Vodafone Response to TRAI consultation on IMT-Advanced Mobile Wireless Broadband Services

We welcome the consultation on IMT-Advanced. However, in order to maximise the value of this process we believe it is helpful to consider this topic not in isolation, but in the context of the wider discussions on spectrum policy in India. To do so in a meaningful way requires more time than that which has been currently proposed.

The consultation is focused around IMT-Advanced (LTE-Advanced and Wireless LAN-Advanced) but many of the specific points concern topics which are of more immediate concern for the current generation of '4G' services, in particular LTE and WiMax. Indeed, LTE and LTE Advanced are only different releases of the same standards developed by 3GPP, and all of the examples in Chapter 3 'International Practices on IMT-Advanced' are actually examples of LTE.

We suggest three areas where clarification of the purpose of this consultation would be helpful:

(i) Since IMT-Advanced capabilities are unlikely to be commercially available much before 2015, we believe that the immediate concern should be to ensure that the spectrum is made available for the deployment of LTE. This is a proven technology (Vodafone is already deploying a commercial LTE network in Germany) which brings very significant advances over 3G. We should therefore focus on these benefits, for both consumers and business, and ensure that India becomes a leader in mobile broadband by deploying LTE quickly.

(ii) We believe it is not desirable to focus on the best way to introduce and regulate a new technology that is yet to be implemented in equipment, without considering the context in which it will be introduced. We believe that clarity on the allocation and pricing of spectrum for GSM, 3G and LTE will need to be discussed and decided before IMT-Advanced can be discussed in a meaningful way.

(iii) The discussions on this topic are related to the discussions on the upcoming Spectrum Act and we believe they should be linked. The overall framework needs to be developed before the specifics of any particular band or technology can be finalised.

We therefore present below, our initial responses to the specific questions to the topics raised in the consultation and are very happy to discuss any of these in more detail.

Responses to specific questions:

Q1. Whether there is a need to define a particular user equipment or architecture to be used by the vendors or this may be left to the market forces?

Vodafone believes that making spectrum available on a technology neutral basis enables mobile operators to use it in the most efficient way. We therefore submit that it is not necessary for the Authority to define specific equipment or architectures.

Q2. Whether there is a minimal set of performance characteristics the UE has to meet before it is permitted to enter a network? These characteristics are over and above the inter-operability, protocol conformance and emission tests which presumably the UE has already passed.

Vodafone believes that in a fast-moving technology like mobile wireless broadband, the industry is best placed to define and test the performance requirements needed to deliver value and high quality services to the customer.

In our experience the performance of the UEs in the network is the key for a satisfactory customer experience. We therefore request our vendors to comply with the RF and antenna performance of UEs against a set of performance criteria based on the CTIA 3.1 requirements on Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) in the normal conditions of use of the device (i.e. accounting for the head and hand loss).

Q3. In addition to what has been described above, what can be the other security issues in IMT-Advanced services? How can these security issues be addressed?

Vodafone believes that the consultation paper identifies the main security issues that are likely to exist in IMT-Advanced networks. Many of these security issues are also issues in current 2G, 3G and 4G networks and Vodafone believes that existing methods to secure those networks can be extended and evolved to meet the security requirements of IMT-Advanced.

Vodafone's preferred choice for an IMT-Advanced technology is likely to be LTE-Advanced. The LTE-Advanced security architecture is an evolution of the LTE security architecture and is specified in the Release 10 version of 3GPP TS 33.401. Compared to the initial release of the LTE security architecture, the Release 10 version introduces security features for relay nodes. 3GPP specifications also provide security features for LTE femto cells – these are specified in 3GPP TS 33.320. Lawful interception support in LTE is specified in 3GPP TS 33.107. Vodafone believes that the 3GPP specifications provide an effective suite of network layer security features for LTE-Advanced to meet the needs of users, operators and regulators. Some services running over IMT-Advanced networks will require their own additional application layer security.

Q4. What basic security frameworks should be mandated in all networks to protect customer?

Vodafone does not believe that regulating the security framework to be adopted under IMT-Advanced would be the best approach to protect customers. Rather, Vodafone believes that any regulatory intervention in relation to security to protect customers should be limited to stating the desired outcomes rather than the method to achieve the desired outcomes. Output-focused regulation will be significantly more efficient than outlining the method that operators must adopt.

Vodafone will design and configure our networks to meet the security requirements that our customers desire. Allowing flexibility in the method to achieve security outcomes will ensure that operators can implement suitable security arrangements at lowest cost, using the best methods available. Regulation that specifies the frameworks to be adopted would likely limit the methods we can use, and may lead to sub-optimal solutions. In addition, given the fast paced technology development, any regulations would likely be out of date very quickly – indeed any IMT-Advanced regulations set now would likely be out of date by the time LTE-Advanced is commercially deployed.

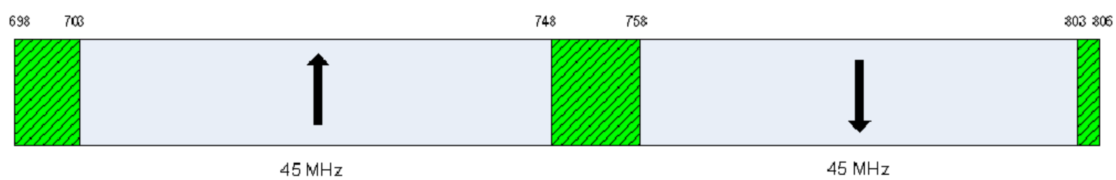
Having said that, we also submit that it is premature to discuss this issue at the current time when commercial deployment of LTE-Advanced is yet to be implemented.

Q5. Which spectrum bands should be identified for the IMT-Services in India?

Vodafone believes that the implementation of harmonized band plans is extremely important for the efficient use of spectrum. From the proposed band list in Chapter 2 point A2.6, we believe that the bands that have most traction across the Industry for IMT systems are the 700MHz (698-806 MHz) and 2.5-2.69GHz bands. The 698-806MHz band is essential for the provision of IMT and IMT-Advanced coverage to rural and indoor locations for smartphone and mobile broadband users, whilst the 2.5-2.69GHz band will allow wider bandwidths to be deployed and therefore provide higher throughput in urban areas.

With this in mind, Vodafone strongly supports the adoption of the Asia-Pacific Telecommunity (APT) band-plan for India. For the first time, the Asia Pacific region has developed technical harmonization for a mobile band through the cooperation between regulators within the Asia Pacific Telecommunity. The APT band-plan presents the most efficient use of the 698-806MHz range. The APT band-plan has many advantages over alternative suggestions – the most important being that it maximizes the amount of usable spectrum within the relevant spectrum range. The APT band-plan is outlined below.

Figure 1: APT Band-Plan



The APT band-plan allows for 45MHz of paired digital dividend spectrum. Vodafone notes that this plan allocates more usable spectrum than alternatives. For example, the European band-plan only has 30MHz of paired spectrum. Vodafone also notes that the European band-plan is not suitable for the Indian IMT range of 698-806MHz. On the other hand, the US band-plan does utilize the 698-806MHz range but has many disadvantages. The central disadvantage is that the US band-plan allocates two national holdings of 2x29MHz and many fragmented regional and unpaired allocations. The two national carriers in the US have been designed to allow only two operators and handset interoperability between operators[1].

Importantly, both Australia and New Zealand have already proposed to adopt the APT band-plan, allocating 2x45MHz FDD spectrum to the mobile industry[2]. This clearly shows that harmonization across Asia-Pacific is likely to occur.

There are significant economic benefits of achieving harmonization in band-plans across the Asia-Pacific region. The Boston Consulting Group (BCG), in a report (enclosed as Annexure-1) for the GSMA notes that[3]:

> *India has the opportunity to take a leading position and shape the development of mobile broadband in the UHF band. Implementing the APT Wireless Forum's suggested band plan for Asia Pacific, India can exploit economies of scale and reduced cost of service to make broadband available throughout the country.*

BCG concludes that the allocation of 700MHZ spectrum to mobile and the adoption of the APT band-plan would deliver the Indian economy an additional benefit of Rs 3.3 trillion (US$68.1 billion) from 2014-20, or Rs 2.2 trillion (US$43.8 billion) in net present value.[4] **The economic benefit of adopting the APT band-plan is estimated to generate more than 328,000 new jobs in 2020, many of them in rural areas. Government revenue is also estimated to experience significant growth through the adoption of the APT band-plan, with an additional Rs 791 billion** (US$16.1 billion) in tax income accruing to the government over the 2014-2020 period.[5]

However, **a key assumption for the estimated economic and social benefits to India** of LTE-advanced technologies over the 700MHz range **is the adoption of the harmonized APT band-plan.** BCG state that the benefits:

> *… are dependent on governments allocating the internationally harmonized frequency band 698-806 MHz, and implementing the Asia Pacific technical harmonization (the APT band-plan for FDD deployment in the 2X45 MHz based technical harmonization) to ensure their consumers and society benefit from the economies of scale in handset and network equipment production … Without access to the 108 MHz of bandwidth [from the APT band-plan], effective rollout may become more difficult. There may be insufficient bandwidth for ensuring effective competition between mobile network operators, which may in turn reduce the range and quality of services, and may lead to increased consumer prices for subscriptions.*[6]

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[1] See discussion at New Zealand Ministry of Economic Development, *Digital Dividend: Opportunities for New Zealand*, 2011.
[2] Ibid., and ACMA, 2011, *Draft spectrum reallocation recommendations for the 700 MHz digital dividend and 2.5 GHz bands.*
[3] Boston Consulting Group, Socio-economic impact of allocating 700 MHz band to mobile in Asia Pacific. A Report for the GSMA. p.75.
[4] Ibid., p.76.
[5] Ibid.,section 5.
[6] Ibid., p.91.

BCG calculates that failure to adopt the harmonized APT band-plan will likely cost India up to 10% of the benefits outlined above[7]. More specifically, failure to adopt APT band-plan is likely to cost India over the 2014-20 period:

- Rs 66 billion in economic growth;
- Rs 40 billion in government revenue; and
- 27,000 jobs, mainly in rural areas.

Finally, but by no means the least important impact, **failure to adopt the harmonized APT band-plan is expected to increase the cost of each handset by around Rs 100** (US$2)[8]. While this does not seem much, when distributed across the expected additional 14 million subscribers as a result of allocating digital dividend spectrum to mobiles, **this amounts to an additional Rs 1.4 billion cost to consumers.**

Vodafone therefore strongly recommends that India adopt the harmonized Asia-Pacific band-plan for the 698-802MHz spectrum range. Not only will this ensure that the benefits of LTE services are maximized, Vodafone further notes that some European and South American countries have expressed interest in adopting the APT band-plan[9]. If greater harmonization occurs outside of Asia-Pacific the above benefits would be expected be even larger.Vodafone notes that the 2010-2025MHz band is too narrow to deliver mobile broadband services (especially if there is more than one licence) and has not been used elsewhere. Vodafone therefore suggests that this band should be a low priority with focus being on the adoption of the harmonized APT band-plan for the 698-806MHz range.

Instead Vodafone suggests that the 2.5-2.69 GHz band should be offered and deployed in conjunction with 700MHz as this will enable operators to adopt an optimal mix between capacity and coverage.
Ideally, all spectrum bands should be technology agnostic and therefore potential candidates for IMT and IMT-Advanced technologies. This would allow operators the freedom to deploy technology advances in their existing holdings in a flexible manner to serve their customers as efficiently as possible. This is a regulatory path which has already started in Europe (e.g. operators in the UK, France, Spain and Italy are replacing GSM technology with UMTS in the 900MHz band) and Asia-Pacific (both Australia and New Zealand are proposing to adopt technology neutrality in the 698-806MHz APT band-plan).

Q6. What should be the block size of spectrum to be put on auction? How many blocks of spectrum should be allocated/ auctioned per service area?

We would recommend that the entire spectrum band (that is, 45MHz of paired spectrum as per the APT band-plan) is made available in the auction at the same time and that the spectrum should be split into 5MHz blocks. Further, operators should be given the option to acquire multiple blocks in the auction so that it can choose to deploy in 10MHz or 20MHz, providing the best possible user experience and spectral efficiency.

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[7] Ibid., p.93.
[8] Ibid., p.93.
[9] Op Cit., n.2

Vodafone suggests using a block size of 5MHz since this is the absolute minimum spectrum block size for effective use of IMT Advanced as explained in section Q7. Ideally, all spectrum should be made available in all service areas at the same time. Reducing the amount of spectrum available will tend to artificially inflate the prices paid and limits the opportunity for operators to secure multiple blocks of spectrum, which would have an impact in the speed of network deployment and quality of service to the customer. Increasingly, it is our experience that customers are expecting to have pan-Indian coverage from their mobile operator. It may be noted that NTP-2011 also talks about one Nation –one license. Whatever allocation/spectrum method is ultimately adopted, Vodafone recommends that the TRAI ensure all service areas auctioned at the same time so as to enable pan-Indian awards.

The LTE channel bandwidths below 5MHz are only intended for existing 2G bands, for migration from 2G to LTE. These narrow bandwidths allow LTE services to be introduced progressively in these bands. This can be seen in the 3GPP specification TS 36.101 (Table 5.5-1), where the narrow channel bandwidths are only specified for bands used for 2G[10].

Q7. What is the minimum spectrum block size for effective use of 4G technologies?

Narrow channel bandwidths below 5MHz are inherently less efficient, limiting their ability to provide evolved or competing service performance relative to existing 3G services. Therefore Vodafone would advise against a block size below 5MHz.

It is reiterated that with a minimum block size of 5MHz, an operator should be allowed to acquire multiple blocks in order to realise the full potential of a high capacity IMT or IMT-Advanced system with a bandwidth of 10 and up to 20MHz per band so as to offer the best network capability.

Q8. What should be the maximum amount of spectrum which a service provider can be allocated through auction?

Vodafone believes that the “maximum amount” of spectrum that a service provider can be allocated should be decided judiciously keeping in mind the need to provide adequate spectrum to offer high quality broadband services, the adverse implications of excessive fragmentation whilst also safeguarding and ensuring adequate competition.

Vodafone is strongly against band-specific/technology specific caps and believes that a cap should be set independent of band and technology mix deployed.

One option could be to cap the spectrum at say 25% of the total spectrum assigned in a service area, irrespective of band and technology mix deployed. Another approach could be to put an overall cap of 2x25MHz of sub-1GHz spectrum.

Q9. Whether there is a need to specify the use of particular duplexing scheme based on the band in which spectrum allocation is done? If yes, in the case of TDD, is it required to specify further the frame duration, mandate frame synchronization using

[10] Apart from one band that is not an exact multiple of 5MHz

one of a specified set of timing sources and a permissible set of Uplink/Downlink sub-frame schemes compatible with the IMT-A standards?

Vodafone believes that it is important for India to make efficient use of the spectrum available for mobile services. This requires the duplexing scheme to be specified, in order to minimise the number of guard bands.

<u>Annexure-2</u> shows the inefficient use of spectrum that can result when the duplexing scheme is not specified. This example is taken from a report by CEPT to the European Commission on the 790-862MHz band, but the conclusions would be similar for any frequency band.

In particular, we submit that for the 698-806MHz (700 MHz) band, India should specify the FDD band-plan that has been defined by APT. In our response to the pre-consultation, we expressed support for the FDD band-plan proposal that was then being considered by APT. However, we believe that the final FDD band-plan of 2x45MHz represents a more optimal trade-off between complexity (and therefore cost) of terminals and use of spectrum.

Vodafone expects that the APT FDD band-plan will be adopted for the 700MHz band in most Asia-Pacific countries as well as in other parts of the world – Australia and New Zealand have already proposed to adopt the band-plan. If India makes this spectrum available in the near future, in addition to being a leader in the deployment of the latest mobile technology it is likely to provide export opportunities for Indian manufacturers as well as simple roaming for Indian travellers. We also note that a harmonized approach across Asia-Pacific to the adoption of the APT band-plan will enable up to an additional 10% economic benefits to India (see BCG work above).

In the 2.5-2.69GHz band too, FDD is preferred duplexing scheme, with most markets in Europe and APAC opting for FDD. Aligning with these markets would provide for efficiency in the eco-system.

TDD is more appropriate in higher frequency bands (in particular, the 3.4-3.6GHz band, where wider bandwidth is available) and spectrum that cannot be used by FDD (such as the 'centre gap' of the 2500-2690MHz band). For these bands, TDD inter-operator synchronisation and UL/DL frame alignment should be left to specific coordination agreements between operators. Note 3GGP Standards already specify a set of possible UL/DL frame ratios.

Under no circumstances should TDD and FDD be mixed as it leads to inefficient spectrum use.. It may be noted that in Asia-Pacific, both Australia and New Zealand have proposed to adopt the FDD-only 700MHz band-plan.

Q10. What should be the reserve price per MHz in different spectrum bands?

Vodafone notes that the current consultation document is not the appropriate fora through which to discuss in detail the reserve price to be set for LTE spectrum. Vodafone believes the reserve price should be considered during the consultation phase for the design of the actual auction process for 700MHz spectrum.

Q11. What should be the eligibility conditions for bidding for spectrum?

We submit that the current consultation document may not be the appropriate fora to discuss the eligibility conditions for the future auction of 700MHz spectrum. Vodafone believes the eligibility conditions should be considered during the consultation phase for the design of the actual auction process for 700MHz spectrum.

Notwithstanding the above, we would suggest that the eligibility conditions applied in the recent 3G auctions may be followed, with the following modifications:

1. Allow operators to bid for multiple blocks, thus giving them the opportunity of combining 5MHz blocks into larger channels to improve performance and efficiency.

2. Restrict the auction only to existing operators. A condition should be imposed that prevents spectrum speculators from participating in the auction. This could be achieved by limiting bidders to exiting operators that have deployed a network. The greatest loss to India will come from LTE spectrum being unused by spectrum holders that do not have the financial ability to deploy a rural-focused pan-Indian network.

Q12. Should there be any roll out obligations for spectrum given through auction? Should it be different in different bands?

We submit that it may be more appropriate to discuss this issue during the consultation phase for the design of the actual auction process for 700MHz spectrum.

Notwithstanding the above, we submit that rollout obligations, if applied, should be different in different bands. For example, the propagation characteristics of the 700MHz range best promotes rural coverage whilst the characteristics of high frequency spectrum mean that it is not suitable for wide-areas coverage in rural areas. It is thus our view that the obligation for ranges above 2GHz must be far less onerous than the 700MHz obligation as the propagations characteristics are fundamentally different.

Q13. Whether there should be any specific rollout obligations in respect of rural areas?

As noted above, the greatest benefits of 700MHz spectrum comes from deployment of mobile broadband services in rural areas. Vodafone believes that rural obligations could help achieve sufficient rural coverage. It is not appropriate to go into details on what obligations should be imposed in any future auction for 700MHz, but we outline below international experience in relation to the imposition of rural obligations.

Other countries, including Germany, France, the UK, Ireland and Sweden have approached the challenge of rural rollout directly, by imposing license conditions to ensure the economic benefits for rural areas are realised. For example:

- **Germany** has imposed an “outside-in” rollout obligation. Each federal state (except Berlin, Hamburg and Bremen) has a list of municipalities without broadband services. These municipalities are classified into four priority classes based on population (5,000, 20,000, 50,000 and above 50,000). Operators have to start the rollout in the lowest population area (priority class 1) and cover 90% of population in the designated municipalities in each federal state by 1 January 2016. Network rollout in a higher priority class cannot start until 90% coverage is achieved in the relevant lower priority class areas.

- In **France**, the regulator ARCEP has set conditions for the 800MHz auction scheduled for December 2011. All 800MHz blocks have rollout conditions attached to them, requiring that 98% of the population is covered within 12 years, with 99.6% of the population covered within 15 years.

- The **UK** regulator Ofcom has imposed a 95% population coverage rollout conditions in one of the 800MHz licences.

- The **Irish** regulator ComReg has proposed a 70% population rollout requirement on 800MHz, 900MHz and 1800MHz, which is expected to be auctioned in February 2012.

- The **Swedish** regulator PTS has a list of homes and businesses that do not have adequate broadband. The rollout conditions specify that 75% of the PTS list is covered by the end of 2013. From 2014 onwards, PTS will annually produce a list and operators will be required to cover all the sites by 31 December of that year.

It is likely to lower the value of spectrum considerably if all operators have to meet extensive rural rollout and we need to consider whether it is the most sensible use of scarce resources to deploy many competing infrastructures in rural areas. Shared networks, or a single licence with rollout obligations, would probably be a better way of meeting the overall policy aim.

Q14. What should be the spectrum usages charges? Should it be based on revenue share or be a fixed charge?

We believe that a uniform and common framework should be developed and applied across all bands, irrespective of the quantum of spectrum and technology mix used.

In general, Vodafone prefers a fixed charge regime rather than revenue share. A fixed charge regime encourages efficient use of the spectrum – it does not penalise those operators who are successful and have many customers.

Q15. Using MIMO technology what can be the possible infrastructure sharing issues and what can be the probable solutions.

The gains of deploying MIMO orders beyond 4x4 (and in some cases 2x2) are rather limited, so Vodafone does not consider a priority to evolve their network beyond this. Besides, new compact antenna designs for MIMO should make possible to accommodate this in a shared site. Infrastructure sharing can also be extended to include antenna sharing between multiple operators as well. Therefore we do not foresee that MIMO will impose any severe limitations to infrastructure sharing.

Q16. What regulatory mechanisms are to be provided for delivery of voice services over IMT-A systems?

The regulatory mechanism will be based on and governed by the underlying license conditions, i.e. voice services are permissible only under UAS License. This principle has to be continued for the purpose of level playing field.

Q17. Should the interoperability of services to legacy 2G/3G systems be left to market forces?

Vodafone's preferred network evolution path, LTE and LTE-Advanced, are fully backwards compatible with legacy 2G and 3G systems and allow handover between them. Therefore, this can safely be left to market forces.

Q18. What are the QoS measurements that can be reported on IMT-A systems? Suggest the appropriate KPI for data and voice services to guarantee customer satisfaction.

For voice services, the call metrics already provided to TRAI are sufficient for IMT-A systems. Indeed, it is impossible to use different metrics, because a voice call can be handed over between 2G, 3G and IMT-A networks. Vodafone would revert with more specific suggestions on call metrics for voice services during the Open House Discussions.

For data services, there is widespread agreement between industry and regulators that transparency is a primary means of ensuring an open internet, allowing customers to choose the operator with the service that most suits their needs in term of pricing, features and quality offered. The traditional way of presenting information to users based on the theoretical maximum speed (i.e. "up to x Mbit per second") is clearly insufficient for these purposes.

Vodafone has undertaken an extensive QoS testing campaign across all operating companies in Europe and the rest of the world. The measurements covered 16 countries with almost 50,000 data test samples over 315 measurement days of testing from September 2010 until January 2011. Based on this experience, we believe that a robust QoS measurement approach should include the following Key Performance Indicators:

- Download speed or throughput: (in kbps or Mbps)
- Upload speed or throughput: (in kbps or Mbps)
- Latency: (normally expressed in milliseconds (ms))
- Web browsing session time: (measured in seconds on a reference page)

These measurements should be undertaken using specialised QoS testing tools.

Vodafone would be happy to discuss its experience in more detail with TRAI.

Q19. In view of the likely deployment of scenarios where the cell radius is scalable to much smaller levels using the concepts of femto and pico cells:

Vodafone promotes the use of femto and pico cells as they are a cost-effective way of deploying additional targeted capacity in traffic hotspots and enhanced customer experience. However the decrease in cell size cannot be seen as a substitute for additional spectrum. Rather, the use of femto and pico cells is complementary to our existing macro network. Femtocells are located in customers' homes and are connected to the network using fixed broadband connections. They therefore rely on suitable fixed infrastructure being in place. Vodafone notes that the absence of widespread fixed broadband connections in India is likely to limit the benefits of femtocell deployment to large urban areas.

a. What will be the impact of femto cells/SoN architecture on KPI?

   The inclusion of femtocells and SON in our networks will be another step in Vodafone's aim of being the 'Best Network' and we consider them key in our strategy of enhancing the customer experience. As mentioned before, sufficient spectrum is needed in order to have an efficient interaction of the layers in a heterogeneous network.

b. What will be the impact of Relays/femto cells on spectrum policy?

   Vodafone's view is that spectrum licences should be technology-agnostic and that spectrum should not be reserved for a specific technology. It is most efficient for operators to determine themselves the most efficient way to utilise the spectrum.

c. What will be the impact on infrastructure sharing?

   It is not clear to us yet what commercial agreements will be most appropriate.

d. What policy guidelines are required to encourage low emission low energy and high capacity architecture like femto cells overlaid over macro cells?

   Operators have strong commercial incentives to make the most efficient use of their spectrum and minimise their use of energy (especially where cell sites are powered by diesel generators). There is no need for policy guidelines to achieve these objectives.

