducing the overall value add to the industry. Therefore, the total economic impact of allocating 700 MHz band to broadcast is likely to be lower than the results reported in this study.

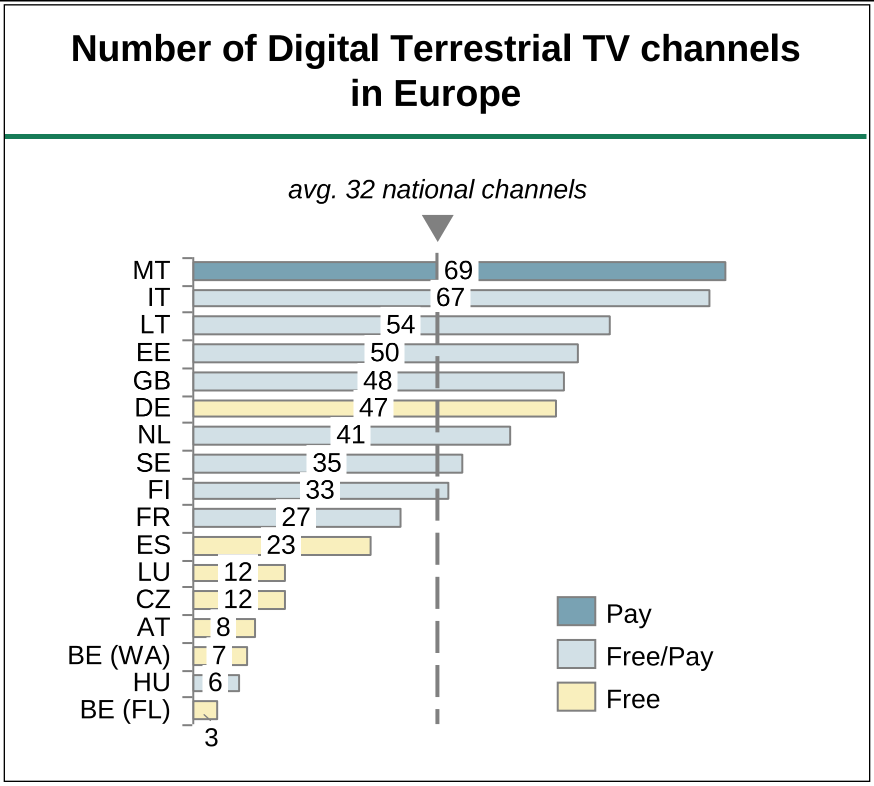


Exhibit A.12 Number of DTT channels in Europe

A.5 Extrapolation methodology

Having compared various scenarios for the study countries (mobile broadband, non-harmonization, broadcast), we can now generalize the results to the region. In order to estimate the economic impact across Asia Pacific, the region[6] is divided into three clusters based on three key benefit drivers; UN's Human Development Index (HDI), level of urbanization and current mobile penetration. GDP per capita is also used as an underlying driver for extrapolation.

Given that the benefits of the 700 MHz based mobile broadband will be primarily rural, countries with lower levels of urbanization would expect to see greater uplift in overall adoption, all things being equal. Mobile penetration is used as a proxy of the technological and Internet sophistication in the country, and countries with lower penetrations would expect to see a bigger impact from the lower cost of infrastructure

[6] Due to lack of reliable public data, the countries of Kiribati, Marshall Islands, Micronesia, Tuvalu and North Korea are omitted from this study

rollout and ability to target current non-adopters. Finally, countries with lower levels of overall human development would also expect to see a bigger social benefit as mobile broadband solutions can be tailored to address their most pressing needs.