Socio-economic impact of allocating 700 MHz band to mobile in Asia Pacific

INTRODUCTION

The impending switchover in the UHF band from analogue to digital broadcasting across the Asia Pacific presents a one-off opportunity to boost the development of countries in the region.

The GSMA appointed The Boston Consulting Group (BCG) to undertake a rigorous analysis of the social and economic benefits of allocating the 700 MHz band to mobile broadband, relative to its likely alternative, digital broadcasting. This study uses a proprietary methodology to estimate Internet adoption by households and businesses, and to translate that adoption into impact on total output, productivity, jobs, and other critical economic indicators. It also explores the social benefits of allocating the 700 MHz band to mobile broadband, in terms of its potential ability to improve education, healthcare and financial inclusion for rural and underprivileged groups.

The approach throughout the study is to use conservative assumptions that are likely to understate the socio-economic benefits of mobile broadband over broadcasting. Given the size and diversity of the Asia Pacific region, four countries representing the range of socio-economic development and current internet adoption – Korea, Malaysia, Indonesia, and India – were studied in detail, and the findings for those countries were subsequently extrapolated to similar countries to build up the picture for the entire region. The result, we believe, is an objective assessment of the merits of mobile broadband relative to the alternatives.

The GSMA and BCG would like to thank our partners, Telenor Group (Telenor) and Telefonaktiebolaget LM Ericsson (Ericsson) for their invaluable support and contributions throughout this project.

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BCG has not independently verified all of the data and assumptions used in these analyses, although we have attempted, where possible, to test for plausibility. Changes in the underlying data or operating assumptions will clearly impact the analyses and conclusions. Further, BCG has made no undertaking to update these materials after the date hereof notwithstanding that such information may become outdated or inaccurate.

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EXECUTIVE SUMMARY

The impending switchover in the UHF band from analogue to digital broadcasting across the Asia Pacific presents a unique opportunity for assisting the development of countries in the region.

Assigning and allocating the 698-806 MHz band (the 700 MHz band) to mobile broadband will increase adoption, particularly among rural users, as well as boosting indoor coverage in urban areas. Using this band would reduce capital and network costs for providers, thereby accelerating rollout and lowering prices for end users.

This will bring much greater economic benefits than are obtainable through allotting the 700 MHz band to any other use, such as broadcasting. For instance, BCG projects that allocating this band to mobile broadband would add $729B to the GDP of Asia Pacific nations by 2020. Broadcasting would generate less than a tenth of that, at $71B. Similarly, deploying broadband in the 700 MHz band is expected to add 2.2M more jobs and generate 4.7 times more in tax revenues compared to broadcast.

Allocating the 700 MHz band to broadband would also bring significant social benefits, particularly in rural areas which currently lag behind urban living standards. Better access to education, improved healthcare and financial inclusion are all likely to result from widespread access to high-speed mobile broadband. Mobile broadband could also greatly increase efficiency in the provision of government services, especially in rural areas, and improve interactions between the government and businesses and consumers.

In addition, access to the 700 MHz band means the mobile operators can improve indoor availability and indoor quality of mobile broadband services in urban areas. The unique propagation characteristics of the 700 MHz band means cost-efficient in-building penetration will improve significantly compared with, for example, HSPA services using the 2100 MHz band. For many mobile services it is vital to ensure seamless coverage when consumers move between outdoor use and indoor use, and improved indoor coverage will enhance the consumers' experience of such services.

Two conditions are, however, essential for fulfilling the potential of mobile broadband in the Asia-Pacific region:

- All Asia Pacific countries should allocate the 698-806 MHz band to mobile broadband services.
- All Asia Pacific countries should implement the same technical specifications – the APT 2X45 MHz bandplan for the 698-806 MHz band - to achieve harmonization and ensure that every country and its consumers benefits from economies of scale in equipment and handset production. This will in turn enable the lowest possible subscription and handset prices.

The Asia Pacific region as a whole has developed into a sufficiently large market to drive economies of scale in equipment and handset production, and the region now has its first opportunity to play a lead role in setting the standards for technical harmonisation for a mobile band. Traditionally, the Asia Pacific region has tended to adopt and adjust to technical harmonisation standards developed in more mature markets in North America or in Europe. The tremendous growth and the extraordinary performance of the mobile industry in Asia Pacific region recently has been based on governments of the region adapting to existing mobile band allocations and implementing technical harmonisation plans developed elsewhere.

However, this time, the Asia Pacific region, through the APT platform for cooperation between countries in the region, has seized the opportunity and developed their own technical harmonisation standard for the 698-806 MHz band. The APT plan will deliver more aggregated bandwidth for mobile then the existing US bandplan, and has the potential to create a technical harmonisation basis for lower cost equipment and handsets than the US alternative. Each individual Asia Pacific country can, by allocating the harmonised band to mobile, and by adopting the 2X45 MHz APT bandplan, ensure those benefits are enjoyed by their consumers. In so doing, they will also take the region one step closer towards playing a more vital role in setting the global agenda for developing mobile broadband services.

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered.

It is estimated that non-harmonization would reduce the benefits of 700 MHz band across the whole region – costing up to 6% of the projected increase in GDP, 16% of the jobs and 19% of the extra tax income that would be generated by a harmonized rollout.

Governments should also be aware that the bulk of the societal benefits from allocation of valuable spectrum resources to mobile broadband will come from welfare improvements and indirect incomes to the state. There is a risk that excessive focus on short-term state revenues, such as auction revenues and fees imposed on operators, will hamper rollout and adoption of services. This could be particularly damaging to uptake of services among the lower income segments, and could negate the benefits of the 700 MHz band entirely, depriving rural residents of the low-cost services essential for their needs.

1 THE REGIONAL PICTURE

1.1 Introduction

The impending digitalisation of television broadcasting has created a unique opportunity to reallocate bandwidth to new uses. Because digital television at current levels will take 25 per cent or less of the current spectrum used by analogue broadcasting, spectrum can be freed up – a once-in-a-lifetime 'Digital Dividend'.

The Digital Dividend refers to seizing the opportunity created when terrestrial broadcasting moves from analogue to digital, which reduces the amount of spectrum required to transmit the same number of TV channels by 50-75 percent. It creates an historic opportunity for society to consider how to deploy the very valuable frequency resources in the UHF band and to seek to maximize the benefits to society. Possible uses include wireless and mobile communication, digital broadcasting, low power and indoor devices or other public use.

In North America, Latin America and the Asia Pacific, the Digital Dividend refers to the 700 MHz band – specifically, the 698-806 MHz band. USA has adopted and implemented its national bandplan, taking into consideration US-specific concerns about spectrally adjacent services. The rest of North America, Latin America and Asia Pacific are in the process of preparing and making their decisions on the technical harmonization of the 700 MHz band. In Europe, the Digital Dividend is about the 800 MHz band; the 790-862 MHz band. For Europe, the CEPT, the equivalent of APT in Asia Pacific, has developed a 2X30 MHz harmonised bandplan which is supported by the mobile industry. This has been implemented by the first European country to auction 800 MHz band licenses (Germany in 2010).

By far the most productive use, in both social and economic terms, would be to allocate the 698-806 MHz band to mobile broadband. In Exhibit 1.1, the potential benefits of mobile broadband are plotted against the alternatives – including fixed wireless Internet

– on five economic and four social criteria. They demonstrate an overwhelming case for mobile broadband.

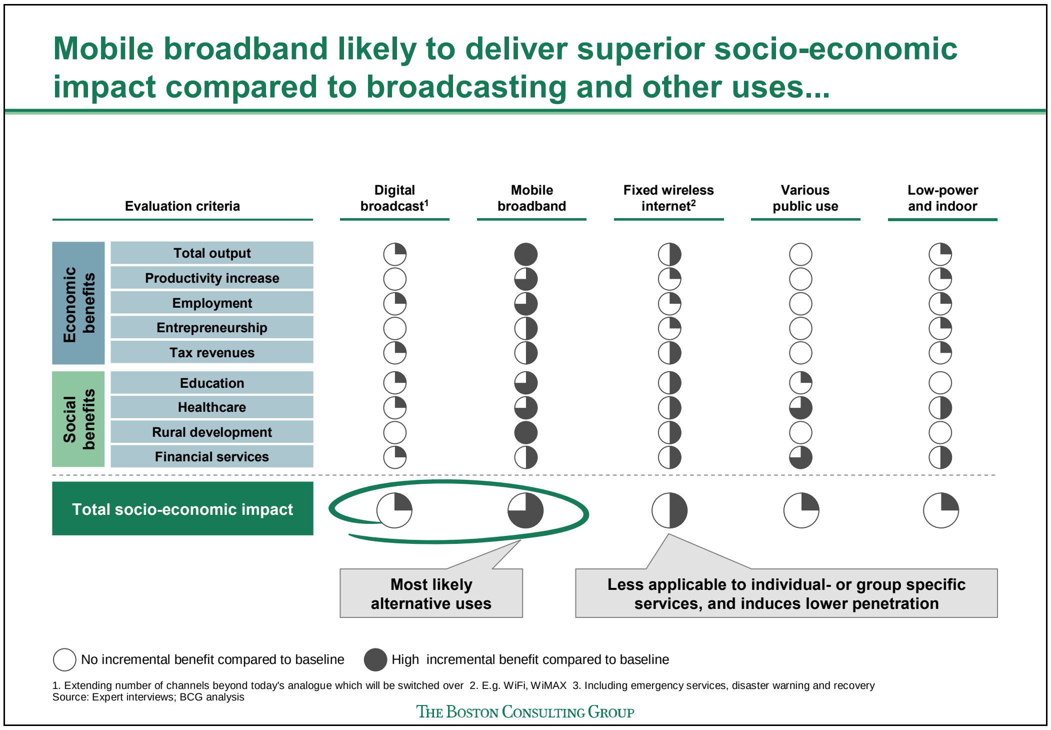

Exhibit 1.1 Impact of alternative uses of 700 MHz band

The 700 MHz band offers a sweet spot for mobile services, with an ideal combination of range and data capacity. At 700 MHz the signal covers a reception radius of 10 km, compared to six kilometres for a 2100 MHz based signal. Costs are correspondingly lower, with the 700 MHz band requiring only one third of the infrastructure expenditure needed for deployments in the 2100 MHz band. Halving capital costs is conservatively expected to take at least 5 to 10 per cent off service costs, benefiting low income groups.

These advantages underpin the benefits that come from allocating the spectrum to mobile broadband. Rural areas in particular would benefit, while entrepreneurs and small companies everywhere would be given access to a much wider range of customers. A substantial economic increment would come from increased productivity in all sectors, the spur given to entrepreneurs and new businesses, and higher levels of infrastructure investment and tax income. Social benefits would be weighted towards rural and other less developed areas – better education and healthcare, more effective rural development and improved access to information, financial services and entertainment.

BCG foresees two stages in the development of regions given access to mobile broadband by the Digital Dividend. In the short term, the availability of local content and services will be improved. The longer-term will see usage capabilities and trust in services built up, with general literacy and IT skills improving as individuals recognize the greater benefits of IT literacy and take advantage of the availability of general and technical education.

Existing businesses, many already connected to the Internet by fixed line, will also experience additional benefit from the cheaper service made available by mobile broadband. Studies estimate that companies in the United States benefited to the extent of $31.4B in broadband-related productivity gains in 2005 as the range of mobile broadband services complemented their fixed line access, such as accessing email on the go and real-time access to inventory and customer records.

1.2 Analysis

This study applies a rigorous cost-benefit analysis approach to estimate the increments that will accompany the allocation of the 700 MHz band to mobile broadband. The BCG model looks at five economic factors – total output, productivity, employment, entrepreneurship and tax revenues - to reach a comparative understanding of the impact of allocating the band to either mobile or the likeliest alternative, broadcasting.

The economic impact is further examined and the social impact assessed with reference to the main challenges for the Asia Pacific region, as defined under the United Nations Development Programme (UNDP). Exhibit 1.2 illustrates the extent to which mobile broadband would enable the achievement of a wide range of objectives set out as priorities under the UNDP.

Four social impact levers to help address the most important challenges across Asia Pacific[1]

Levers enabled by utilizing the Digital Dividend

Main challenges defined by UNDP[1]	New jobs and businesses	Increased productivity	1 Accessible education	2 Improved healthcare	3 Financial services[2]	4 Rural development
Largest mass of income poverty in the world	✓	✓	✓	✓	✓	✓
Persistence of hunger despite high growth	✓	✓	✓	✓ (indirect)	✓	✓
High un-employment and under-employment	✓	✓	✓	✓	✓	✓
Inequality within countries and across the region	✓		✓	✓	✓	✓
	Economic		Social			

✓ Direct benefit
✓ (dashed) Indirect benefit

1. As defined by United Nations Development Programme (2009) 2. Including e.g micro-finance, micro-insurance and infrastructure for targeted financial aid from government and NGOs
Source: UNDP

THE BOSTON CONSULTING GROUP

Exhibit 1.2 Effect of broadband on UNDP challenges

While conservative assumptions have been used when modelling the benefits of mobile broadband, conversely, the benefits from broadcasting have been calculated on a best-case basis, so as to deliberately underestimate the impact of allocating the 700 MHz band to mobile broadband.

Allocating the 700 MHz band to broadcasting would allow for more television channels, generating additional revenue across the supply chain, along with new jobs and tax income. Analysis of this is based on assumptions on the maximum number of additional TV channels and optimistic revenue projections. In reality it is unlikely that the maximum number of TV channels will be commercially viable on a broadcasting platform, and that total addition to television revenues will be lower as additional TV channels cannibalise existing offerings. Many of the new TV channels will also likely be niche operations with small audiences and staff.

The estimate of regional impact has been based on a sample of four countries – Korea, Malaysia, Indonesia and India – selected to represent three different clusters of countries in the region, grouped according to current human development, urbanisation and mobile penetration. This is illustrated in Exhibit 1.3.

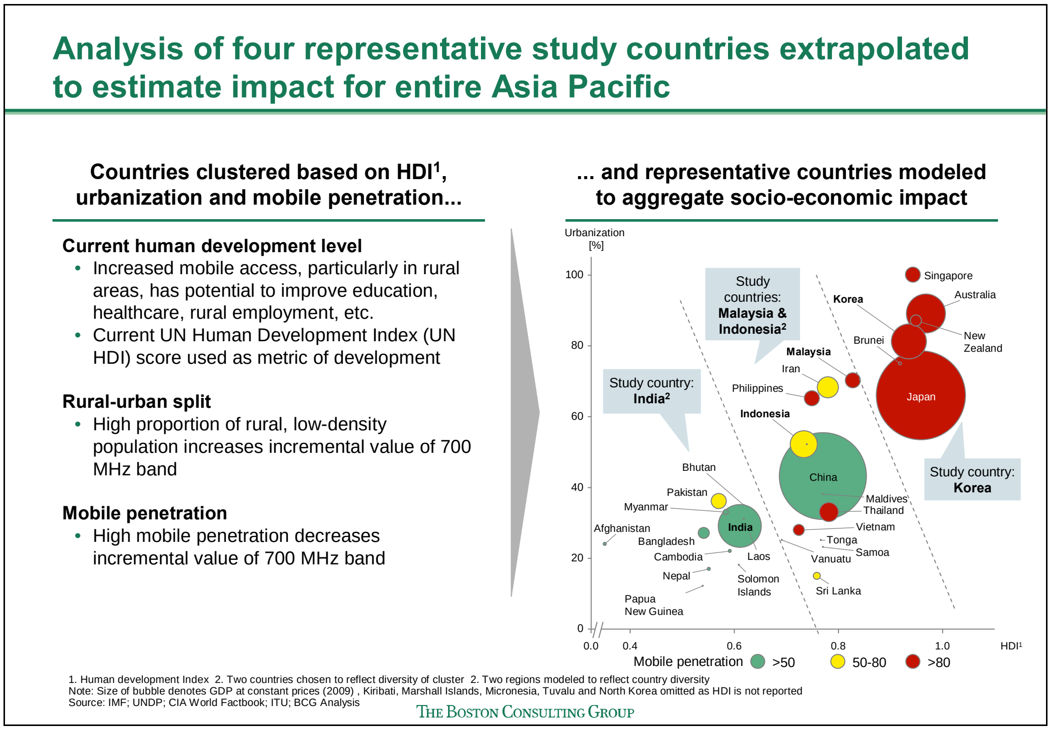

Exhibit 1.3 Clustering of countries in Asia-Pacific

- Korea represents Cluster A, highly urbanized and developed societies with high mobile penetration of more than 80 subscriptions per 100 population.
- Malaysia and Indonesia were chosen as the study countries for Cluster B, which are less developed and significantly less urbanized than Cluster A.
- Cluster C encompasses the least developed countries, with low urbanization and the lowest Human Development Index according to UNDP. India is the representative country for Cluster C.

1.3 Adoption

BCG analysis shows that there would be a considerable incremental adoption effect, particularly in rural areas, as a result of allocating the 700 MHz band to mobile broadband (Exhibit 1.4). As an increment on top of the baseline growth projections, this would amount to 21 per cent increase in Active Subscriptions[1] in India, 22 per cent in Indonesia, 23 per cent in Malaysia and 14 per cent in Korea, an increase equal to more than 25 million extra rural Internet users in these four countries alone. These rural increases amount to an overall addition of 2 per cent in additional Internet users overall in Korea, 5 percent in Malaysia, 8 per cent in Indonesia, and 6 per cent in India. These increases, when extrapolated across the region, have been found to generate considerable economic effects.

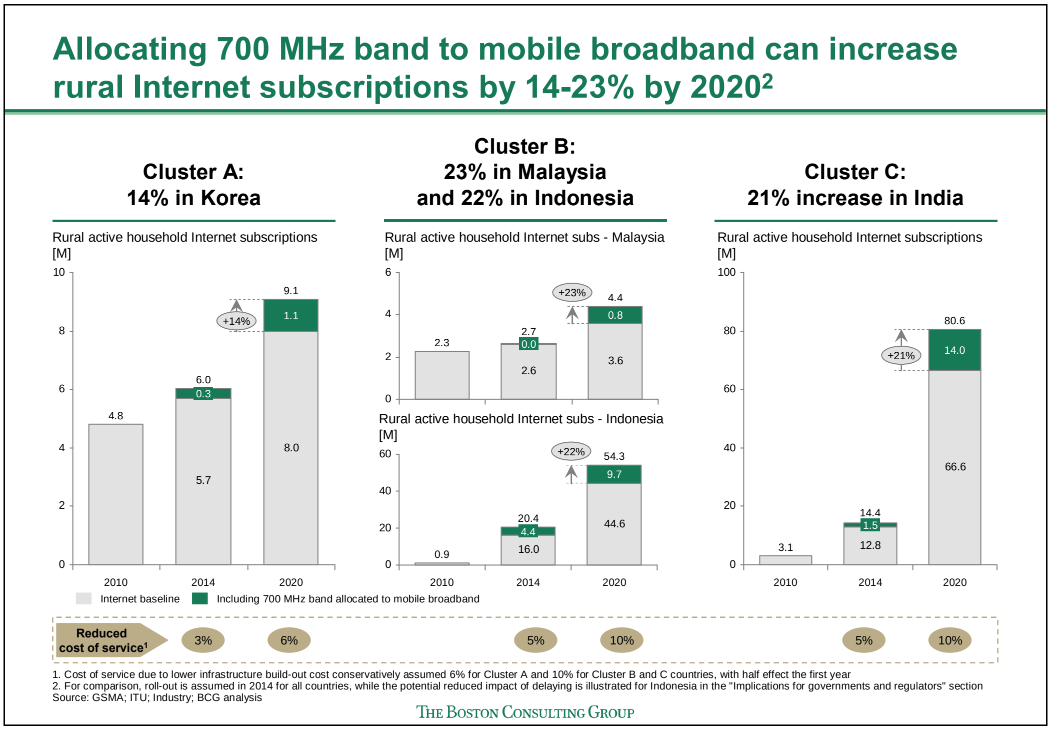

Exhibit 1.4 Increase in rural subscriptions

[1] For more accurate estimates of economic impact, only active subscriptions are included in the calculations. For fixed line Internet, users often share subscriptions through e.g. Internet cafes and a single connection in the household. For mobile Internet users on the other hand, number of subscriptions usually counts people with Internet-enabled phones in areas with 2.5G or better coverage, and thus number of Active Subscriptions would be lower. See Appendix for more details

1.4 Economic Benefits

On every measure of economic benefit – GDP increase, new businesses and jobs and extra government revenue – mobile broadband offers a far greater Digital Dividend than broadcasting[2].

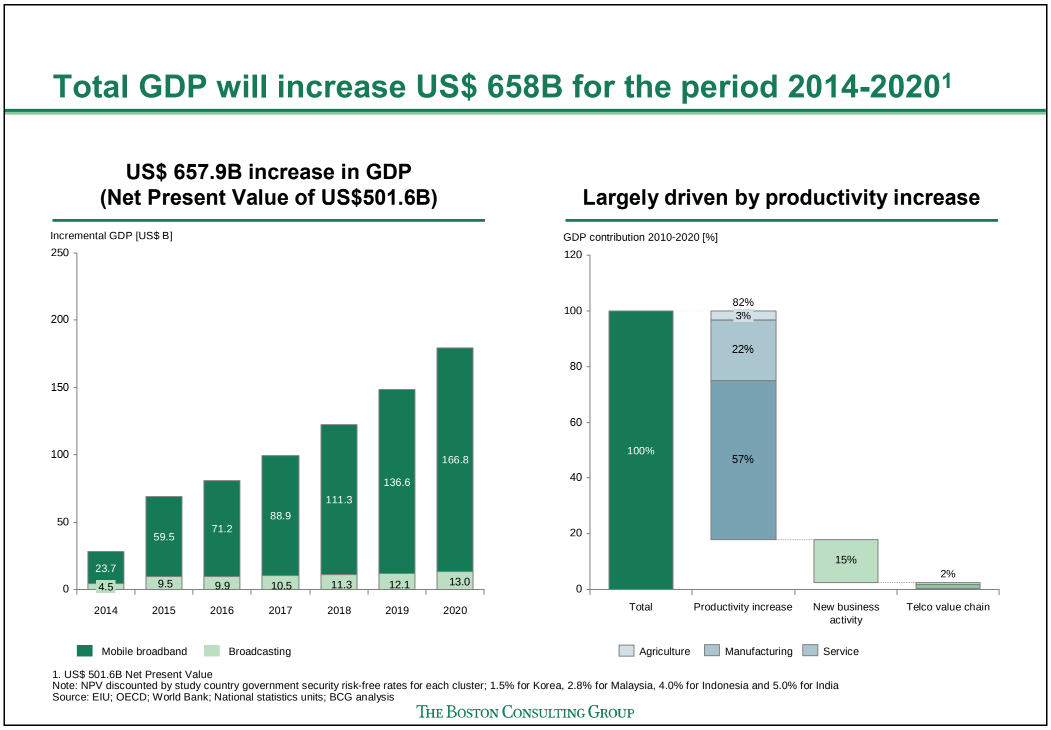

Exhibit 1.5 GDP impact of 700 MHz broadband

On the assumption of rolling out broadband in the 698-806 MHz band over two years, 2014 and 2015, BCG projects that $729B would be added to the GDP of Asia Pacific nations by 2020. Broadcasting would generate less than ten per cent of that, $71B. Therefore, as seen in Exhibit 1.5, mobile broadband would add $658B (net present value of $502B) more in GDP compared to broadcasting. The majority of mobile broadband benefits would come from productivity gains in existing businesses, as increased Internet adoption would help streamline their processes.

[2] India does not currently use the 700 MHz band for broadcasting, but for conservativeness alternative use will be modeled as broadcasting, having the highest potential impact

- Suppliers will benefit from integrated supply chains reducing lead times and stock levels, while logistics and cash management are made more effective
- Customer satisfaction can be improved by online services, which are also capable of reducing costs. E-commerce and online marketing offer fresh selling opportunities
- Internal processes will be made more efficient and less time-consuming, allowing employees to focus on core activities, while the introduction of systems such as Intranets and internal email assist knowledge sharing
- The replacement of face to face and paper transactions with electronic processes will save travel time and money in dealing with third parties such as banks and the government.

Allocation of spectrum in the 700 MHz band to mobile, and the anticipated increases in rural adoption, will spur additional productivity benefits by accelerating the network externalities of Internet adoption, such as:

- Increasing adoption of the Internet by rural enterprises
- Encouraging more businesses to use the Internet as a sales and marketing channel, particularly if their products target rural customers

57 per cent of GDP gains from improved productivity across the region would come from the service sector, 22 per cent from manufacturing and 3 per cent from agriculture. Only 2 per cent would come from the telecoms value chain, emphasising that while mobile broadband generates money by itself, the bulk of the benefits are seen in its wider impact on the economy and society.