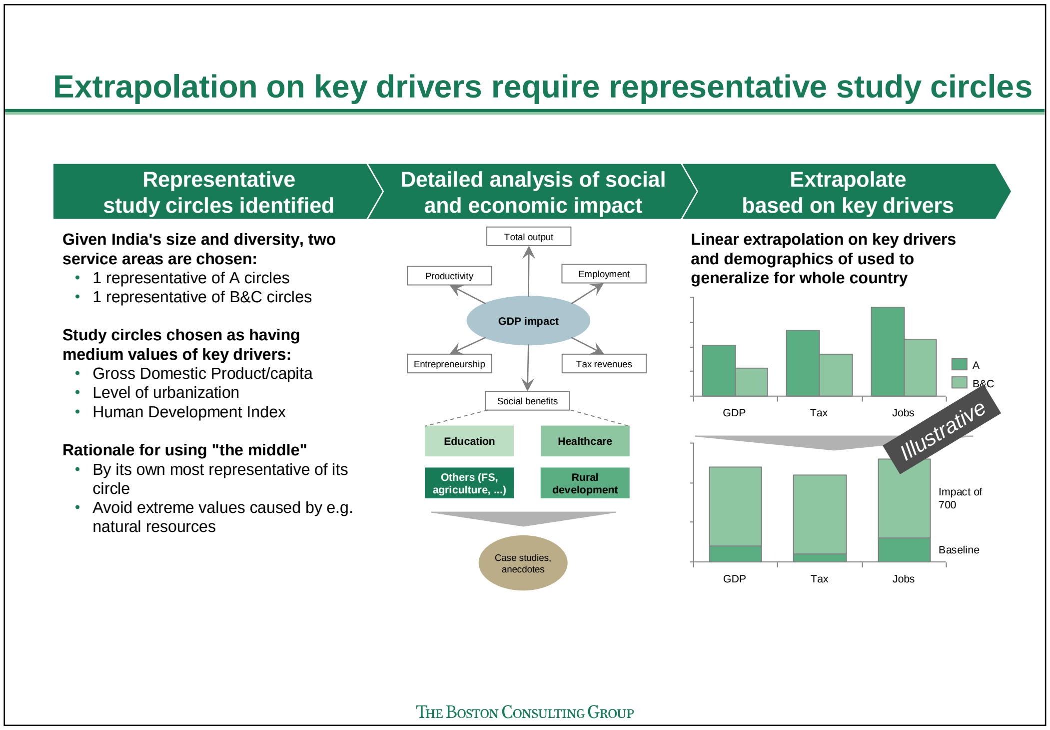


Exhibit A.13 Extrapolation methodology

Cluster A – study country Korea

Consists of countries high on HDI and level of urbanization; Australia, Brunei, Japan, New Zealand and Singapore. These have all currently more than 90 mobile subscriptions per 100 inhabitants, HDI above 0.9 and fairly high level of urbanization, with the exception of Japan at 66 per cent urban population.