The region could expect to see 1.1 million new business activities, both additional units in existing operations and entirely new enterprises, between 2014 and 2020. Some examples of potential new enterprises can be seen in Exhibit 1.6.

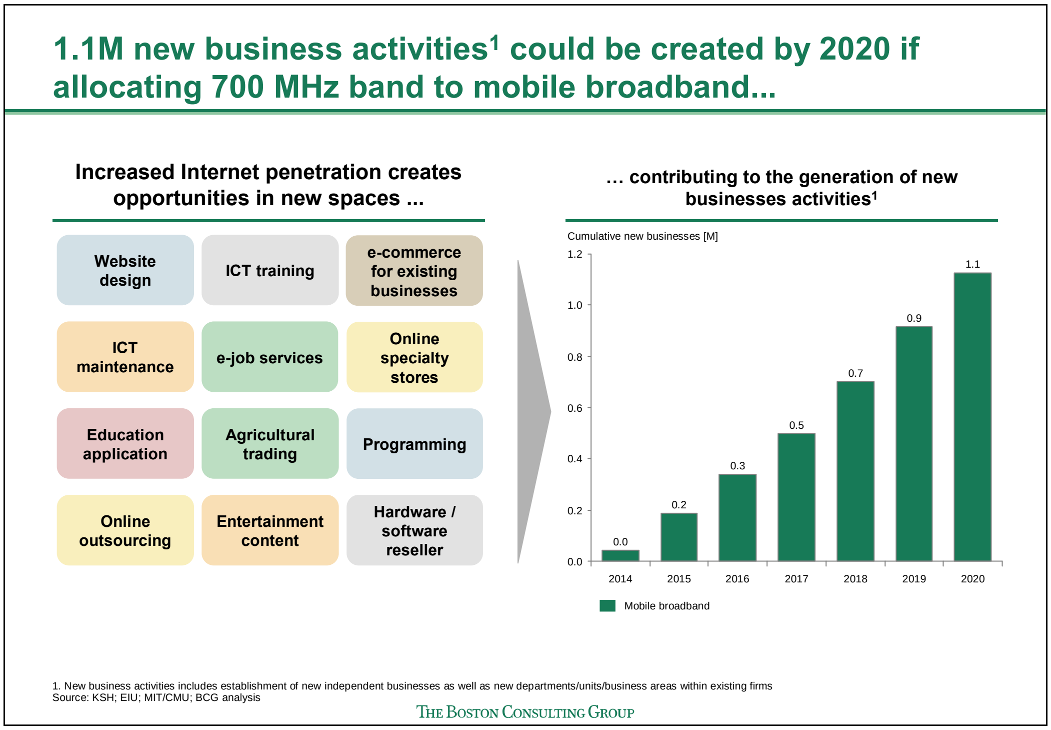

Exhibit 1.6 New business activities

This range of fresh enterprises, many of them in rural areas that previously had little or no Internet presence, is projected to generate 2.3 million new jobs between 2014 and 2020. This is a conservative estimate, excluding any jobs generated by increased productivity in existing firms. In contrast, broadcasting is expected to generate less than 100,000 jobs.

All of this would add up to a considerably greater tax take for governments in the region, who could look forward to enhanced income primarily from corporation tax, VAT and income tax. The government revenues generated by mobile would come to $131B over the period from 2014 to 2020, of which more than half would come from corporation tax. As broadcasting is only expected to yield tax revenues of $28B, mobile broadband will yield US$103B (net present value of US$76B) more than broadcast with respect to taxes.

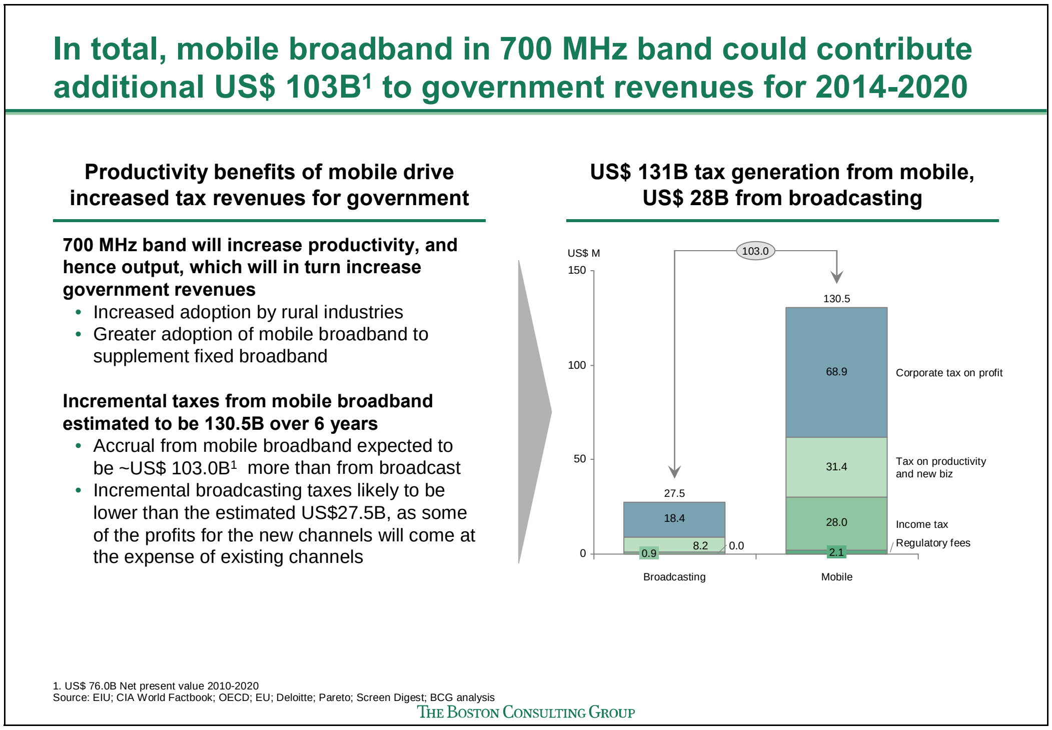

Exhibit 1.7 Government revenues

Apart from its greater economic impact, mobile broadband will also generate far greater social benefits than broadcasting, particularly since the primary social benefits from broadcasting (e.g., showcasing local culture, public service broadcasting) could easily be met without the 700 MHz band.

1.5 Social Benefits

One of the greatest challenges facing the Asia Pacific over the next decade will be addressing the UN Millennium Development goals. In spite of progress over recent years, it is still some way behind on a number of targets, and needs to find means of empowering individuals and giving opportunities to excluded groups, such as women.

Its greatest worry is the persistence of hunger and poverty, where little progress is being made. The region includes the world's largest mass of income poverty and 14 countries rated as "least developed" in the UN Human Development Index. It is highly exposed to economic crises and natural disasters and still, in spite of its recent growth, suffers persistent hunger. Income inequalities are severe and widening, with the per capita income ratio of the richest and poorest 5 per cent of the population doubling between 1980 and 2005.

Also, much of the region's agriculture and industry remains inefficient by global standards, while economies depend heavily on exports and competitiveness founded on cheap labour rather than high productivity. Women continue to be held back and disadvantaged.

Mobile broadband would be a highly effective means of addressing these issues, particularly in rural areas where it would facilitate accessible education, improved healthcare and financial inclusion.

1.5.1 Education

In education, serious problems include the lack of adequate schooling resources in rural areas and gender inequalities in access to formal education. Statistics from India, Malaysia and the Philippines show rural areas generally lagging around 20 per cent behind towns and cities in terms of both access to sufficient schooling resources (as defined by the Organization for Economic Co-operation and Development) and access to computers.

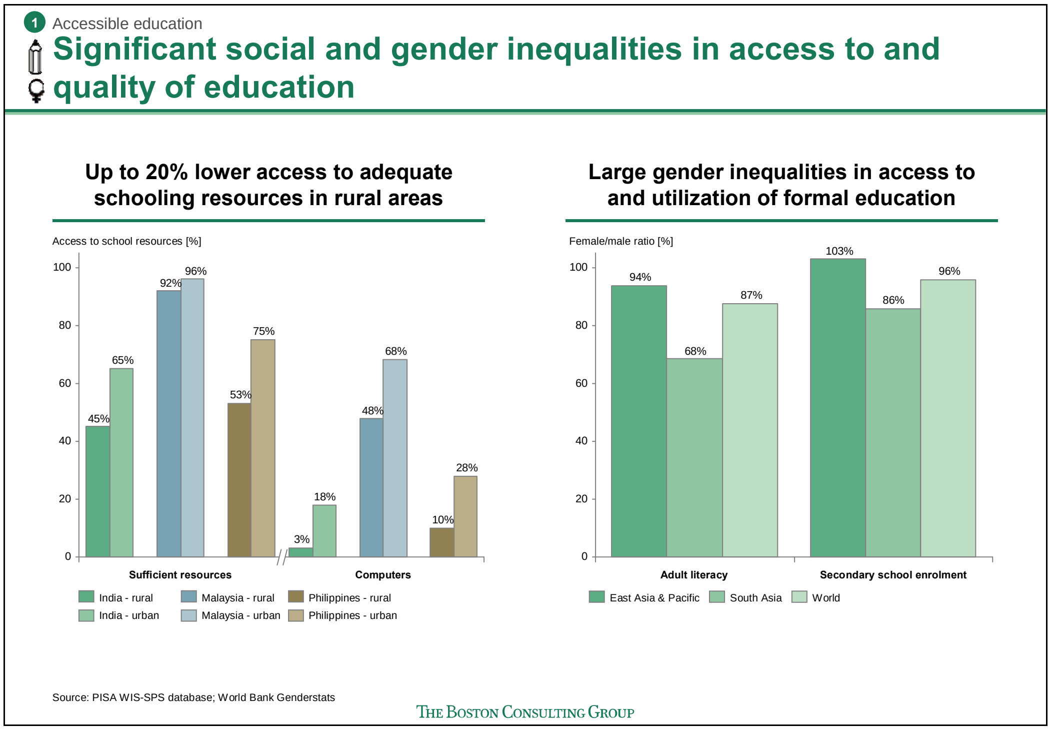

Exhibit 1.8 Social and gender inequalities in education

Gender inequalities in education are particularly pronounced in South Asia, as illustrated by Exhibit 1.8. Female adult literacy is only 68 per cent of male levels in South Asia, compared to a world average of 87 per cent and the East Asia Pacific norm of 94 per cent. A significant element in this is poor access to formal education. Female enrolment levels for secondary schooling in South Asia are 86 per cent of the male, compared to 96 per cent worldwide and 103 per cent in East Asia Pacific

Broadband would provide a highly effective and efficient means of addressing these inequalities. Students in rural areas short of facilities, resources and teachers would have access to low cost resources literally in the palm of their hands, helping excluded groups like women and the poor. Basic devices would, for instance, give access to online tools offering basic distance education. Applications installed on smartphones will encourage students to engage outside the classroom. Project K-Nect in North Carolina, USA, for example, improved student test results in mathematics by 30 per cent using smartphone applications.

Tertiary education would also become more accessible to those who are unable to travel to traditional universities. Online degrees are becoming more widespread and, as they increasingly supplement more traditional degrees, more accepted. A survey of American employers and hiring managers found that 82 per cent would accept an online degree and that 23 per cent rated them as having equal standing with more traditional qualifications. Such alternative methods of education can provide an avenue for rural citizens as well as women to close the income and achievement gap with their urban counterparts.

1.5.2 Health

Similar patterns of rural and female exclusion, which can be addressed through health education and better access to basic services, are evident in healthcare. Rural residents generally have fewer doctors per head than their urban counterparts, and also exhibit lower awareness of the risks to their health. There is also a substantial need for better information on key topics such as family planning and maternal health. Exhibit 1.9 shows that, for example, up to 40% of women in Laos and 25% in Nepal have unmet needs for information on family planning and contraception.

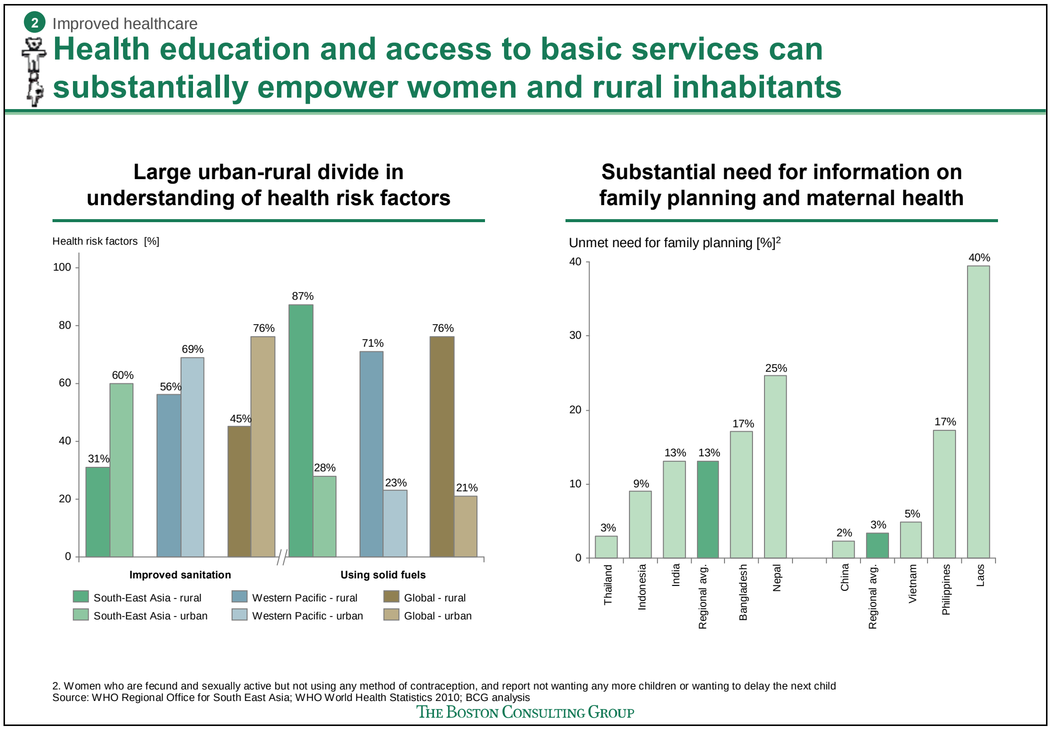

Exhibit 1.9 Empowerment of women and rural inhabitants

Mobile broadband can provide better services, education and awareness that would improve the lives of excluded groups:

- Rural areas could mitigate the shortage of local doctors and specialists by mobile programmes linking them to urban experts via medical assistants in the field and webcams. For example, the Alokito initiative in Bangladesh sends teams of nurses out to rural areas, while the doctors provide diagnosis and treatment advice from urban hospitals via high-speed video-conference.
- UNAIDS has been using social networking sites such as Facebook and Youtube to spread information on HIV/AIDS. Family planning issues can be addressed through similar channels.
- Mobile broadband can increase access to critical health education by offering online training for health workers and making critical disease information available in underserved areas.

- In addition, mobile broadband can facilitate two-way communication to enable the tracking of rural health issues and improve the collection and analysis of the health information essential to policy making.

1.5.3 Financial Exclusion

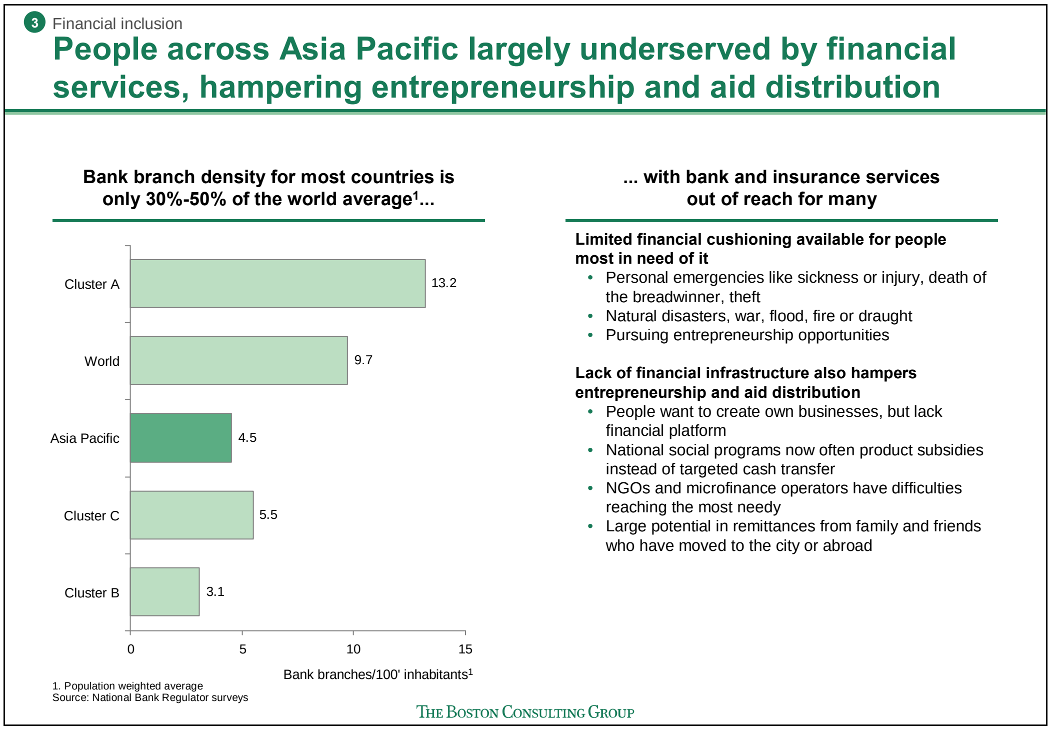

Exhibit 1.10 Lack of financial services in Asia Pacific

Among the most serious handicaps facing Asia Pacific is the lack of financial services, which hampers both entrepreneurship and the distribution of aid. As Exhibit 1.10 shows, bank branch density across the region is less than half the world average, falling to less than a third across the Cluster B countries (which include Malaysia, Indonesia and China).

Many either lack awareness or find bank and insurance services too expensive and inaccessible, leaving them short of financial cushioning in the case of personal emergencies or natural disasters, and without the credit essential to entrepreneurship. National social programmes are forced to operate through subsidies rather than cash transfers, while NGOs and microfinance programmes have trouble reaching the neediest.

Access to banking would also facilitate the receipt of remittances from friends and family who have moved to cities or abroad.

Mobile broadband can help address these issues and improve economic and employment opportunities in rural areas. Internet-enabled mobile terminals would bring banking – with its convenience, security, low costs and access to credit – within the reach of many of those who are now excluded, while micro-insurance via mobile accounts can provide protection against financial shocks.

It would encourage home-based entrepreneurship by increasing the range of possible livelihoods and offering opportunities both to sell goods in regional and global marketplaces – such as the Etsy site for handicrafts – and to participate in outsourced services like website coding and data entry. Home-based work also offers women an opportunity to earn a living and become financially independent in societies where they may not be allowed to leave home to seek work.

Broadband would also offer businesses online tools like inventory planning, and give individuals the opportunity to improve financial literacy and management planning through accessing a vast range of online information and services, like Mint.com for budget tracking and on-line mortgage sites. These tools lower the cost of operations for small businessmen, who may otherwise need to purchase expensive software, and hence could potentially provide rural entrepreneurs the edge they need to succeed.

1.5.4 Facilitation of e-government

Mobile broadband could greatly increase efficiency in the provision of government services, especially in rural areas. For instance in rural Indonesia and India, a significant amount of resources are usually spent on basic paper-based filing, necessitating large staffs and high transportation and material costs. E-government could also improve the quality and availability of government services, reducing processing times and thus improving national competitiveness for many countries across the Asia Pacific. Even countries like Korea, which are already advanced in terms of providing e-Government services for its citizens and businesses, could benefit from 700 MHz band mobile broadband, as it would effectively increase the number of Internet subscriptions in rural areas.

1.6 Implications for Governments and Regulators

Throughout this study, the estimates of benefits have been premised on an appropriate and supportive government policy. They are dependent on governments allocating the internationally harmonized frequency band 698-806 MHz, and implementing the Asia Pacific technical harmonization (the APT bandplan for FDD deployment in the 2X45 MHz based technical harmonisation) to ensure their consumers and society benefit from the economies of scale in handset and network equipment production. Countries which fail on either harmonized allocation of the frequency band or technical harmonization of the frequency band could risk losing out on the potential benefits.

Without access to the 108 MHz of bandwidth, effective rollout may become more difficult. There may be insufficient bandwidth for ensuring effective competition between mobile network operators, which may in turn reduce the range and quality of services, and may lead to increased consumer prices for subscriptions.

Without implementation of the technical harmonisation based on the 2X45 MHz APT bandplan, economies of scale in network equipment and handset production are lost. The 9th Meeting of the APT Wireless Forum (AWF-9), held from 13 to 16 September 2010 in Seoul, Korea, agreed on the planning of the UHF band. It adopted two band plans. One was based on the 2 x 45 MHz with a conventional duplex direction which is the bandplan supported by the GSM Association and its members and associates. The APT harmonised UHF bandplan for IMT is a 2X45 MHz bandplan within the 698-806 MHz band and with a lower guard-band of 5 MHz between 698-703 MHz and an upper guard-band of 3 MHz between 803-806 MHz, as shown in Exhibit 1.11.

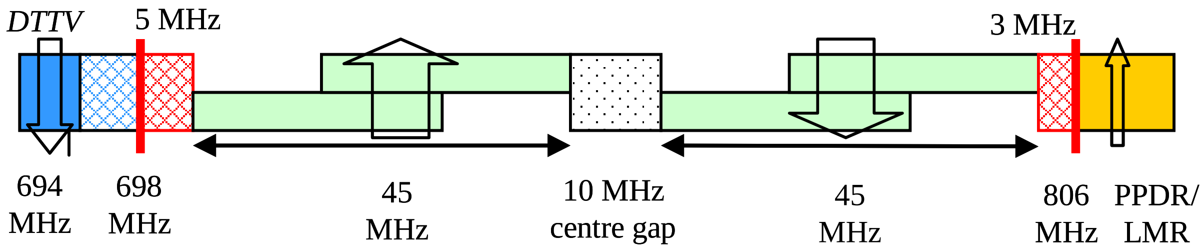

Exhibit 1.11: Harmonised FDD Arrangement of 698-806 MHz band

Countries which are out of sync with the agreed band plans will lose out, because harmonization maximizes economies of scale, limits the risk of cross-border interference and improves overall usage quality. Especially for relatively small markets like Korea, Malaysia and Indonesia, but even for a market of the size of India, in the worst case scenario, handsets may not be available, or the range of models available to consumers will be very limited. In the "best case" scenario, failure to harmonize would raise handsets costs, which negates some of the benefits of 700 MHz broadband. In addition failure to harmonize adds to the cost of establishing and maintaining the mobile network because of the need for technical adjustments, such as filtering solutions and other modifications to transmitters to adjust to non-harmonized band edges.

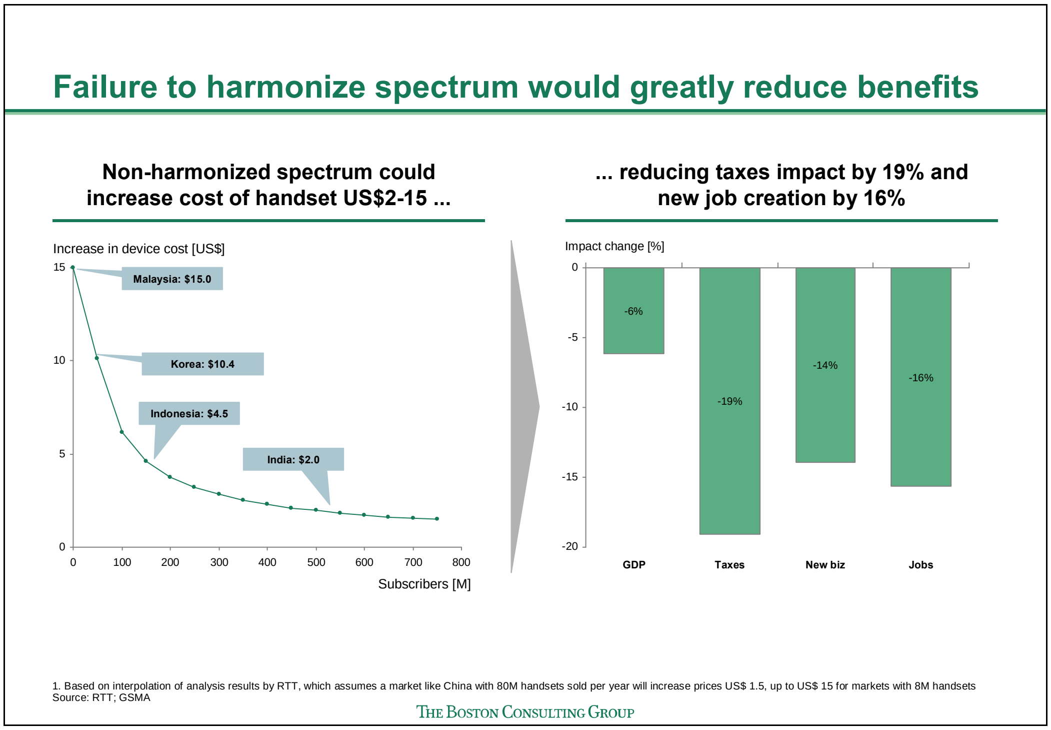

Exhibit 1.12 Potential impact of non-harmonization

The effects would be most acute in smaller markets like Malaysia, with an increase in handset price up to $15. There would potentially be higher handset costs even in India ($2) and China ($1.50), the largest mobile markets on earth. Increased device costs would prohibit poorer users from adopting, which translates into reducing the potential benefits of 700 MHz band across the whole region – costing 6% of addition to GDP, 14% of the new businesses, 16% of the jobs and 19% of the extra tax income that would be generated by a harmonized rollout.