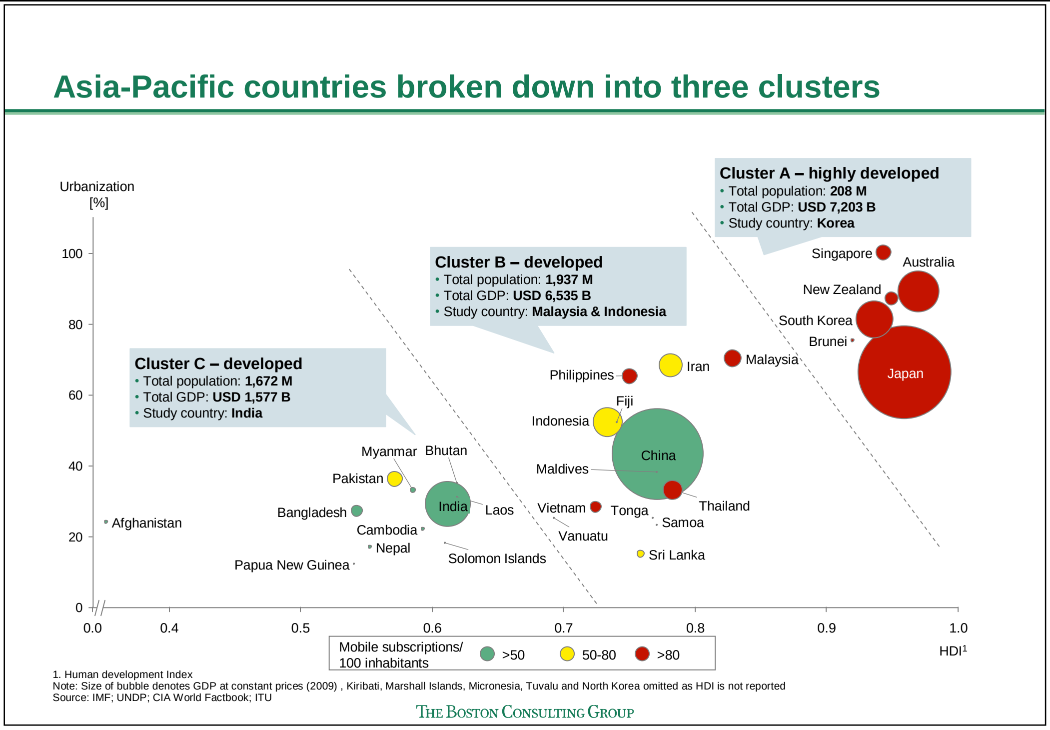


Exhibit A.14 Clustering of Asia-Pacific countries

Cluster B – study countries Malaysia and Indonesia

Two study countries are chosen in order to represent the diversity of this cluster, with HDI varying from 0.73 (Vietnam) to 0.83 (Malaysia), 56 to 148 mobile subscriptions per 100 inhabitants (China and Maldives, respectively) and level of urbanization from 15 per cent (Sri Lanka) to 68 per cent (Iran). The cluster consists of China, Fiji, Indonesia, Iran, Malaysia, Maldives, Philippines, Samoa, Sri Lanka, Thailand and Tonga.

Cluster C – study country India

Being the largest market among the least developed countries in Asia Pacific, India itself is modeled through deep-dives into two states representing the regulatory authorities “Metro & A” and “B&C” circles, namely Maharashtra and Rajasthan, respectively. The study circles are themselves selected to be representative of the other states/regions in the same circle classification, based on HDI and urbanization, as shown in Exhibit A.13.

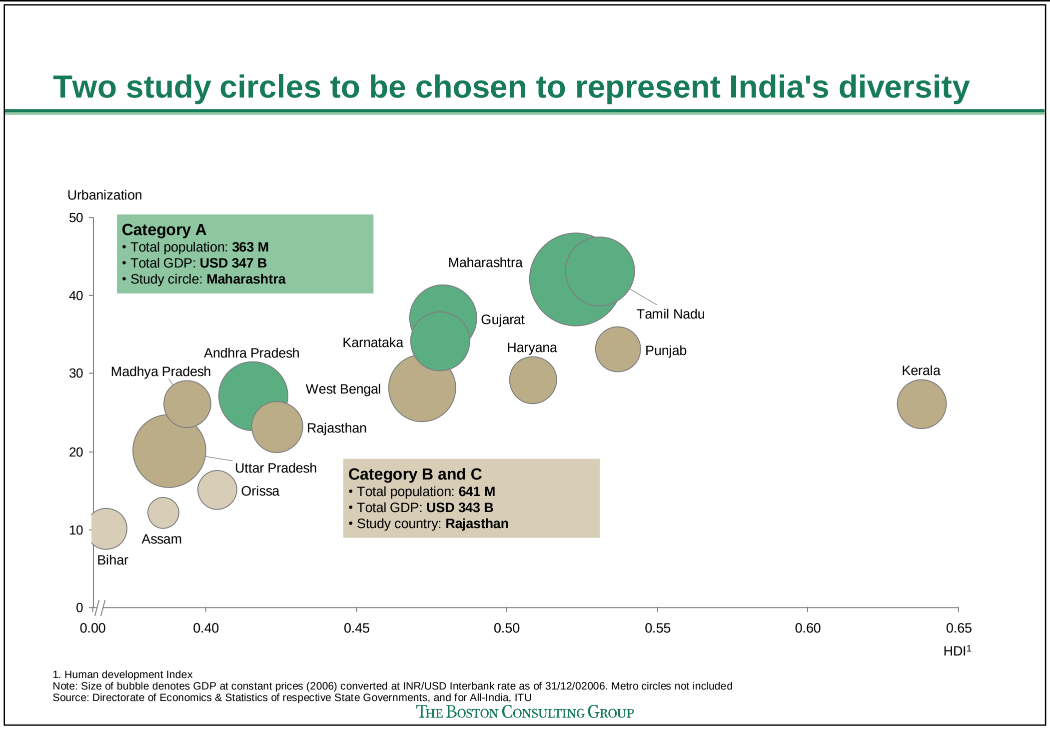


Exhibit A.15 India study circles

Countries in Cluster C are Afghanistan, Bangladesh, Bhutan, Cambodia, India, Laos, Myanmar, Nepal, Pakistan, Papua New Guinea and Solomon Islands.

Uplift factors

In order to scale up the effects from individual study countries to the cluster, all countries in the cluster are assigned an uplift value that is calculated based on the key drivers. The uplift factor adjusts the results for the study country to all other countries in the cluster based on their relative level of urbanization and mobile penetration, which, as noted above, are the key drivers of expected economic benefit.

As shown in Exhibit A.16, the uplift factor is calculated as the inverse of the average of urbanization and penetration. For countries in Cluster B, the countries' urbanization and penetration numbers are indexed towards the average of study countries Malaysia and Indonesia. Similarly, Indian states are indexed towards the average of study circles Maharashtra and Rajasthan.