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered.

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2 KOREA

2.1 Introduction

Korea has a population of 48.8 million (2010). After doubling over the past half century, the population has stabilised, with growth of only 0.3% in 2009.

Formerly an agricultural country, it is now highly urbanised, with 81 per cent of its population living in towns or cities. However, Korea still has substantial and widening income inequality, with the highest income quintile earning 5.76 times that of the lowest quintile in 2009.

That said, Korea's economy and society has undergone vast transformation over recent decades. In the 1960s it was comparable to the poorest countries in Asia and Africa; in 2010 it was rated in the United Nations Human Development Report as having Very High Human Development. Ranked 26th worldwide with a rating of 0.94 it is topped in Asia only by Singapore (23rd) and Hong Kong (24th). It ranks much higher than 26th on gross enrolment ratio, in which it is 9th, and on the HDI education index (also 9th), but does poorly on women's issues, ranking 98th on the gender-rated development index and 148th on the female enrolment percentage.

2.2 Adoption

Korea is close to saturation on mobile phone ownership, with penetration above 90 per cent. It already has one of the highest broadband penetrations in the world at 34 per cent. Korean penetration is well ahead of the United States and Japan, as well as the OECD average of 23 per cent.

Korea also enjoys faster broadband than most European countries. Its average speed of 53 Mbps per second is exceeded only by Japan, Portugal and France – none of which can match its level of penetration.

However, while Korea can fairly claim to be a world leader in the provision of high-speed fixed line broadband, allocating the 698-806 MHz band to mobile broadband can still be beneficial. Such an allocation would generate significant increments in adoption, particularly in the rural areas.

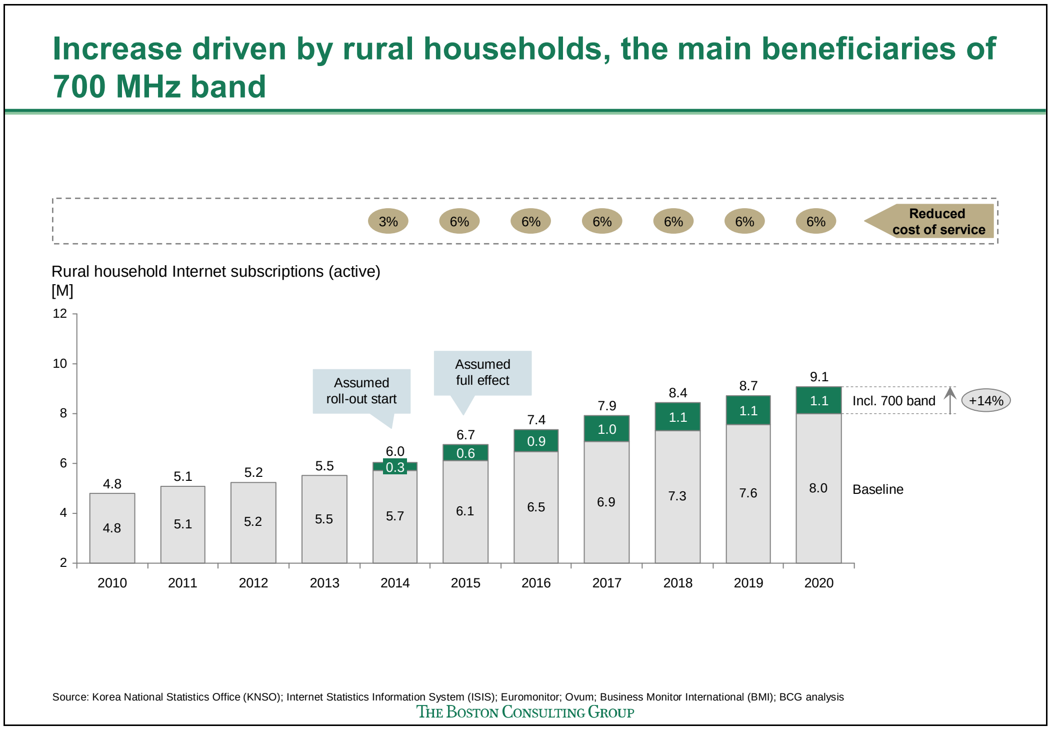

Exhibit 2.1 Increase in rural adoption

Making use of the Digital Dividend would make a significant difference to the take-up of broadband in Korea's rural areas, as demonstrated in Exhibit 2.1. Without it, take-up will grow more gradually– from 4.8 million active rural Internet subscriptions in 2010 to 8.0 million in 2020. With mobile broadband in the 700 MHz band, rural Internet subscriptions would increase to 9.1 million by 2020. Those extra 1.1 million subscriptions represent a 14 per cent increment on the total number of rural broadband connections.

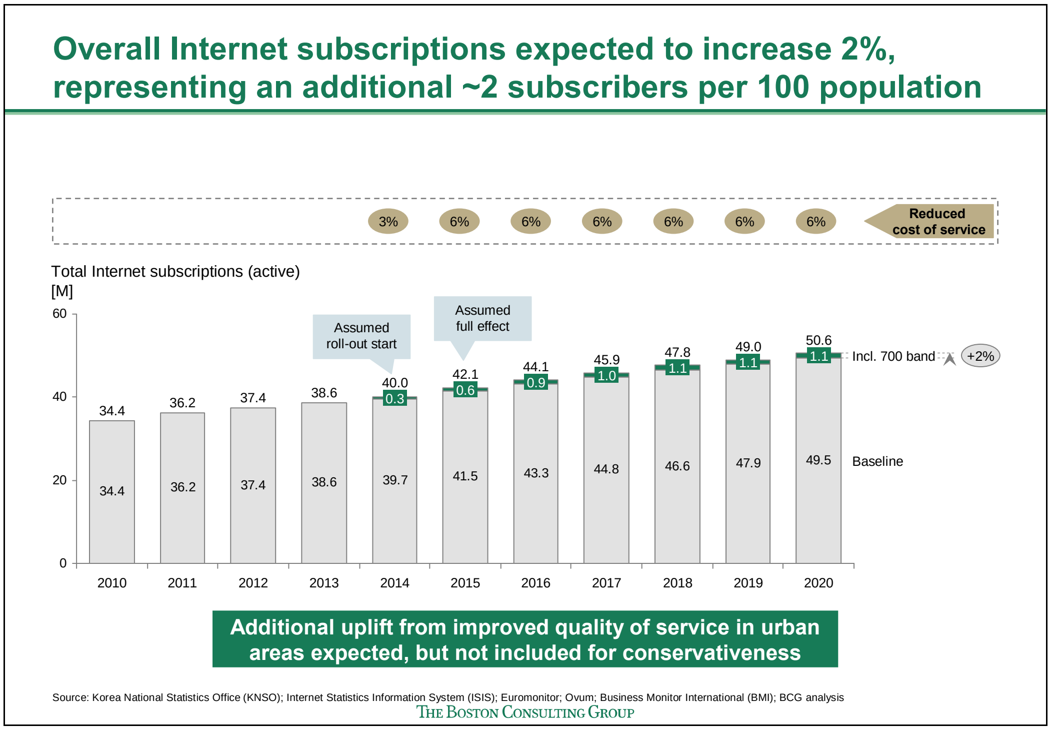

Exhibit 2.2 Increase in overall subscriptions

They would also account for a national increase of 2 per cent in Internet subscriptions, which would help take penetration close to 100% (Exhibit 2.2). This is not unlikely, given that increasing numbers of households already have multiple Internet connections, one at home, on their mobile, and perhaps at work.

2.3 Economic Benefits

Even starting from a relatively high base, the increase in adoption brought about by broadband in the 698-806 MHz band would still bring greater economic benefit to Korea ,compared to broadcasting.

Estimates are based on the assumption of a 50 per cent roll out in the first year (2014), with completion in the second, but are pitched conservatively – excluding, for instance, new jobs likely to be generated by increased efficiency in existing firms from analysis of job creation. They show that enabling high speed mobile broadband can bring significant added value even to what is already a large, highly sophisticated economy with world-leading fixed line broadband capacity.

Korea's annual GDP has already passed the trillion dollar barrier, and it can expect to add $68.3B in GDP in the six years to 2020 should it devote the 700 MHz band to mobile (net present value of $59.8B), over and above the expected contribution from broadcasting.

More than 75 per cent of this would come from improved productivity in existing companies, taking advantage of the greater speed and flexibility offered by mobile connections.

The main beneficiary of these improvements would be the service sector, which is expected to enjoy a 0.8 per cent increase in productivity directly attributable to 700 MHz band mobile broadband, as can be seen in Exhibit 2.3. Manufacturing would benefit by approximately 0.4 per cent. In contrast, allocating the Digital Dividend to broadcasting would generate no additional productivity increase.

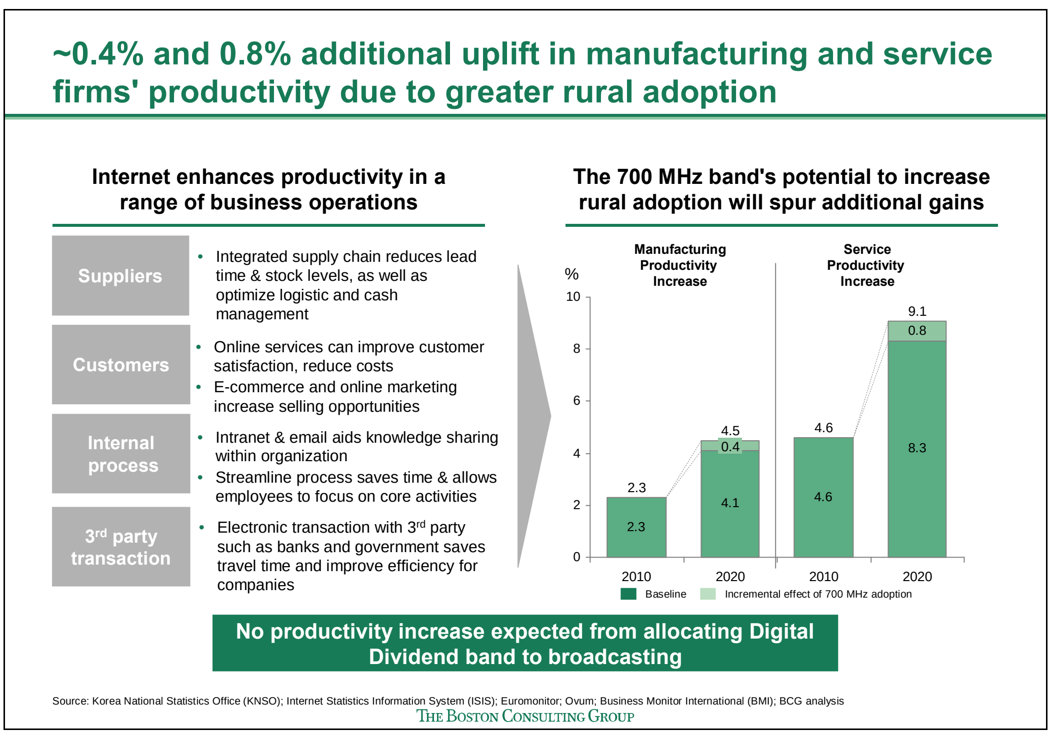

Exhibit 2.3 Productivity uplift from broadband in the 700 MHz band

Slightly under a quarter of the GDP impact would come from the additional 19,600 new business activities that will be stimulated by the 700 MHz band. These would include not only directly web-related enterprises such as web design, service development and ICT maintenance and training, but also businesses whose existence is made possible by more widely available, faster broadband connections. These include agricultural traders, online specialty stores and providers of entertainment and education. Broadcasting is not expected to significantly stimulate new business activities outside its own value chain.

More than 37,800 jobs, many of them in Korea's rural regions and varying from highly sophisticated technical posts to basic service functions such as distribution would be created by these new companies. Broadcasting would, by contrast, likely create only 3,000 new jobs.

All of this would give the government of Korea a substantial tax dividend in return for any decision to devote its Digital Dividend to mobile broadband. The increased adoption of mobile broadband not only by rural industries getting online for the first time, but also as a supplement to fixed broadband for companies that are already connected, would generate a further $7.2B in tax revenues between 2014 and 2020. The bulk would come from taxing corporate profits, with VAT and Income Tax also contributing. The tax dividend from a broadcasting option would be less than a third of the mobile tax take, at $2.3B.

2.4 Social Benefits

While the potential economic benefits from allocating the 700 MHz band to broadband are clear, they are just one aspect of the potential benefits, as the social dividend from such a decision is also likely to be significant.

Wider availability of quick, inexpensive mobile broadband would bring the benefits of the Internet to those currently excluded. In particular it has the potential to help alleviate poverty in Korea's rural areas, and become a lever towards reaching targets set out in Korea's Five-year Basic Plan for Rural Development, as shown in Exhibit 2.4.

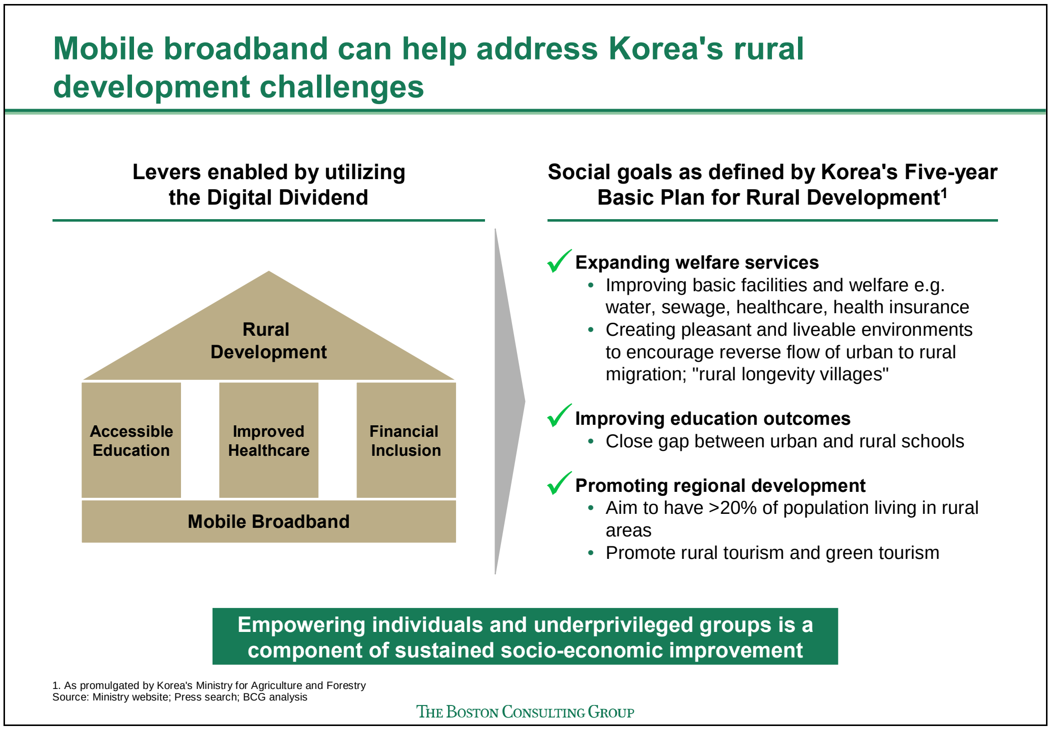

Exhibit 2.4 Korea's Five-year Basic Plan for Rural Development

This plan focuses on main issues such as expanding welfare services, improving education outcomes, and specifically promoting regional development. The rural population has not only failed to share in Korea's spectacular economic growth, but can be argued to have been victims of it, as summarized in Exhibit 2.5.

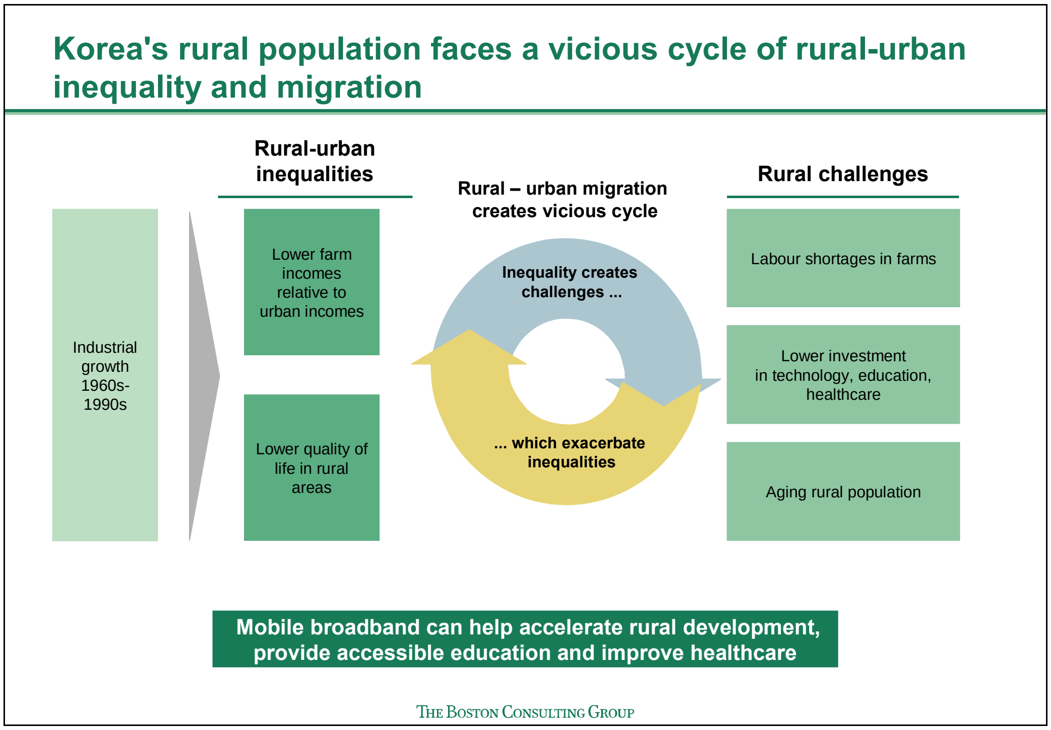

Exhibit 2.5 Rural-urban migration cycle in Korea

As urban incomes rose as a consequence of rapid industrialization from the 1960s onwards, the youngest, most energetic and most capable among Korea's rural population deserted the countryside for the city. More than 72 per cent of Korea's people lived outside the towns and cities in 1960. In 35 years this proportion fell to 22 per cent. While the drift has slowed since – in 2005 the figure was 19 per cent – disparities between rural and urban incomes have continued to grow. In 1995 agricultural household income was 95 per cent of the urban norm. By 2005 this was down to 78 per cent.

Rural areas are afflicted by a vicious cycle where rural-urban migration hollows out the rural areas and exacerbates rural challenges. The population has aged, with nearly one third of farmers in 2005 being more than 65 years old, and rural industries experience a chronic shortage of workers. Education has become a concern as rural schools become subscale. Such developments encourage further migration and perpetuate the cycle.

2.4.1 Rural Development

Readily available mobile broadband will help rural areas to become more competitive, helping to reverse their decline. For example, it can help make small, backward and unprofitable farms more productive. Broadband phones can access data essential for planning and decision making – a good example is the FieldServer system in Japan which costs less than $300 but offers access to sensors for temperature, solar radiation and moisture.

This data can be integrated with web-based Geographical Information Systems, leading on to higher yields and cost efficiency. This enables better use of resources like water and fertilizer, dynamic decision support on matters like pest identification and remote diagnosis by experts connected through videoconferencing.

Farmers will have to be trained in the adoption and use of these technologies, but this in itself will be made more feasible by more accessible broadband. So too will the diversification of income sources needed by rural areas.

Mobile broadband can also create wider opportunities for entrepreneurs. High bandwidth enables innovative businesses such as 'virtual farms' operated via webcams under which farmers tend crops on behalf of the urban owners, helping the farmers diversify their sources of income and vulnerability to crop prices.

It would also give fresh impetus to Korea's developing rural tourism market. Urban Koreans are showing an increasing taste for countryside outings and holidays, a market that has grown at a compound annual rate of 8 per cent in the decade to 2011. A substantial proportion of businessmen working in this sector (39 per cent) saw web marketing as their most effective tool for promotion, with higher bandwidths enabling better customer service and more imaginative marketing. At the same time, increased broadband infrastructure makes it far easier for businessmen and home-based entrepreneurs to operate from rural areas, further helping to boost tourism.

2.4.2 Education

Nowhere is the vicious cycle of rural decline more evident than in the education sector. As can be seen in Exhibit 2.6, decreasing numbers of students leads to school closures, declining achievement, loss of confidence in remaining rural schools and a further drift to the city. Nearly one third of rural schools are classified as small – with fewer than six classes - compared to 1 per cent in the city. All of this impacts performance. Korean students as a whole perform well by international standards, doing 3 per cent better than the OECD average under the Programme for International Student Assessment. For rural students, though, the pattern is reversed, with pupils from the Korean countryside performing 4.7 per cent worse than the OECD norm and 12 per cent worse than their urban compatriots.

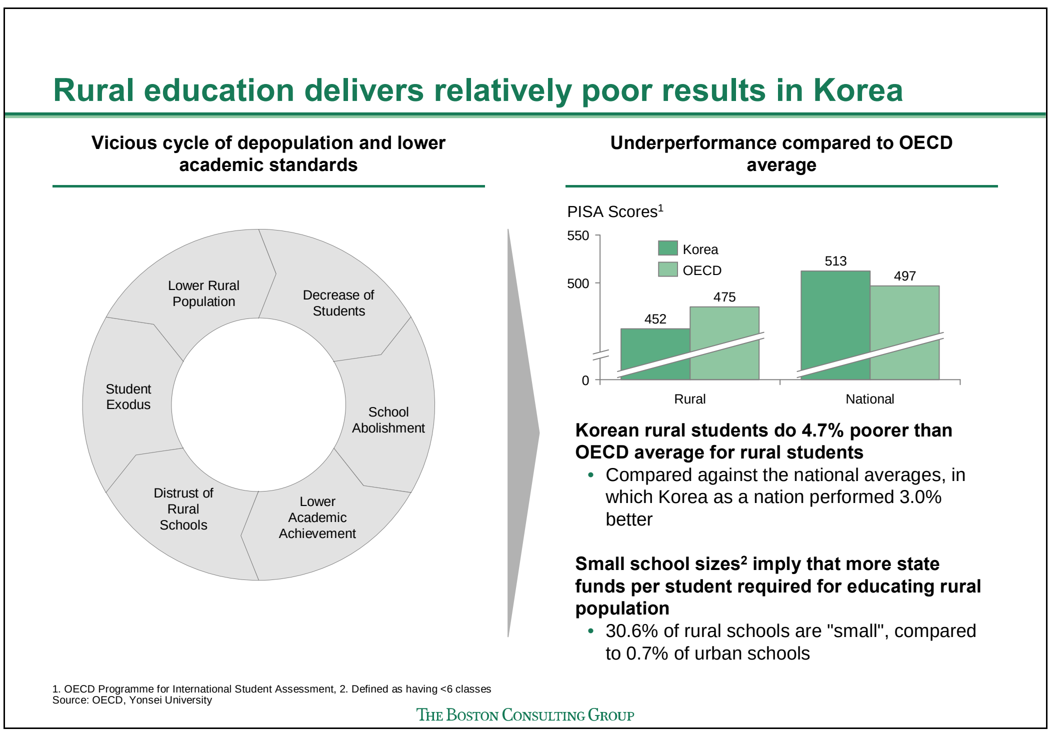

Exhibit 2.6 Status of rural education

This decline could be reversed by basic distance education in remote areas, often using inexpensive online tools that remove the need to buy costly programmes such as dictionaries. Smartphone applications like Project K-Nect, which improved the mathematics performance of students in North Carolina, USA by 30 per cent, can encourage learning outside the classroom.

Online learning also assists in developing the language skills increasingly important in a globalised world. Eleutian Technology has already used Skype to teach English in Korea while Livemocha, the world's largest language learning community, offering free and paid online courses in 35 languages, with direct contact via a website to native speakers for conversation practice.

Tertiary education would also benefit, with online courses – much more easily accessible to those in remote areas or with work and family commitments – becoming more available. As such courses become more familiar, they are also becoming more widely accepted. A survey in 2008 of American employers and hiring managers found that 82 per cent would accept an online degree as credible, with 23 per cent rating them as highly as more traditional qualifications.

All of this would add to up to a transformation of Korea's rural areas, allowing them to share in the benefits now taken for granted in its cities.

2.4.3 Healthcare

Local healthcare in rural areas faces special challenges due to the quickly aging population (both natural aging and as a result of migration of young people to urban areas). Exhibit 2.7 shows that, in 2005, nearly one in five rural residents was reported to be 65 or over, more than twice the proportion in cities. Furthermore, those heavily engaged in agriculture have special health challenges. Farmers have higher incidences of arthritis, back disorders and chronic respiratory diseases than the population as a whole, and are 37 per cent more likely to visit their doctor than urban workers.

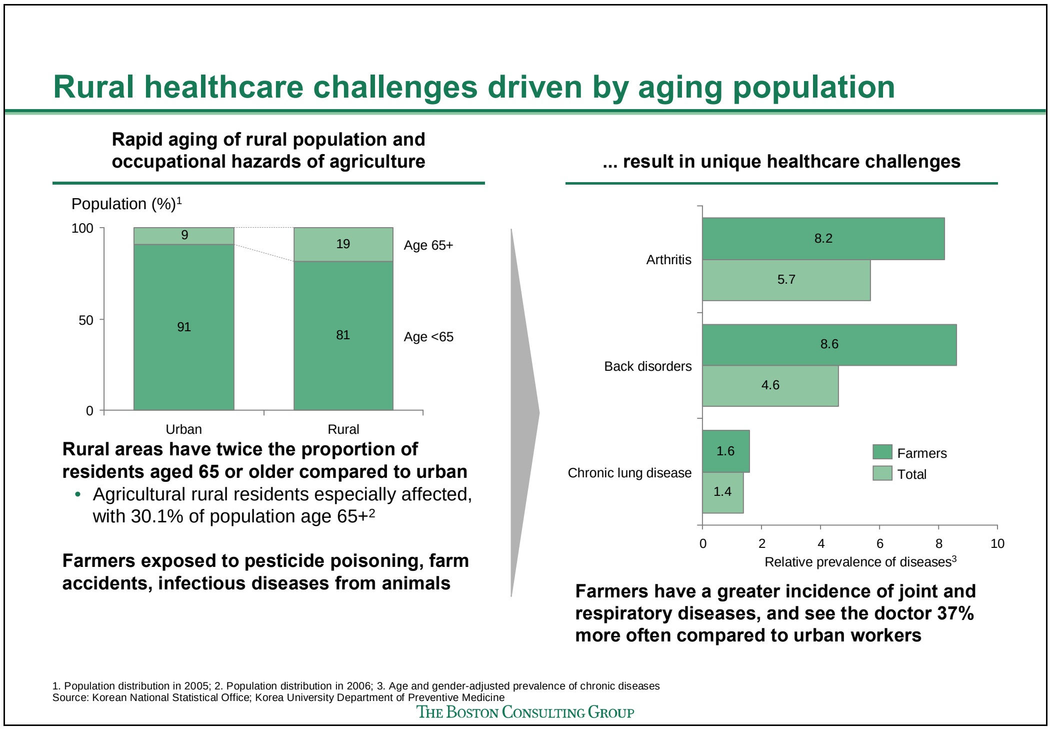

Exhibit 2.7 Healthcare challenges in Korea

Mobile broadband would give health workers in rural areas better access to training and up-to-date information on medical science and treatments. Critical information and services provided by government and NGOs would be much more readily available, helping in particular with 'taboo' issues like HIV/AIDS and sexual health.

Specialist expertise previously confined to the cities can be made available to patients in the countryside via remote connections. Virtual consultations, made possible by inexpensive webcams and rural broadband, can take place over websites. Companies like KW Corp will be able to extend 'Ubiquitous Healthcare' services, which are currently only rolled out in the cities, to the rural areas, with remote payments possible for consultations and drugs.

Patients will also be able to do more to help themselves through home-based monitoring systems and movement sensors, reducing the need for clinic visits and assisting the elderly to live independently. Doctors will have better information on drug usage and compliance with prescriptions, and could dispense medication in GlowCaps, containers that remind patients when to take their doses.

2.4.3 e-Government

Korea is currently ranked by the United Nations as the world leader in e-Government, with extensive services provided for citizens and businesses, and in government-to-government interaction, as shown in Exhibit 2.8. However, there is a persistant digital divide between urban and rural users, who would benefit greatly from access via mobile broadband in the 700 MHz band. For rural residents, access to e-Participation, e-Voting and online citizen services would reduce transaction costs and travelling time, while businesses and entrepreneurs would also benefit from gaining access to services like tax return, e-Procurement, paperless trade and e-Customs.

Allocating the 700 MHz band to mobile broadband would potentially also benefit rural governmental institutions, empowering them with e-Inclusion services like e-Document handling, local e-Learning and the On-nara BPS information system for improving efficiency of governmental business procedures.

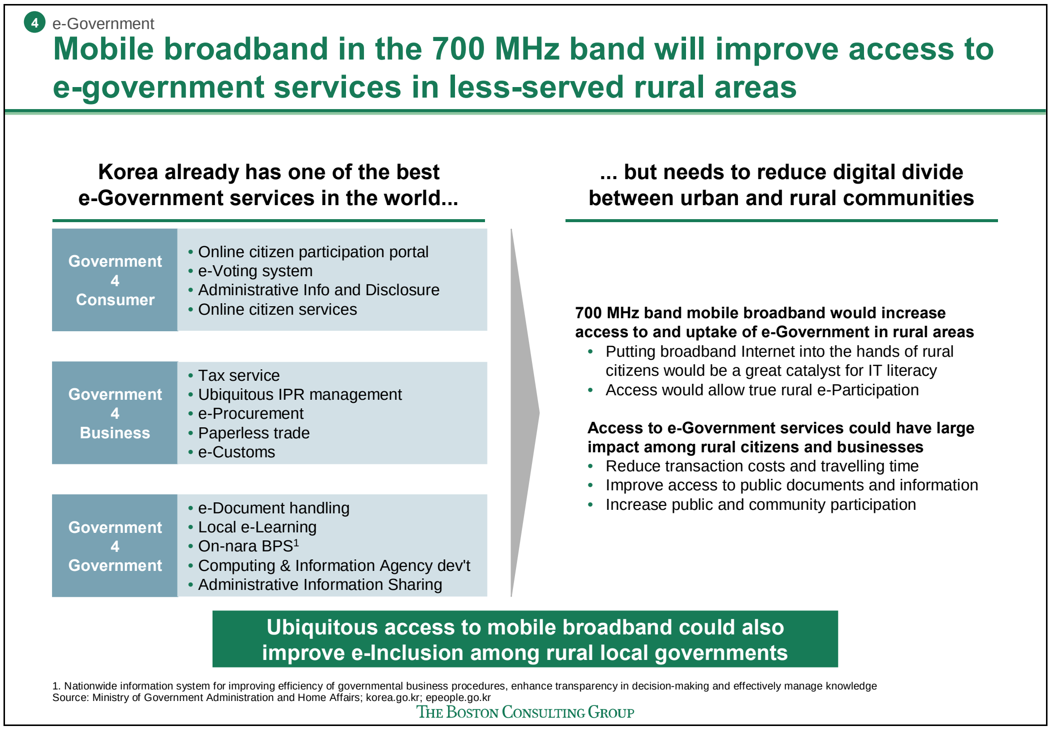

Exhibit 2.8 Korea's e-Government

2.5 Implications for Governments and Regulators

Throughout this study, the estimates of benefits have been premised on an appropriate and supportive government policy. They are dependent on governments allocating the internationally harmonized frequency band 698-806 MHz, and implementing the Asia Pacific technical harmonization (the APT bandplan for FDD deployment in the 2X45 MHz based technical harmonisation) to ensure their consumers and society benefit from the economies of scale in handset and network equipment production. Countries which fail on either harmonized allocation of the frequency band or technical harmonization of the frequency band could risk losing out on the potential benefits.

Without access to the 108 MHz of bandwidth, effective rollout may become more difficult. There may be insufficient bandwidth for ensuring effective competition between mobile network operators, which may in turn reduce the range and quality of services, and may lead to increased consumer prices for subscriptions.

Without implementation of the technical harmonisation based on the 2X45 MHz APT bandplan, economies of scale in network equipment and handset production are lost. The 9th Meeting of the APT Wireless Forum (AWF-9), held from 13 to 16 September 2010 in Seoul, Korea, agreed on the planning of the UHF band. It adopted two band plans. One was based on the 2 x 45 MHz with a conventional duplex direction which is the bandplan supported by the GSM Association and its members and associates. The APT harmonised UHF bandplan for IMT is a 2X45 MHz bandplan within the 698-806 MHz band and with a lower guard-band of 5 MHz between 698-703 MHz and an upper guard-band of 3 MHz between 803-806 MHz.

Countries which are out of sync with the agreed band plans will lose out, because harmonization maximizes economies of scale, limits the risk of cross-border interference and improves overall usage quality. Especially for relatively small markets like Korea, Malaysia and Indonesia, but even for a market of the size of India, in the worst case scenario, handsets may not be available, or the range of models available to consumers will be very limited. In the “best case” scenario, failure to harmonize would raise handsets costs, which negates some of the benefits of 700 MHz broadband. In addition failure to harmonize adds to the cost of establishing and maintaining the mobile network because of the need for technical adjustments, such as filtering solutions and other modifications to transmitters to adjust to non-harmonized band edges.

It is estimated that non-harmonization would reduce the projected increment in adoption by 15%, GDP impact by 16% and other economic benefits by 60% or more.

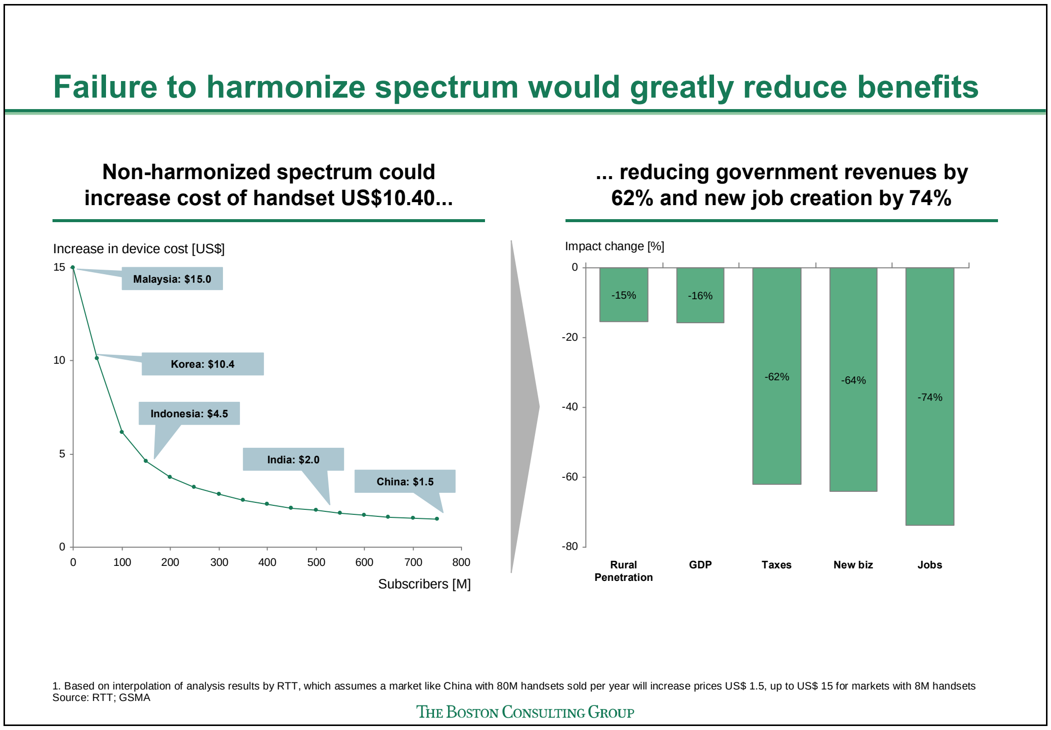

Exhibit 2.10 Impact of non-harmonization

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered. In particular, prices for spectrum fees should be set to ensure that rural areas get the low-cost provision essential for their needs.

3 Malaysia

3.1 Introduction to Malaysia

Malaysia has a current population of 28.3M (2009) following growth over the past decade of around 2 per cent per annum. It has also been subject to rapid urbanisation, at an annual rate of around three per cent - currently 68.2% of Malaysia's people live in towns and cities. By 2020 this proportion is likely to have risen to more than three-quarters (78.5 per cent).

The United Nations ranks it as a country of High Human Development. The 2009 UN Human Development report ranked Malaysia 66th worldwide on its Human Development Index, with a rating of 0.829. Malaysia ranks higher than 66th on a number of key indicators within the index – 25th on the Human Poverty Index, 29th on the likelihood of surviving to the age of 40, 55th on life expectancy and 62nd for adult literacy (91.9 per cent). It does less well on gross education enrolment (102nd) and on issues affecting women, and is ranked 76th on the gender-related development index.

3.2 Adoption

Mobile phone subscriber growth has slowed in Malaysia as the country is close to saturation. Following extremely rapid growth before 2009, there are now more than 30 million SIMs in Malaysia - 107 for every 100 head of population.

Internet use has also grown, with just under half of the population – 45.9 per cent in 2009 – using the net. There has been a recent increase in the number of these people using broadband, with the number of fixed broadband subscriptions increasing by 25 per cent in 2008 and 53 per cent last year.

Malaysia is also planning substantial investment in high speed fixed line broadband (High-Speed Broadband or HSBB project), with a RM2.4B public private partnership contract announced as part of a stimulus package in March 2009. The HSBB project, spread over the next 10 years, prioritises those already well served, with commercial zones the number one priority and rural areas only third.

In contrast, allocating the 700 MHz band to mobile broadband could create 800,000 additional subscribers in rural districts by 2020 (as can be seen in Exhibit 3.1). This represents a 23% increase on the baseline. Rural households currently account for one in five Malaysian Internet subscriptions, even though they make up nearly one third of the population. Given the Digital Dividend, rural areas will close this gap by 2020 – accounting for 24 per cent of subscriptions and 26 per cent of the population.

Overall, the Digital Dividend is projected to increase Malaysia's Internet subscribers by 5% in 2020, equivalent to 3 subscribers per 100 population.

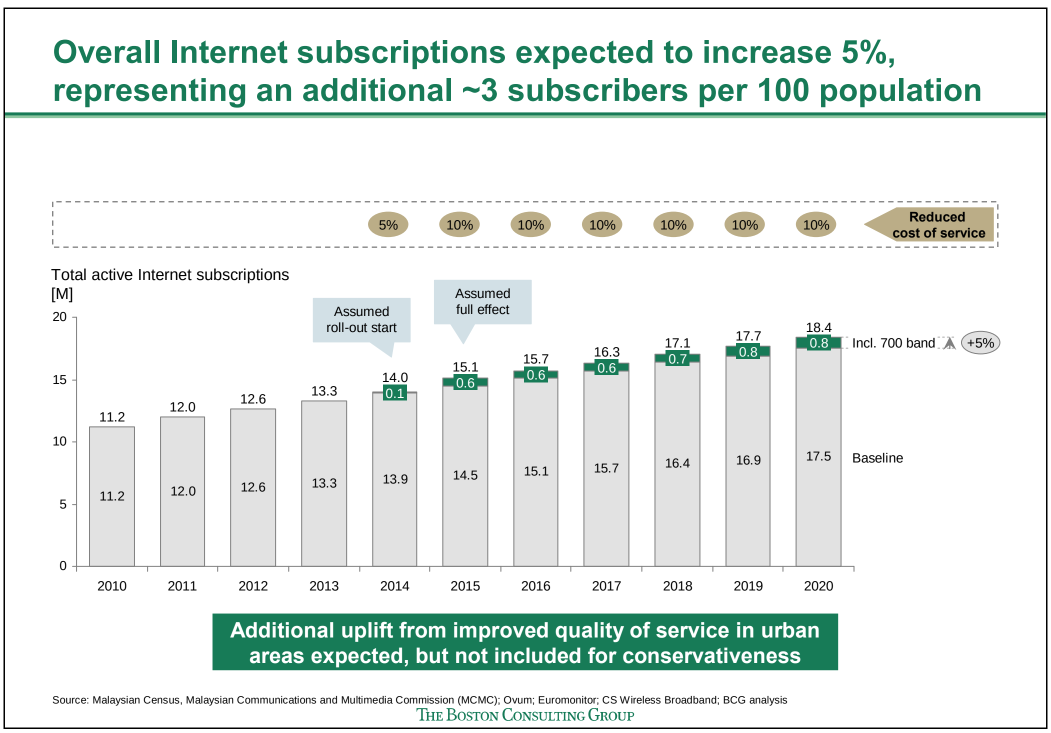

Exhibit 3.1 Effect of 700 MHz broadband on Internet subscriptions

3.3 Economic Benefits

The economic impact of this increased adoption is clear, even when assumptions are cast conservatively. Assuming a 50 per cent rollout effect in the first year of conversion (2014) and 100 per cent in the following year, mobile broadband will be much more effective than the likeliest alternative user of the 700 MHz band – broadcasting – in generating gross domestic product, government revenues, new businesses and extra jobs.

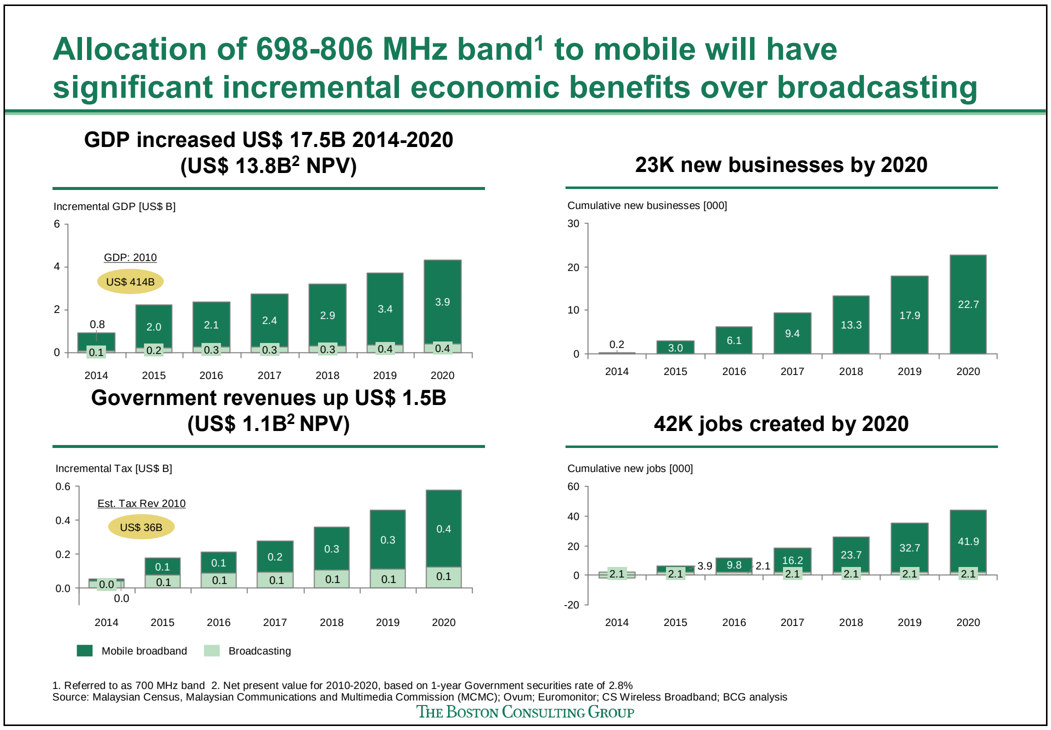

Exhibit 3.2 Economic impact of allocating 700 MHz band to mobile broadband

Exhibit 3.2 summarizes the effects of allocating the 700 MHz band to mobile broadband. The economic opportunities created by improved access to mobile broadband would be expected to generate, at current prices, an extra $17.5B in GDP for the period 2014-2020 (net present value of $13.8B - equivalent to around three per cent of estimated 2010 GDP), over and above the expected impact of broadcasting. Over 90% of the GDP benefits are generated by increased productivity in existing businesses.

The incremental productivity benefit to industry of deploying mobile broadband in the 700 MHz band is estimated at 0.6% for services, and 0.3% for manufacturing. In contrast, no incremental productivity benefits are expected from allocating the 700 MHz band to broadcasting.

A further economic dividend would come from close to 23K new business activities that would be created by 2020 as a result of the allocation of the 700 MHz band to mobile. There is a strong correlation between increased Internet penetration and new business activity, as companies are attracted by the opportunity to access a bigger pool of customers. This will in turn spur additional opportunities to serve these new businesses, such as web design, e-commerce platforms, etc. In Malaysia, the new business activities would account for a further $1.1B in increased GDP (in 2010 net present value terms). In total, increased Internet adoption will bring close to 44,100 new jobs in functions as varied as website design, ICT training, agricultural training and developing entertainment content. Many of these jobs would be in rural areas. By contrast only 2,100 extra jobs would be generated if the 700 MHz band was allocated to broadcasting.

All of this enhanced economic activity would drive greater tax revenues for the government of Malaysia. Mobile broadband will generate a further $2.1B in revenues between 2014 and 2020, with the bulk from corporation tax on profits ($1.2B). This compares to current annual tax revenues of $36B. Taking the broadcasting option would add less, at approximately $0.6B.

3.4 Social Benefits

While the potential economic benefits from allocating the 700 MHz band to broadband are clear, they are just one aspect of the potential benefits, as the social dividend from such a decision is also likely to be significant.

Malaysia's social and economic development priorities are laid out in the Tenth Malaysian Plan (10MP), adopted in 2010 to define national objectives over the next five years and pave the way to becoming a high income, fully developed nation by 2020 (see

Exhibit 3.3). 'Inclusiveness and equity' are among the overarching principles of the 10MP, with bridging urban-rural divides and raising the standards of the bottom 40 per cent among the main objectives. Making mobile broadband readily available to rural areas would serve all of these aims, by making education more accessible, improving healthcare, and bringing financial services to rural areas.

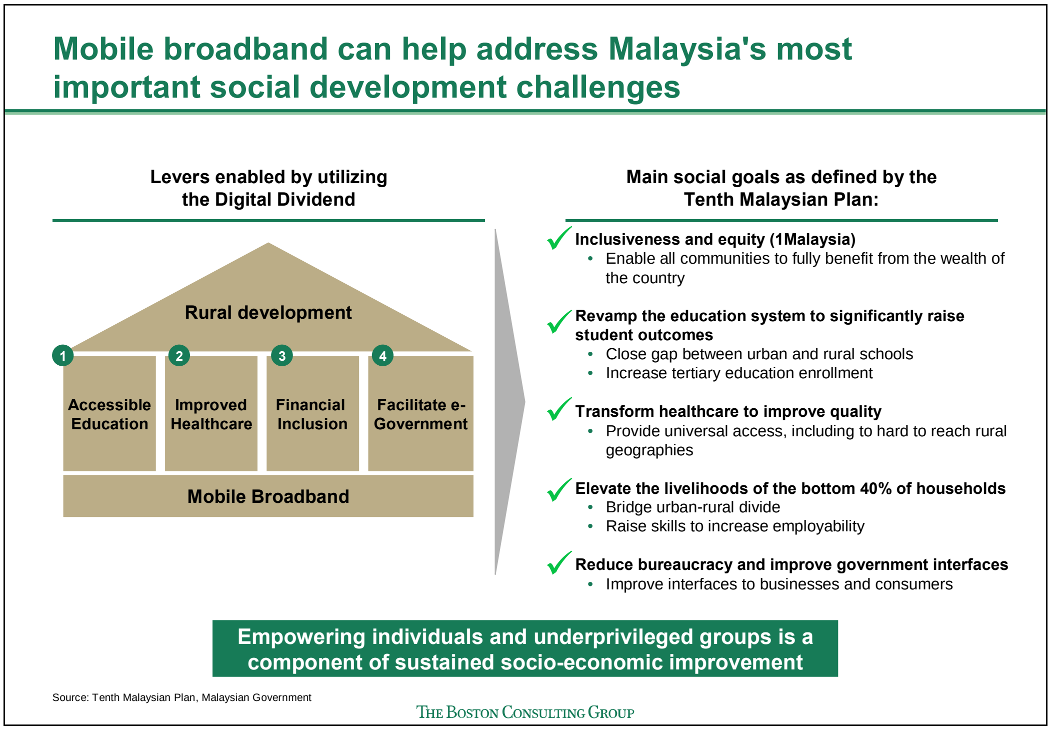

Exhibit 3.3 Malaysia's social goals

While the existing Internet infrastructure already contributes by bringing access to information, basic IT literacy, news and current events and links to remote markets, 700 MHz band will bring about a step change in availability and speed, particularly in rural areas that have the greatest need but the poorest access to infrastructure.