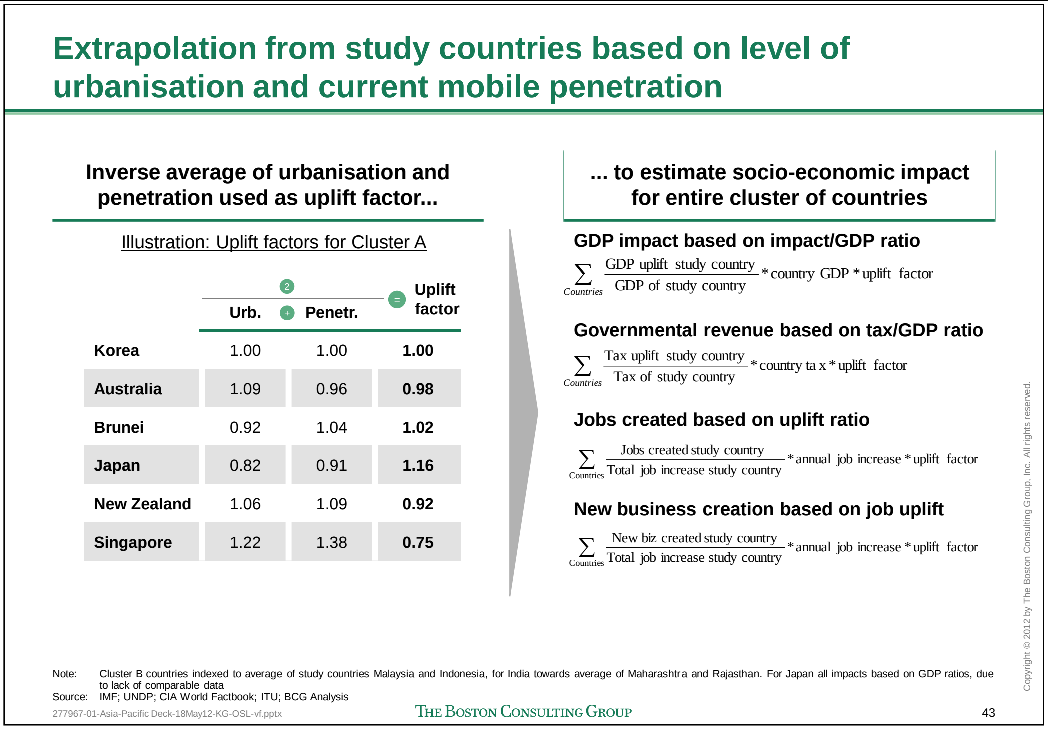


Exhibit A.16 Extrapolation calculations

As shown in Exhibit A.14, total impact across Asia Pacific is extrapolated along the four main socio-economic factors. Total GDP impact is calculated for each country as the country's GDP multiplied with the study country's GDP uplift, multiplied with the respective uplift factor. Total tax impact is calculated based on a tax/GDP ratio, while both jobs and new business creation are based on the relative uplift in job creation. The latter is due to lack of reliable, comparable multi-country statistics on business creation.

Uplift factors for all countries are shown in Exhibit A.17.

Uplift factors estimated for all countries relative to their cluster study country/countries

Cluster A	Cluster B[1]	Cluster C[1]
Australia: 0.89	China: 1.51	Afghanistan: 1.34
Brunei: 1.02	Fiji: 1.24	Bangladesh: 1.19
Japan: 1.16	Indonesia: 1.00 (study country)	Bhutan: 0.95
New Zealand: 0.93	Iran: 1.02	Cambodia: 1.18
Singapore: 0.77	Malaysia: 1.00 (study country)	India: 1.00 (study country)
Korea: 1.00 (study country)	Maldives: 0.94	Laos: 0.93
	Philippines: 1.07	Myanmar: 1.74
	Samoa: 1.61	Nepal: 1.81
	Sri Lanka: 1.94	Pakistan: 0.93
	Thailand: 1.31	Papua New Guinea: 2.30
	Tonga: 2.23	Solomon Islands: 2.82
	Vanuatu: 1.30	
	Vietnam: 0.94	

1. Uplift factors based on driver values indexed to the average of the study countries/circles
Note: Kiribati, Marshall Islands, Micronesia, Nauru, North Korea and Tuvalu not included due to lack of reliable data
Source: IMF; UNDP; CIA World Factbook; ITU; BCG Analysis

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Exhibit A.17 Uplift factors

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OECD Broadband portal: http://www.oecd.org/sti/ict/broadband
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