3.4.1 Education

The goals of the 10MP include revitalizing the education system so as to achieve better student outcomes. Particular aims are to close the gap between urban and rural schools and increase enrolment in tertiary education, which currently lags behind countries like Singapore and Korea.

Rural schools are significantly handicapped by comparison with their urban equivalents, suffering from shortages of teachers qualified in specialized subjects such as the sciences and limited access to vital out-of-class resources, including libraries and computers. These problems account for relatively poor performance by rural schools, which have higher drop-out rates (16.7% compared to 9.3% in urban schools) and lower scores in maths and science than their urban counterparts.

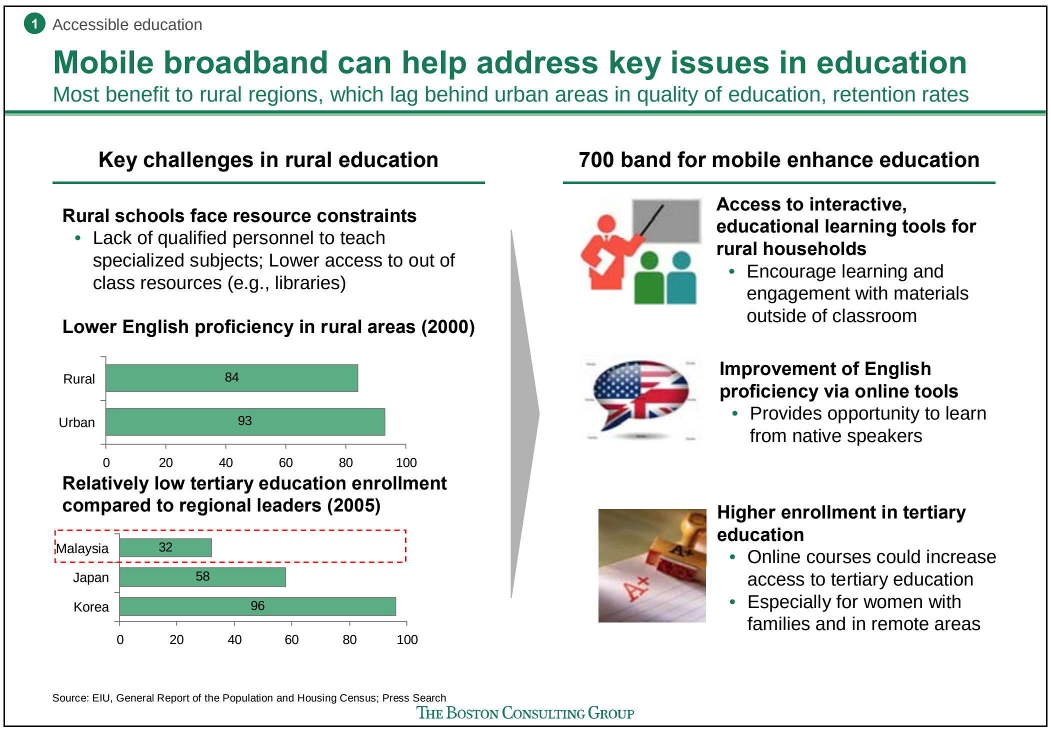

Exhibit 3.4 Rural-urban divide in Malaysian education

As can be seen in Exhibit 3.4, citizens in rural Malaysia perform particularly poorly in English language proficiency, an increasingly important skill in a globalizing economy, although this is part of a wider national problem with low mean scores across the country. A further national problem is low enrolment in tertiary education, which at 32 per cent is far lower than regional leaders such as Japan and Korea.

Broadband can assist with addressing these issues. It offers access to a range of interactive learning tools that can be used within rural households and can encourage learning and engagement outside the classroom. Rural users with basic devices can access free online word processing programmes rather than pay for expensive software, while interactive systems can encourage learning outside the classroom. In the United States, Project K-Nect improved testing results in mathematics for students in North Carolina by 30 per cent using applications accessed through smartphones.

There are similar benefits to be found in language teaching, with online programmes offering accessible and affordable means of improving language skills. For example, Livemocha, the world's largest language learning community, offers free and paid online courses for 35 languages, combining online classes and conversation with native speakers via a website which matches members.

In tertiary education, online degrees provide a means by which people who would otherwise be excluded for cost, family or work reasons – women with families and in remote areas are particularly handicapped – can study for qualifications.

As they become more common, online courses are also gaining acceptance by employers – a survey in the United States found that 82 per cent of employers and hiring managers would accept an online degree, with 23 per cent regarding them as credible as more traditionally delivered programmes.

3.4.2 Health

Mobile broadband is similarly capable of addressing the key health issues confronting Malaysia. One is that it has comparatively fewer doctors, especially outside the major cities – one for every 940 people – which increases to one for every 2,248 people in Sabah and 1,709 in Sarawak. This creates particular problems in rural areas, where there is a shortage of doctors and specialists and only a limited number of private hospitals, leaving public institutions over-stretched and often forcing patients to travel long distances to seek diagnosis and treatment.

Growing prosperity has brought with it some of the associated medical issues, with sharp increases in hypertension, diabetes and obesity recorded in recent years. There are also continuing problems with infectious diseases, in particular tuberculosis and AIDS.

Mobile broadband can help address some of these concerns. Malaysia already has a set of telemedicine initiatives designed to bring specialist advice to less populated areas. For example, Tawau Hospital in Sabah was connected in March 2008 to the much larger Queen Elizabeth Hospital, thus allowing specialist consultations over the Internet. 700 MHz band based mobile broadband can bring this a step further into mobile handset-based tele-consultation in the field rather than in a medical facility.

Mobile applications can also be used to improve health by allowing individuals to take responsibility for their own well-being. The Ministry of Health's MyHealth advice service would become more widely available, along with apps like Mayo inTouch, which allows users to track personal statistics like weight and blood pressure, and apps which provide nutritional information.

Mobile systems like Alerta Disamar in Peru and Handhelds for Health in India have already shown how disease outbreaks can be spotted early and tracked. Officers in the field can update real-time information quickly and accurately, and these feeds allow constant communication of up to date threat levels to the public. Health organizations are enabled to track confirmed cases and deaths and to map the spread of an outbreak.

3.4.3 Rural Development

As well as improving education and health in rural areas, mobile broadband would bring jobs to these areas by addressing some of the underlying causes of rural economic disadvantage.

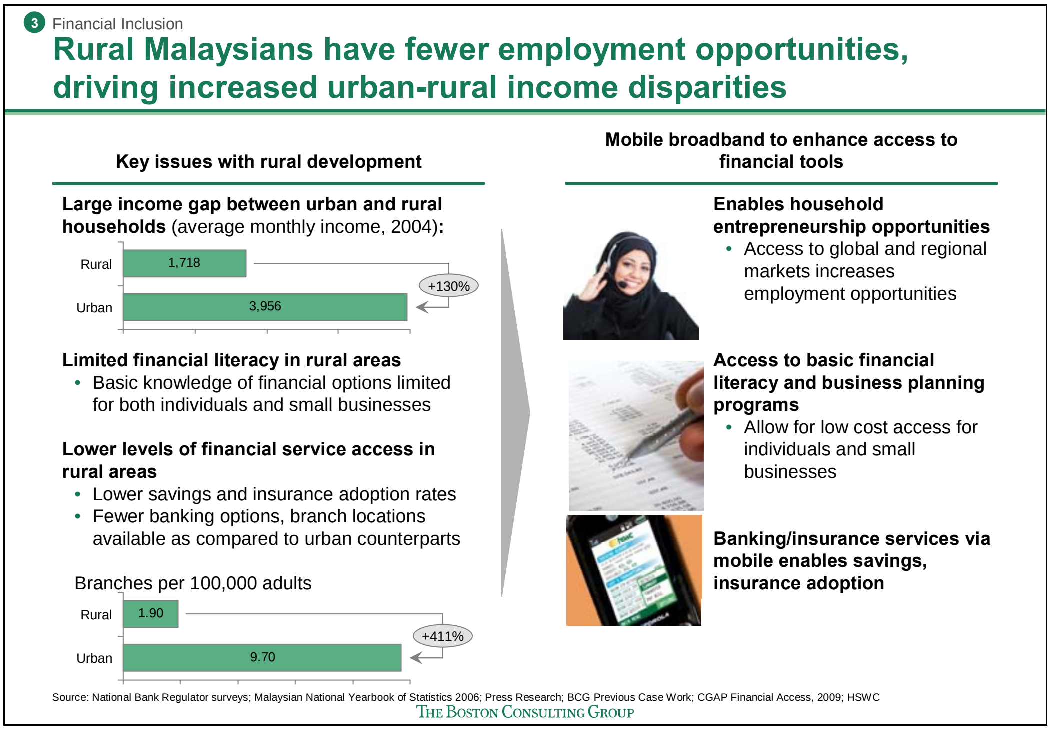

Exhibit 3.5 Rural development challenges in Malaysia

There is a significant disparity between urban and rural household incomes in Malaysia, with urban households receiving 130% more income than their rural counterparts, as Exhibit 3.5 demonstrates. Among the problems depressing rural incomes are limited financial literacy, with both individuals and businesses unaware of options available to them, and limited access to financial services. There is also less frequent use of savings and insurance, as financial institutions do not offer the density of branch networks and other banking options available in cities.

Mobile broadband can help close the gap by addressing these deficiencies. It opens up both regional and global markets to local entrepreneurs. With a broadband connection, a rural business can sell its goods, such as the handicrafts offered on Etsy, to the global marketplace as easily and cheaply as somebody based in a city. It also offers the possibility of working in outsourced global services like website coding and data development.

Small businesses would get easier, cheaper access to basic business and financial tools like inventory planning and accounting software. Individuals can improve financial literacy through better access to information sources and online budget tracking devices like mint.com,

Leading Malaysian banks are already offering online services. Better, quicker broadband would bring these within the reach of rural households, offering them a convenient, safe and inexpensive way of saving money and access to credit for enterprises. Micro-insurance can act as protection against financial shocks, while mobile accounts will reduce transaction costs and credit risks for insurers. While behaviors may take time to change, increased adoption by rural users will enhance the incentives for businesses to reach out to them and educate them on the benefits, creating a virtuous cycle.

3.4.4 Facilitation of e-government

Mobile broadband could greatly increase efficiency in the provision of government services, especially in rural areas, and improve interactions between the government and businesses and consumers. This is recognized as an important principle for transformation in The Tenth Malaysian Plan. Particularly in rural areas, a significant amount of resources are spent on basic paper-based filing, necessitating large staffs and high transportation and material costs. E-government could also improve the quality and availability of government services, reducing processing times and thereby helping to improve national competitiveness.

3.5 Implications for Governments and Regulators

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It is estimated that non-harmonization would reduce the projected increment in adoption by 10%, GDP increase by 2%, and other economic benefits by 16% or more.

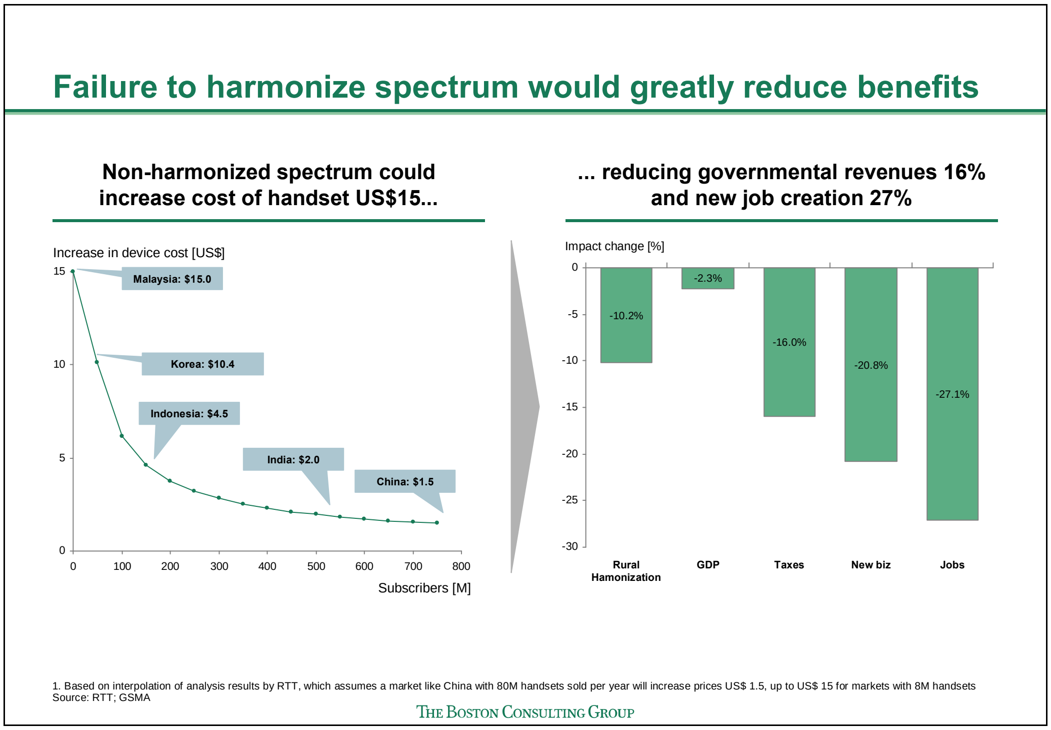

Exhibit 3.6 Impact of non-harmonization

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered. In particular, prices for spectrum fees should be set to ensure that rural areas get the low-cost provision essential for their needs.

4 INDONESIA

4.1 Introduction

Indonesia has the fourth highest population in the world, currently estimated at 240 million, and is currently growing at a rate of a little over 1 per cent per annum. It is urbanising rapidly, with an annual rate of 3.3 per cent movement from the country to towns and cities over the past five years. Town and city dwellers have only become the majority recently, currently representing 52 per cent, but on current patterns are likely to be more than two-thirds of the population by 2030. Agriculture still accounts for more than 40 per cent of the workforce.

The United Nations currently ranks Indonesia as a country of Medium Human Development. The 2009 UN Human Development Report ranked it 111th worldwide, with a Human Development Index rating of 0.734. It ranks well above 111th on adult literacy (62nd), the risk of not surviving until 40 (67th) and the poverty index (69th). It scores less well on GDP per capita (122nd) and combined primary, secondary and tertiary education enrolment (127th).

4.2 Adoption

Indonesia has high mobile penetration and a large number of Internet users, but very few broadband connections, and thus offers an interesting opportunity for mobile broadband adoption.

Mobile use has grown extremely rapidly, at an annual average of 37 per cent, in recent years. The number of phone subscriptions doubled between 2006 and 2008 and by the following year represented around 70 per cent penetration, compared to less than 30 per cent only three years earlier.

Internet use is growing even more rapidly, although from a lower base – tripling between 2006 and 2009, with the bulk of the growth in the last two years, so that there are now an estimated 25 million Internet users in Indonesia. Only a tiny proportion of these, though, use broadband, with the number of subscriptions yet to reach one million. The Internet also has yet to reach more than a very small minority of the 100 million plus Indonesians living outside the cities and towns.

Allocating the 700 MHz band to mobile broadband would make a significant difference to take up in rural areas, generating 9.7 million more Internet subscriptions by 2020. This would represent a 22 per cent increment on top of the considerable baseline expansion already expected over this period.

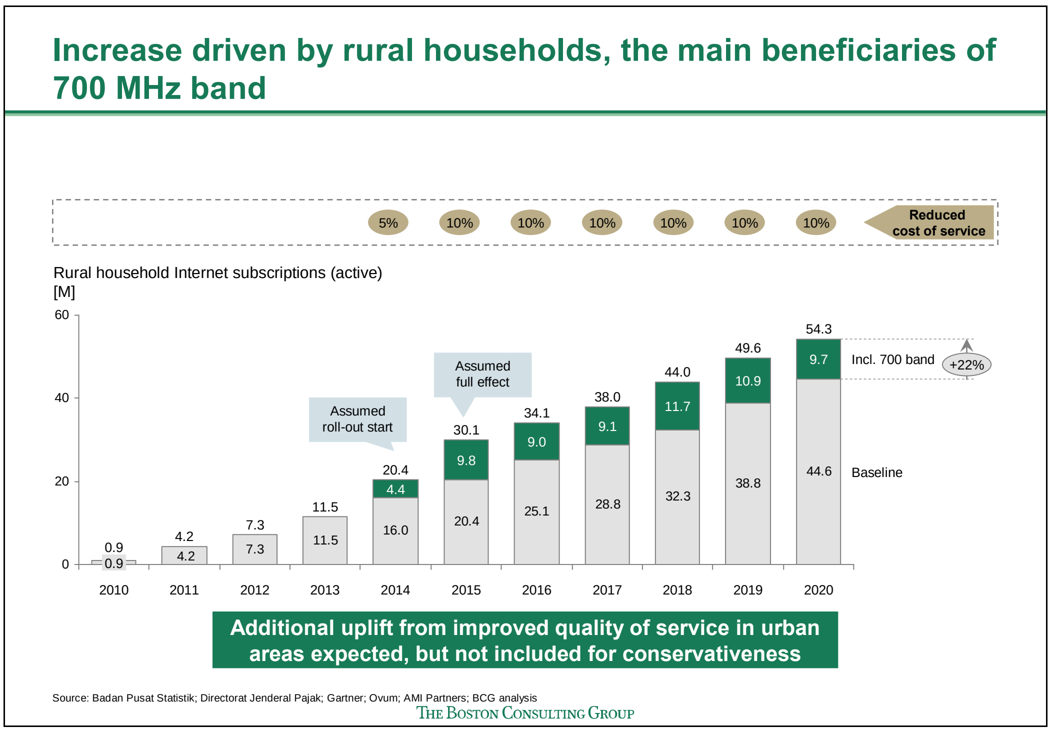

Exhibit 4.1 Rural Internet penetration

In order to ensure model consistency, roll-out starting in 2014 is assumed, like the other countries across Asia Pacific. Indonesian authorities have however indicated digital switch-over might not happen until 2018, something which would greatly reduce the short-term socio-economic impact. This impact has been calculated in Section 4.5: Implications for Governments and Regulators.

Roll-out of mobile broadband in the Digital Dividend band would also mean an 8 per cent increment across the entire nation – a conservative projection which excludes further uplift likely to occur as a result of improved service in urban areas. The increment would increase the proportion of rural subscriptions in 2020 to around 38 per cent.

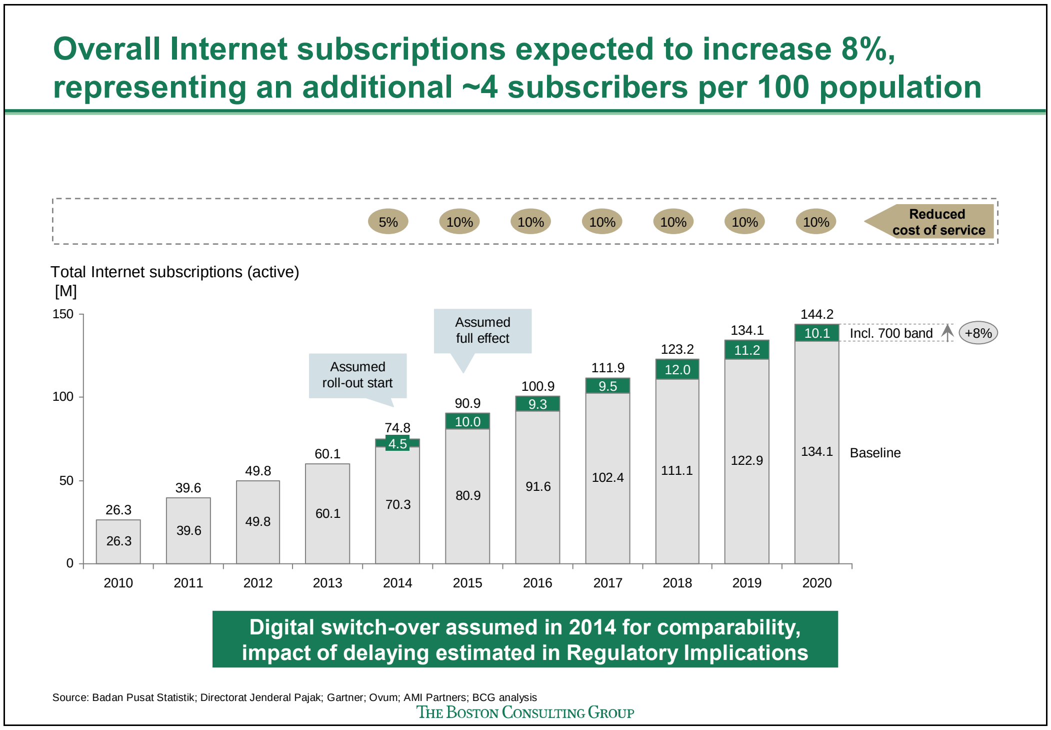

Exhibit 4.2 Total Internet penetration

4.3 Economic Benefits

Indonesia will be able to look forward to a substantial economic benefits should it choose to allocate the 700 MHz band to mobile. Whether measured in terms of GDP, government revenues, new businesses or job creation, this would be vastly more productive than allocating the band to broadcasting.

In GDP terms, mobile broadband would generate an extra $22.6B relative to broadcasting over the period 2014-2020, or $15.9B in 2010-2020 net present value. The incremental benefits over the period, on a net present value basis, would be 2.9% of Indonesia's current GDP.

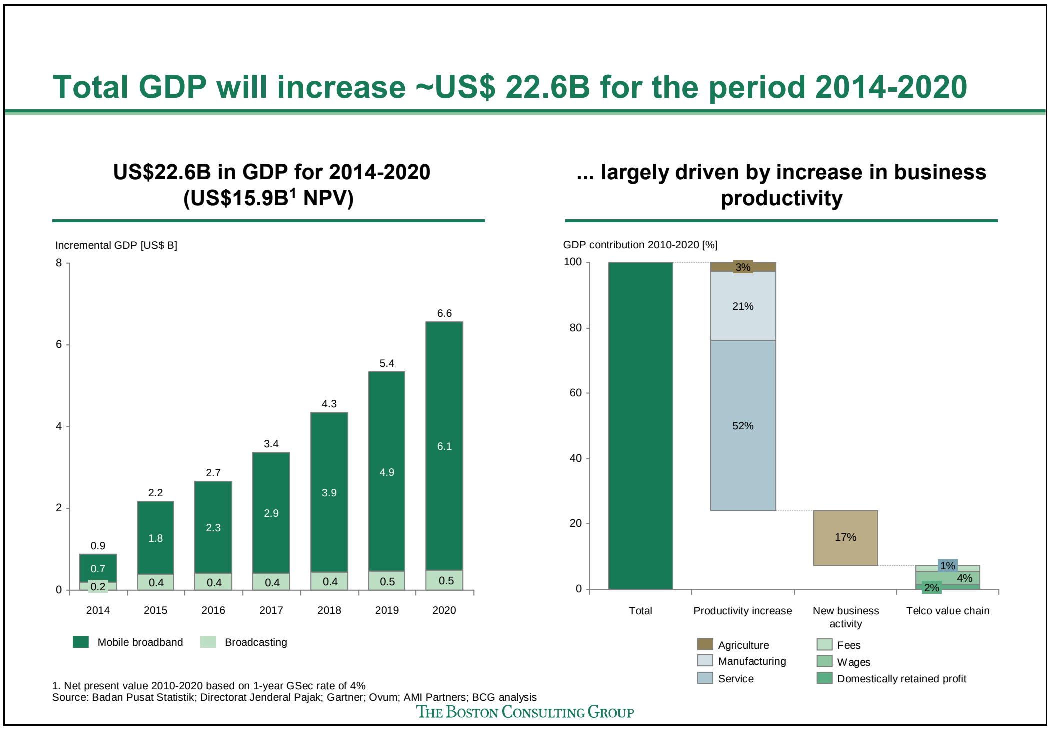

Exhibit 4.3 GDP impact

The bulk of the increase in GDP, 52 per cent, would come from increased productivity in the service sector. 700 MHz band based mobile broadband will stimulate estimated additional productivity gains of 0.4 per cent for service industries, and 0.2 per cent for manufacturing. In contrast, no incremental productivity benefits are expected from allocating the 700 MHz band to broadcasting.

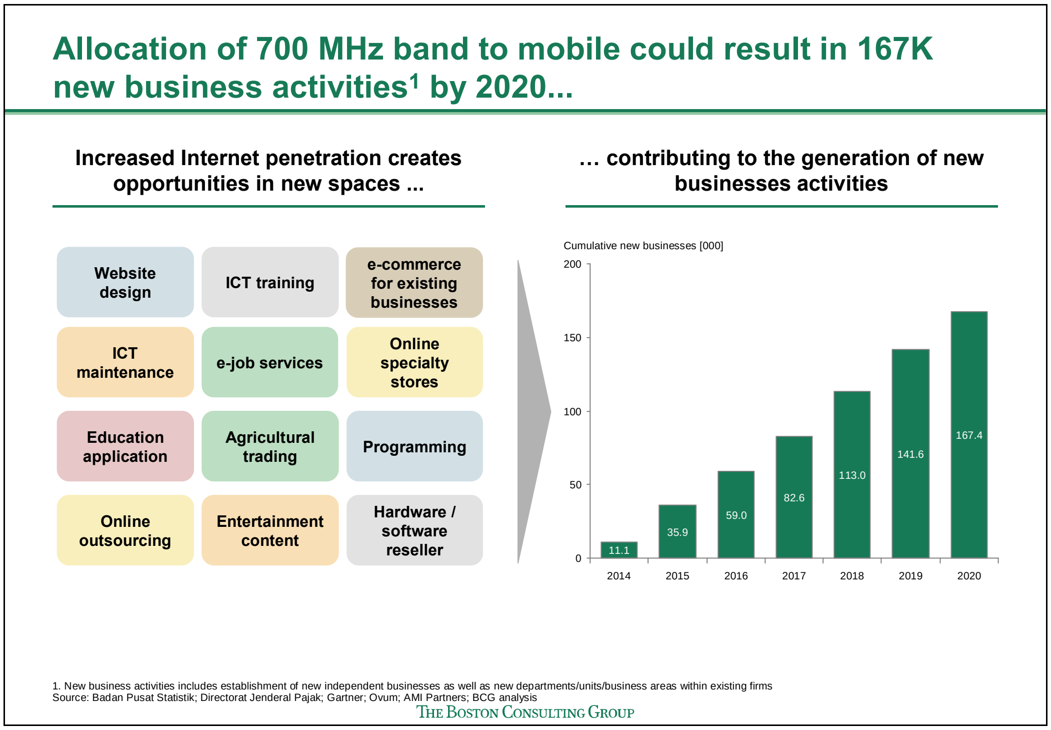

Exhibit 4.4 New business activities

A total of 167K new business activities, divided between new operations within existing companies and wholly new enterprises, are expected to be created between 2014 and 2020 as a result of allocating the 700 MHz band to mobile. These new enterprises would be in a range of activities, from those directly concerned with the Internet, such as website design and ICT maintenance, to those enabled by faster, cheaper access, such as e-job services, online speciality stores and online outsourcing. This would lead to the creation of about 327,000 jobs in 2020– a significant proportion of them in rural areas. This is a conservative estimate, since it excludes jobs likely to be created as a result of improved productivity in the new firms. Nevertheless, it is still significantly more than the 2,100 new jobs that would be created if the band were allocated to broadcasting.

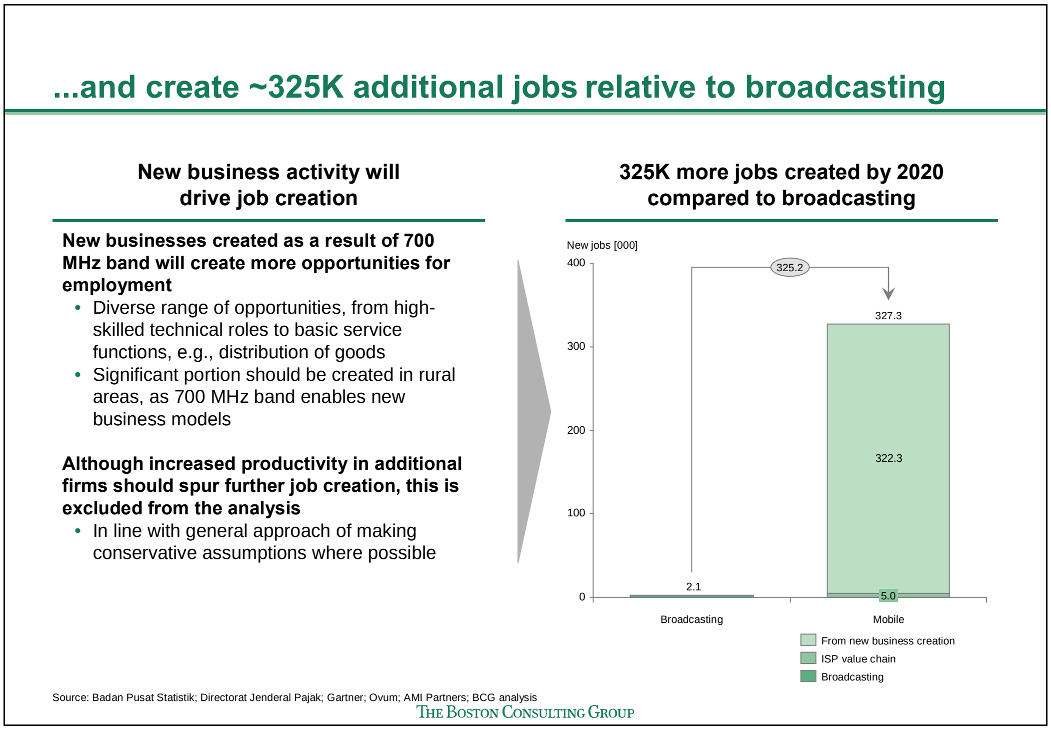

Exhibit 4.5 New jobs

All of this would generate greater tax revenues for the Indonesian government. It could expect to see an increase in tax revenues of $9.4B between 2014-2020 if it allocates the 700 MHz band to mobile. Giving it to broadcasting would generate far less, at just $1.0B.

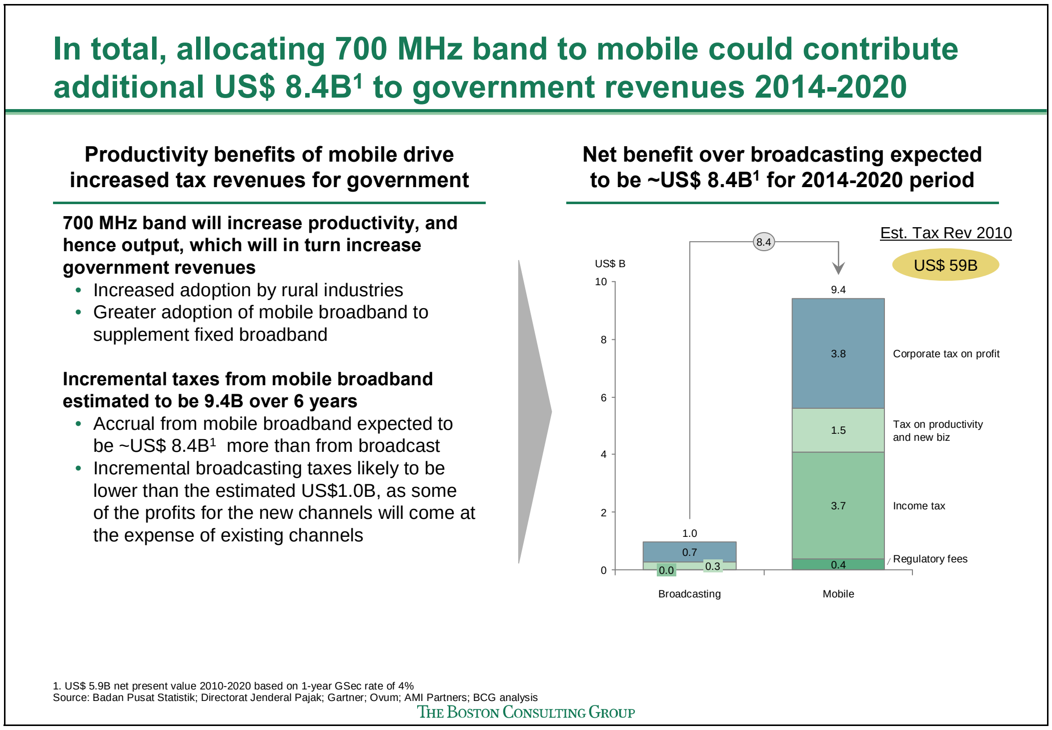

Exhibit 4.6 Governmental revenues

So the potential economic benefits from allocating the 700 MHz band to broadband are clear. They are just one aspect of the potential benefits, as the social dividend from such a decision is also likely to be significant.

4.4 Social Benefits

Indonesia could expect to take substantial steps towards its overarching goal of "Development for All" laid out by the President in 2009[3], should it decide to use its Digital Dividend to speed the development of fast, inexpensive and widely accessible mobile broadband.

The National Priorities, as laid out in the Medium-Term Development Plan 2010-2014:

- Reform the Bureaucracy and Governance
- Increase access to education

[3] President's address to House of Representatives 19 August 2009

- Improve healthcare
- Reducing poverty and improve inclusion of all

700 MHz band based mobile broadband can help to address these through its effects on accessible education, better healthcare and economic employment opportunities.

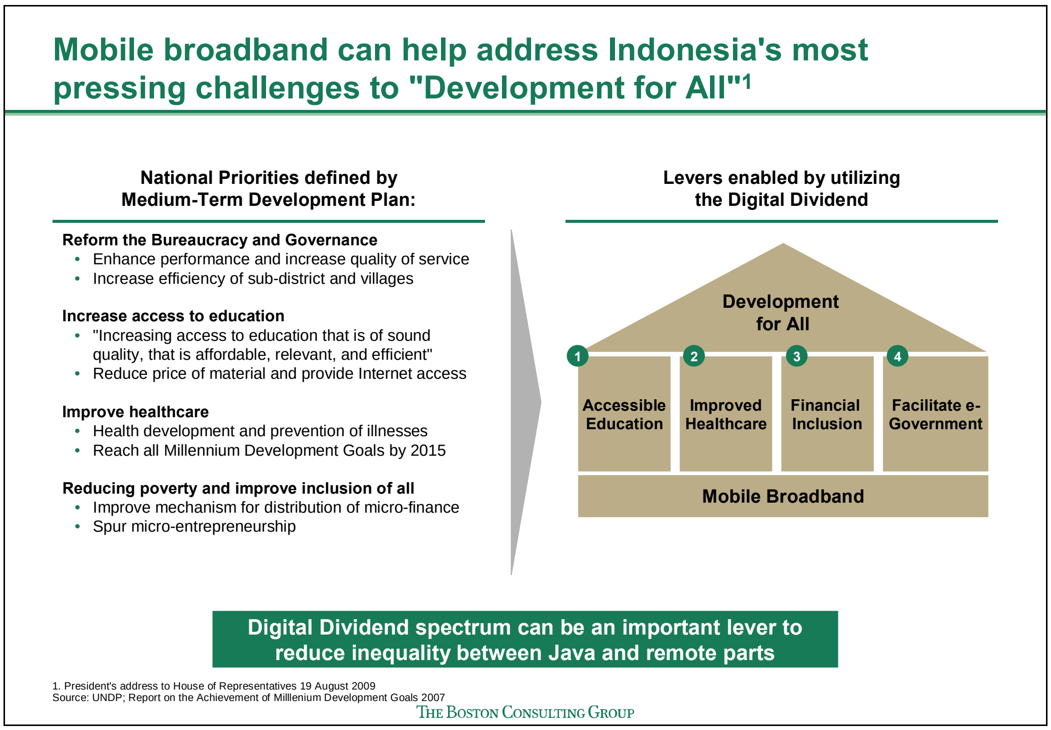

Exhibit 4.7 Indonesia's challenges

4.4.1 Education

Education in rural Indonesia faces problems familiar to other countries – resource constraints, low enrolment and poor performance. They often lack both sufficient qualified teachers and classroom resources like textbooks and equipment. School enrolment is depressed as young people seek income opportunities rather than staying in school, and there is a sharp lag in rural enrolment, with a secondary school enrolment ratio of only 36%, compared to 56% per cent in the towns and cities. Indonesian illiteracy rates are also higher than those of its neighbours – 10 per cent in 2007, compared to 8 per cent in the Philippines and 7 per cent in Malaysia.

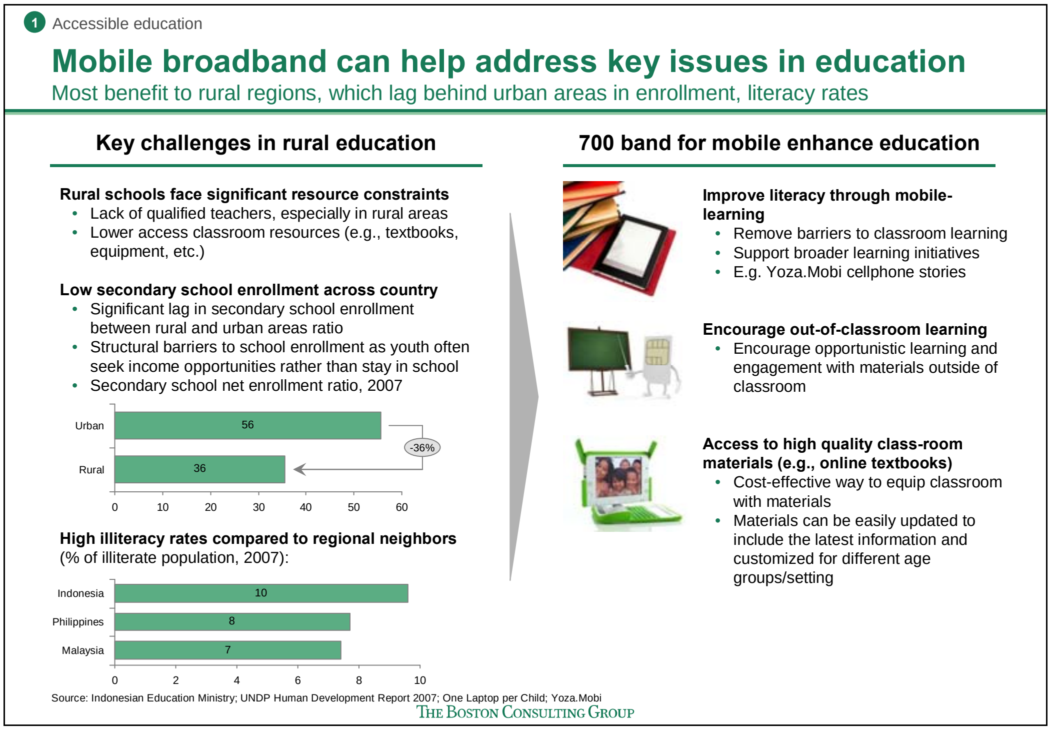

Exhibit 4.8 Issues in education

Mobile broadband can supply the tools with which to address these problems. Children may have difficulty in getting to school, or be required to help support the family from a young age, but mobile technology supplies a means by which these obstacles can be overcome. Projects like CITRUS Seed in Niger, which installed special literacy programmes on the phones of 1,750 villagers, can help overcome barriers to school enrolment by making learning available anywhere and at any time.

A key element in assisting learning is to encourage students to learn opportunistically outside the classroom. The Millee project, which installed interactive language games on smartphones in China and India, found that rural children would voluntarily use phones to access the content, while BBC Janala, a multimedia initiative in Bangladesh, enrolled 12,000 pupils seeking access to 3,000 English quizzes available over mobile phones and the Internet.

Online tools, made much more accessible and inexpensive by a high-speed broadband connection, can give access to high-quality resources currently out of reach for many –

often proving a cost-effective replacement for bulky, expensive textbooks with a limited lifespan – while cloud-based programmes could remove the need to buy potential expensive proprietary tools, such as dictionaries or word processing software.

4.4.2 Health

Indonesia faces a number of acute medical issues. Rural areas are extremely short of qualified medical staff – with only 6 doctors for every 100,000 people in the countryside. This compares to an urban rate of 38 per 100,000, itself less than half the number in Malaysia, which in turn still regards itself as facing a shortage of doctors. Awareness of health risks and access to information on good practices is also lower in the rural areas. This is part of the explanation for extremely high maternal mortality rates, with an average of 307 mothers dying per 100,000 live births – eight times as high as in Malaysia and nearly three times as high as Thailand. The bulk is in rural areas where one in six home births takes place without the involvement of skilled health workers.

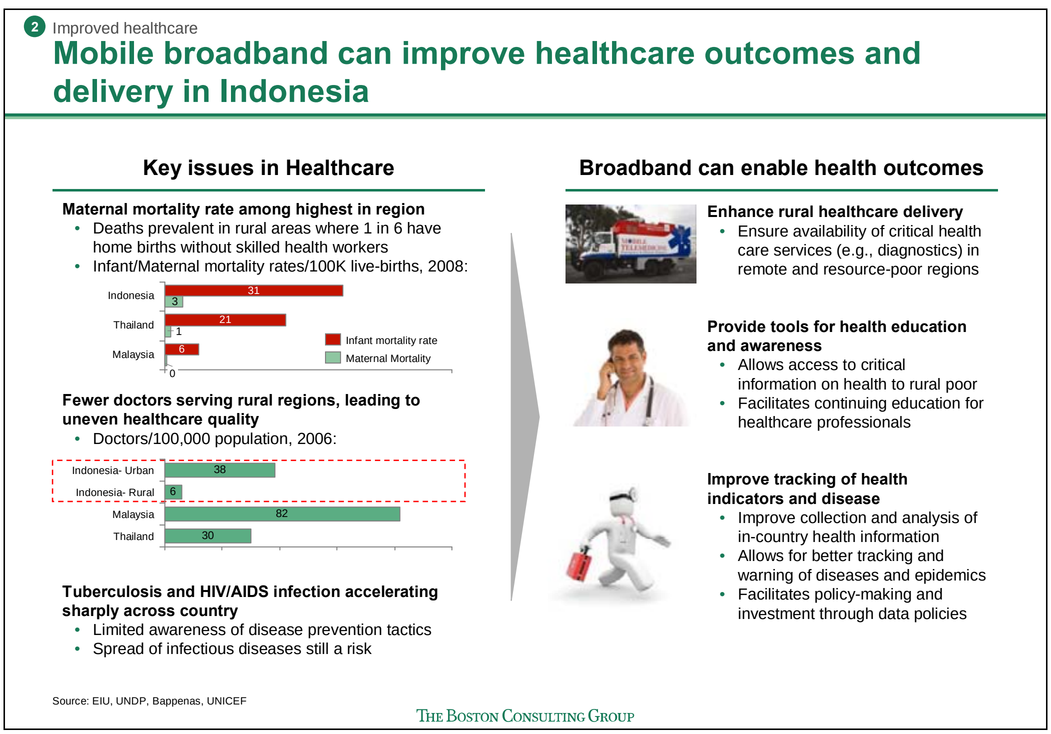

Exhibit 4.9 Key issues in healthcare

Mobile broadband can offer an effective means for addressing these issues. Rural doctor shortages could be addressed by schemes similar to the Alokito e-health initiative currently operating in Bangladesh and India. Under this scheme, nurses go into rural areas to meet patients, set up equipment and dispense medication and mobile connections enable doctors in urban hospitals to make diagnoses.

Mobile applications can also assist in the training of healthcare workers in rural areas. This has been done in Peru, with physicians given 3D learning scenarios adapted for smartphones as part of continuing education programmes. Healthcare workers can also be kept informed about advances in treatment or critical disease information.

To facilitate the transmission of information on health practices, UNAIDS has used social networking sites like Facebook and Youtube to spread information on HIV/AIDS. Such methods will become increasingly effective as broadband penetration, and could even be used as a two-way communication device to both disseminate information and collect data from users

4.4.3 Economic Employment Opportunities

Basic Internet access can help economically empower individuals and underprivileged groups. It offers access to information, basic IT literacy, knowledge of news and current events, and access to remote markets. By making this access faster, cheaper and much more widely available to rural areas, mobile broadband will greatly enhance the opportunities available to low income and rural communities, enfranchising excluded groups like women and the elderly, and creating new opportunities for home-based micro-entrepreneurs.

Such opportunities are acutely needed in rural Indonesia, which lags the towns and cities in basic living standards and in education and health provision. There is a massive gap between rural and urban incomes – in 2004 the average monthly income in the towns and cities was more than three times higher than the rural norm. More than one in six of the rural population – 20.6 million people – was living below the poverty line in 2009.

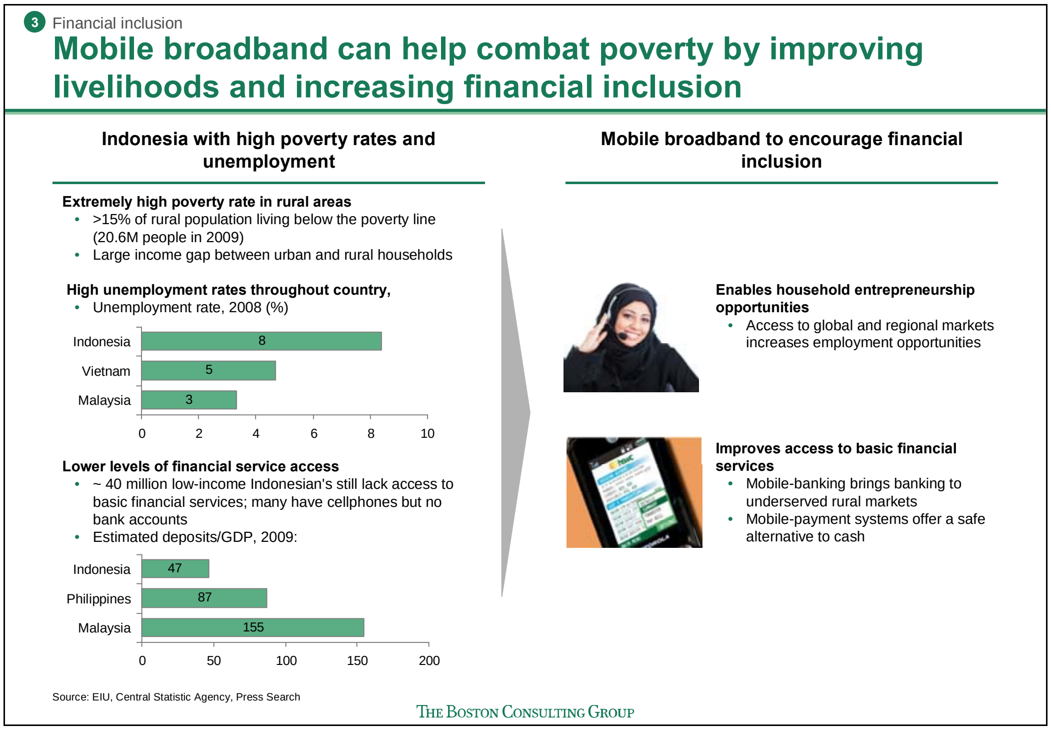

Exhibit 4.10 Financial inclusion

Mobile broadband could address some of these issues by bringing business support services and opportunities within the reach of those currently excluded. Such home-based entrepreneurs are given the opportunity to sell in local, regional and global marketplaces. Broadband connections will also allow rural workers to compete for outsourced IT functions like website coding and data entry.

One aspect of rural deprivation is lack of access to financial services. Many Indonesians have cellphones but no bank account – around 40 million on low incomes lack access to basis financial services. Indonesia's ratio of bank deposits to GDP is lower than that of its neighbours – only 47 per cent compared to 87 per cent in the Phillipines and 155 per cent in Malaysia

Mobile broadband can offer the rural poor access to those services through Internet-enabled mobile terminals. While simple SMS-based systems like the branchless banking offered by Wizzit in South Africa allows customers access to basic transactions, mobile broadband will increase the range of services that can be provided, while offering better security.

4.4.4 Facilitation of e-government

Mobile broadband could greatly increase efficiency in the provision of government services, especially in rural areas, and improve interactions between the government and businesses and consumers. Particularly in rural areas, a significant amount of resources are spent on basic paper-based filing, necessitating large staffs and high transportation and material costs. E-government could also improve the quality and availability of government services, reducing processing times and thereby helping to improve national competitiveness.

4.5 Implications for Governments and Regulators

Throughout this study, the estimates of benefits have been premised on an appropriate and supportive government policy. They are dependent on governments allocating the internationally harmonized frequency band 698-806 MHz, and implementing the Asia Pacific technical harmonization (the APT bandplan for FDD deployment in the 2X45 MHz based technical harmonisation) to ensure their consumers and society benefit from the economies of scale in handset and network equipment production. Countries which fail on either harmonized allocation of the frequency band or technical harmonization of the frequency band could risk losing out on the potential benefits.

Without access to the 108 MHz of bandwidth, effective rollout may become more difficult. There may be insufficient bandwidth for ensuring effective competition between mobile network operators, which may in turn reduce the range and quality of services, and may lead to increased consumer prices for subscriptions.

Without implementation of the technical harmonisation based on the 2X45 MHz APT bandplan, economies of scale in network equipment and handset production are lost. The 9th Meeting of the APT Wireless Forum (AWF-9), held from 13 to 16 September 2010 in Seoul, Korea, agreed on the planning of the UHF band. It adopted two band plans. One was based on the 2 x 45 MHz with a conventional duplex direction which is the bandplan supported by the GSM Association and its members and associates. The APT harmonised UHF bandplan for IMT is a 2X45 MHz bandplan within the 698-806 MHz band and with a lower guard-band of 5 MHz between 698-703 MHz and an upper guard-band of 3 MHz between 803-806 MHz.

Countries which are out of sync with the agreed band plans will lose out, because harmonization maximizes economies of scale, limits the risk of cross-border interference and improves overall usage quality. Especially for relatively small markets like Korea, Malaysia and Indonesia, but even for a market of the size of India, in the worst case scenario, handsets may not be available, or the range of models available to consumers will be very limited. In the "best case" scenario, failure to harmonize would raise handsets costs, which negates some of the benefits of 700 MHz broadband. In addition failure to harmonize adds to the cost of establishing and maintaining the mobile network because of the need for technical adjustments, such as filtering solutions and other modifications to transmitters to adjust to non-harmonized band edges.

It is estimated that non-harmonization would reduce the projected incremental adoption of 700 MHz by 6%, resulting in a 2.5% decrease in GDP benefit and a 7-10% decrease in jobs, new businesses and taxes that could be generated by the Digital Dividend.

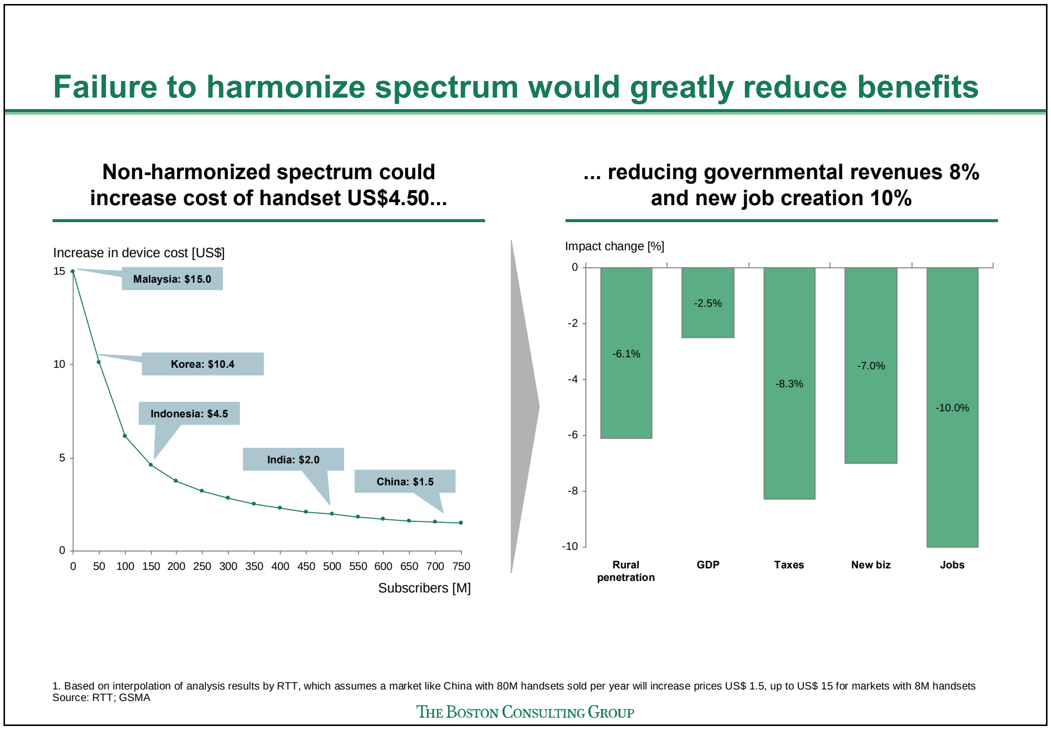

Exhibit 4.11 Impact of non-harmonization

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered. In particular, prices for spectrum fees should be set to ensure that rural areas get the low-cost provision essential for their needs.

Postponing the digital switch-over and potential allocation of the 700 MHz band to mobile broadband until 2018 compared to 2014 for most countries across Asia Pacific would also significantly reduce the socio-economic impact, as shown in Exhibit 4.12. The 2010-2020 net present value of projected increases in GDP and government revenues would decline as much as 54% and 69%, respectively, while total new job creation would decrease by 78% in the same period.

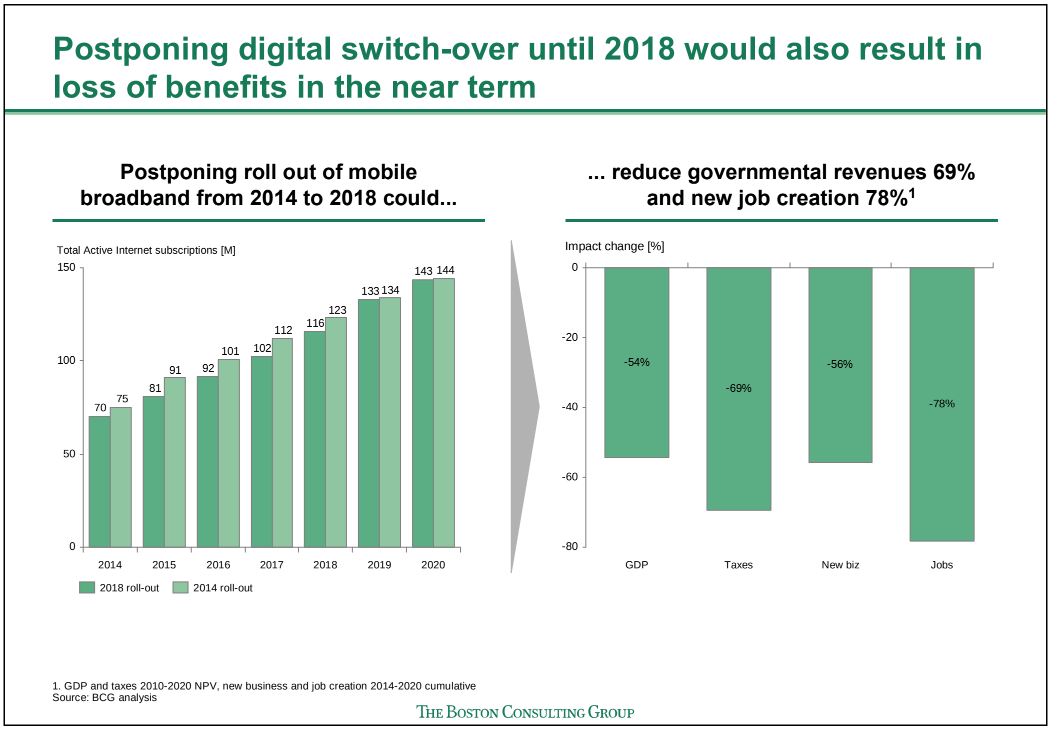

Exhibit 4.12 Impact of postponing switch-over

5 INDIA

5.1 Introduction

India has a population of 1.15B, the second highest in the world after China. While still predominantly rural, with only 29 per cent of its population living in towns and cities, India is urbanising rapidly at a rate of 3.4 per cent each year. Agriculture still accounts for more than half of the work force, but only 17 per cent of GDP. One quarter of the population, close to 300 million people, still live below the poverty line.

The United Nations rates India as a country of medium human development. The 2009 United Nations Human Development Report ranked it 134th worldwide, with a rating of 0.61. It also rates 128th on life expectancy, 120th for adult literacy and 134th on enrolment rate. It does poorly on gender issues, rating 139th on the gender-related development index, 153rd on female life expectancy, 123rd (out of 145 nations rated) on female literacy and 142nd on female enrolment in education.

While its economic expansion slowed in 2009, it was only to a level – 7.4 per cent – for which most countries would be grateful at the best of times, and its economy is expected to continue to generate spectacular growth over the next few years.

India's sheer size makes analysis a formidable challenge. For the purposes of this report, BCG has made a detailed study of two representative states – Rajasthan and Maharashtra – and used them to extrapolate the impact of decisions on the 700 MHz band for the whole country. Between them they have a population of 175-180 million, which would make them the sixth largest country in the world by themselves. Maharashtra is more urbanized than the norm for India, at a little over 40 per cent, and among the more developed states, and is most representative of India's A circles. Rajasthan on the other hand is more representative of the B and C circles, with close to average urbanisation and relatively lower levels of development.

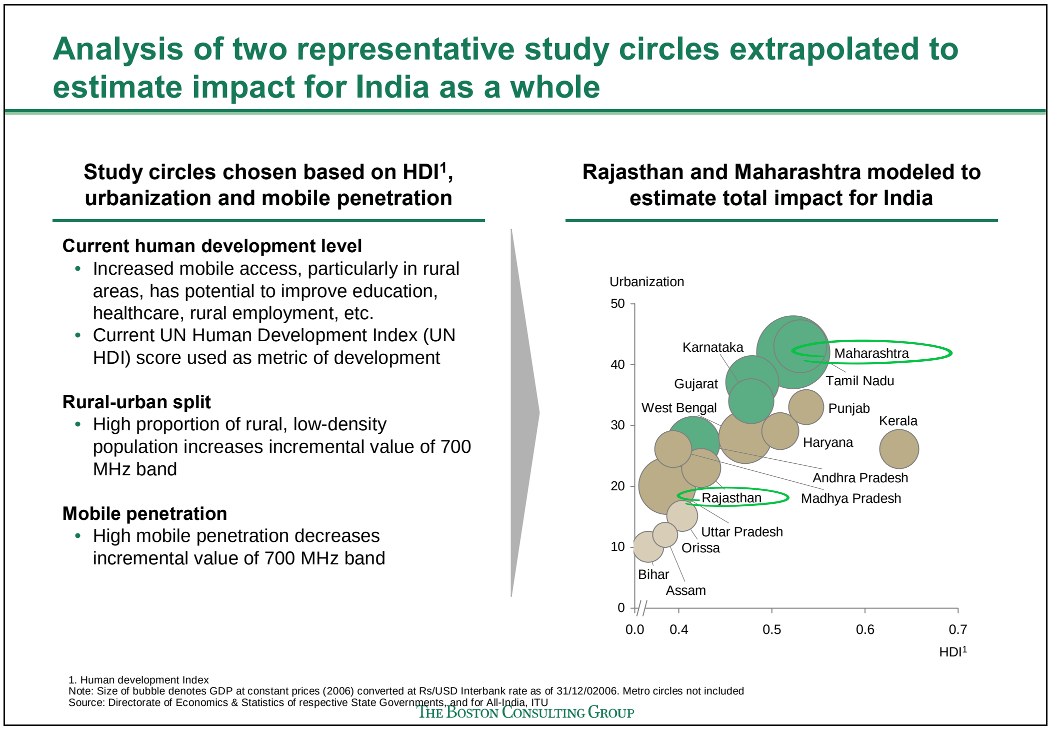

Exhibit 5.1 Study circles

Results from the detailed modelling of the two study circles were extrapolated to estimate the economic impact for the whole country. Levels of urbanization and current mobile penetration were used to calculate an uplift factor for each state in order to estimate its contribution. The uplift factor it is a measure of the potential impact of mobile broadband in the particular state, with a higher potential impact for states with lower levels of urbanization and mobile penetration. Calculation of the uplift factors for each state is shown in Exhibit 5.2, and more details are in the Appendix.

Extrapolation from study circles based on level of urbanization and current mobile penetration

Urbanization and penetration used to estimate uplift factor...

	Urb.	Penetr.	Uplift factor
Andhra Pradesh	0.84	0.64	1.35
Assam	0.56	0.54	1.82
Bihar	0.54	0.45	2.02
Delhi	0.42	2.19	0.77
Gujarat	0.86	0.88	1.15
Haryana	1.13	1.24	0.85
Karnataka	0.97	0.80	1.13
Kerala	1.55	1.11	0.75
Madhya Pradesh	0.65	1.14	1.12
Maharashtra[1]	1.00	1.00	1.00
Orissa	0.70	0.64	1.50
Punjab	1.44	1.45	0.69
Rajasthan[1]	1.00	1.00	1.00
Tamil Nadu	1.25	1.04	0.88
Uttar Pradesh	0.68	0.89	1.27
Himachal Pradesh	1.49	0.42	1.05
Jammu & Kashmir	0.93	1.06	1.00

... to estimate socio-economic impact for entire cluster of countries

GDP impact based on impact/GDP ratio

$$\sum_{\text{States}} \frac{\text{GDP uplift study circle}}{\text{GDP of study circle}} * \text{state GDP} * \text{uplift factor}$$

Governmental revenue based on tax/GDP ratio

$$\sum_{\text{States}} \frac{\text{Tax uplift study circle}}{\text{Tax of study circle}} * \text{country tax} * \text{uplift factor}$$

Jobs created based on GDP[2]

$$\sum_{\text{Countries}} \text{Jobs created study circle} * \frac{\text{State GDP}}{\text{Study circle GDP}} * \text{uplift factor}$$

New business creation based on GDP[2]

$$\sum_{\text{Countries}} \text{New biz created study circle} * \frac{\text{State GDP}}{\text{Study circle GDP}} * \text{uplift factor}$$

1. Study circle 2. Used instead of new jobs and business ratios, in lack of accurate data for state-wise number
Source: IMF; UNDP; CIA World Factbook; ITU; BCG Analysis

THE BOSTON CONSULTING GROUP

Exhibit 5.2 Indian extrapolation methodology

5.2 Adoption

The adoption of mobile phones in India has been rapid, with numbers expanding by 60 per cent every year over the last four years. Where there were 90 million mobile phone subscriptions nationwide in 2006, there are now 584 million, and this number continues to grow. As in much else in Indian life, there is however a sharp divide between city and country. Penetration is close to 100 per cent in urban areas, but still only around 20 per cent in the rural areas.

Internet penetration and growth has been much slower, leaving immense potential for the adoption of mobile broadband once the more than half a billion handset owners recognise the possibilities and are given cheap, high-speed access. There are currently 15 million broadband users in India, up from nine million four years ago, the overwhelming majority still household rather than business subscribers, which have only just reached the million mark.

In order to more accurately estimate the economic impact of allocating the 700 MHz band to mobile broadband, the baseline was calculated as Active Subscriptions (see Appendix for more details). For fixed line Internet, users often share subscriptions through e.g. Internet cafes and a single connection in the household. For mobile Internet users on the other hand, number of subscriptions usually counts people with Internet-enabled phones in areas with 2.5G or better coverage, and thus number of Active Subscriptions would be lower.

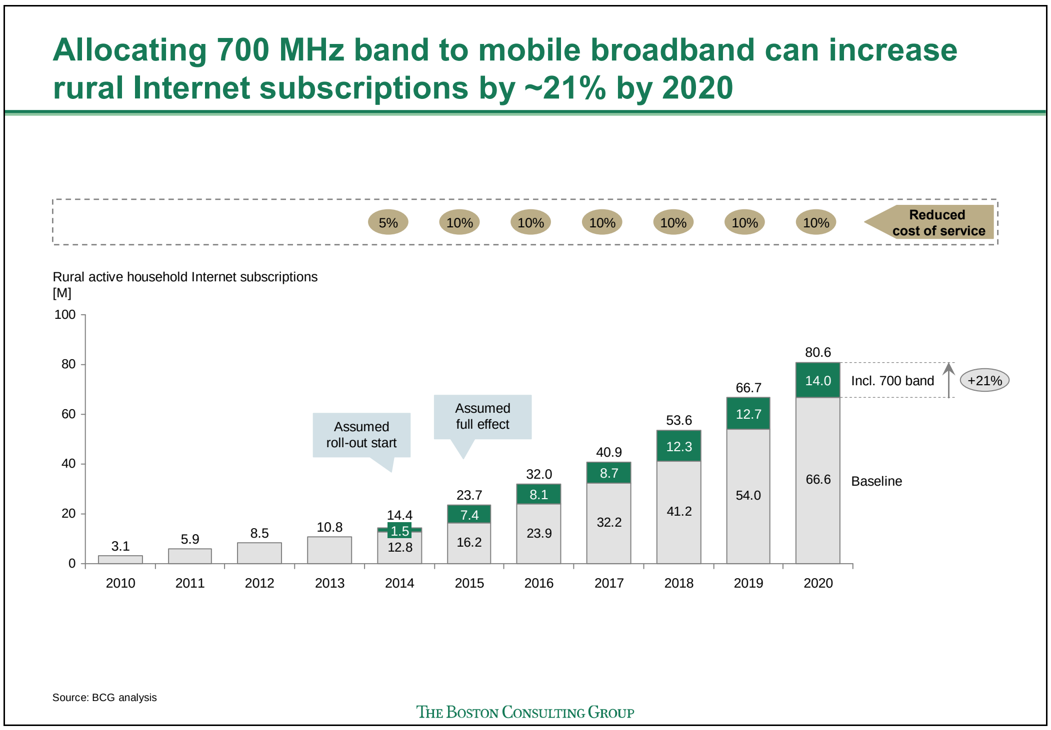

Exhibit 5.3 Rural subscriptions

There are as yet only an estimated three million rural household Internet subscriptions, expected to rise to just under 11 million by 2013 and by steady increments to 67 million by 2020. Allocating the 700 MHz band would create a 21 per cent increment on top of this, equivalent to a further 14 million subscribers. This would equate to a 6 per cent increment on overall numbers, meaning that there should be more than 250 million Internet subscriptions in India by 2020, compared to 39 million in 2010.

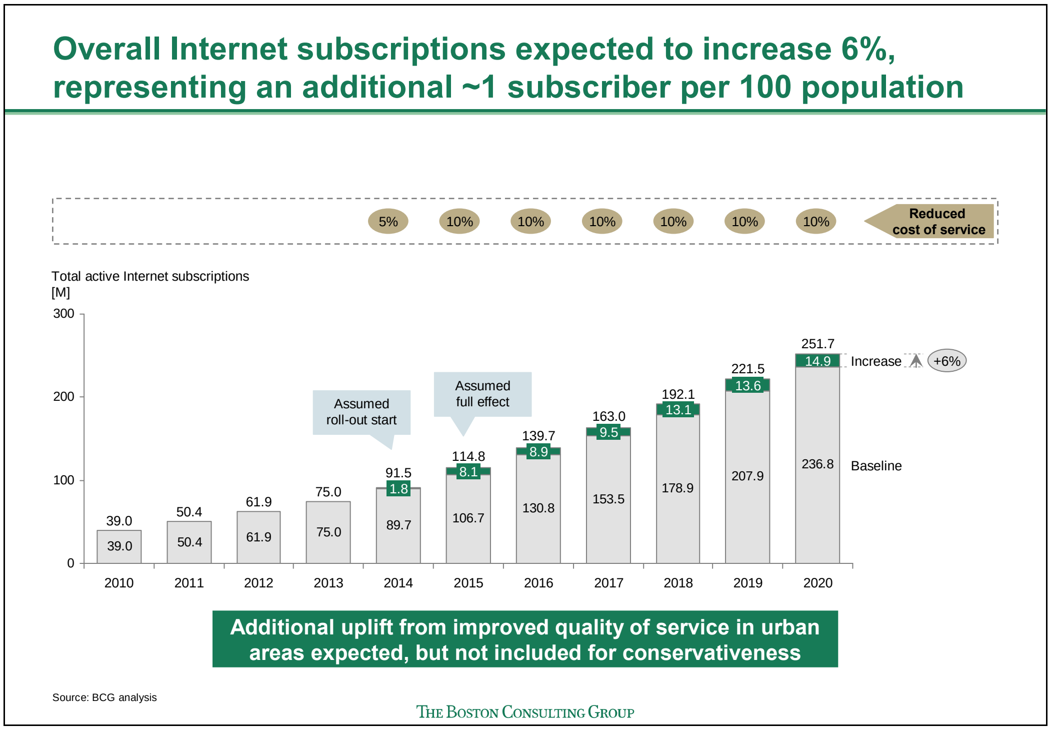

Exhibit 5.4 Total subscriptions

This is a conservative estimate, excluding the extra numbers to be expected as a result of the enhanced quality of service that devoting the Digital Dividend to mobile broadband would also bring to urban areas.

5.3 Economic Benefits

Allocating the 700 MHz band to mobile would bring far greater benefits to India than the current public use. Not having to digitalize current terrestrial broadcasting like its neighbouring nations, India has the opportunity to take a leading position and shape the development of mobile broadband in the UHF band. Implementing the APT Wireless Forum's suggested band plan for Asia Pacific[4], India can exploit economies of scale and reduced cost of service to make broadband available throughout the country. For conservativeness and consistency, the alternative use modelled in this report is broadcasting, even though it is unlikely to be the alternative use in India. This is because

[4] 2x 45 MHz harmonized band plan agreed by the 9th Meeting of the APT Wireless Forum in Sep 2010

broadcasting will likely have the greatest potential economic impact, relative to the other alternatives.

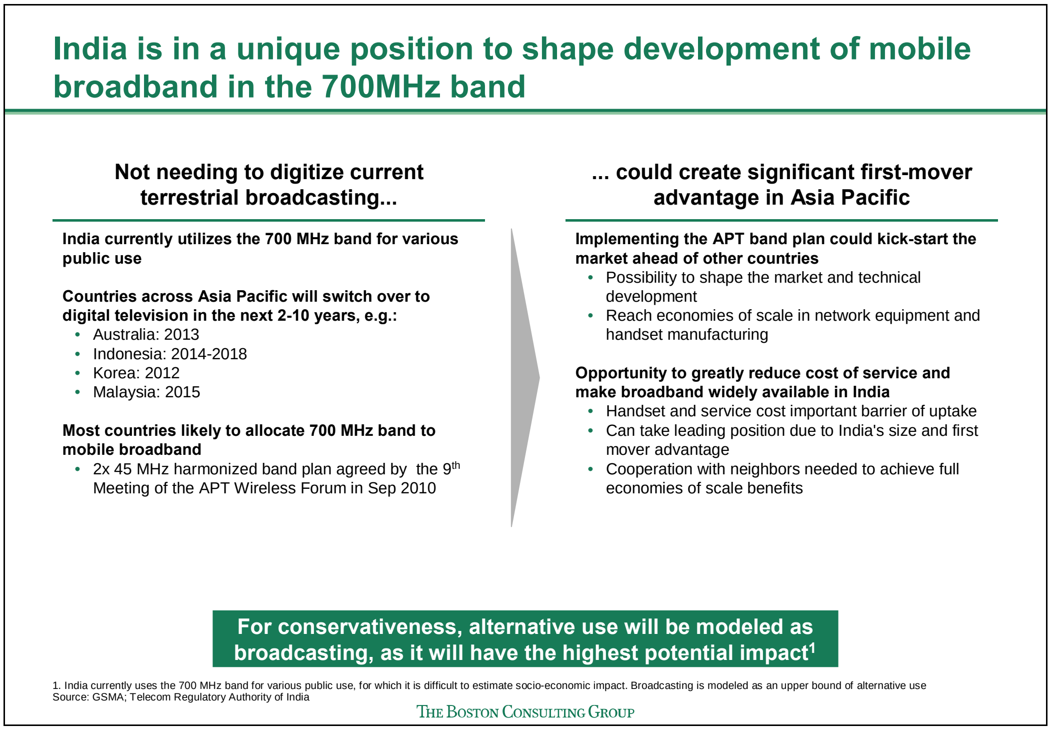

Exhibit 5.5 Shaping 700MHz development

India's GDP is already among the fastest growing in the world, but allocating the 700 MHz band to mobile would still make a significant difference. Mobile broadband can generate a $71B incremental increase over the period from 2014 to 2020. The benefit from broadcasting would be just over one tenth of the mobile dividend - $3.3B. Therefore, allocation to mobile would generate an additional benefit of $68.1B, or $43.8B in net present value.

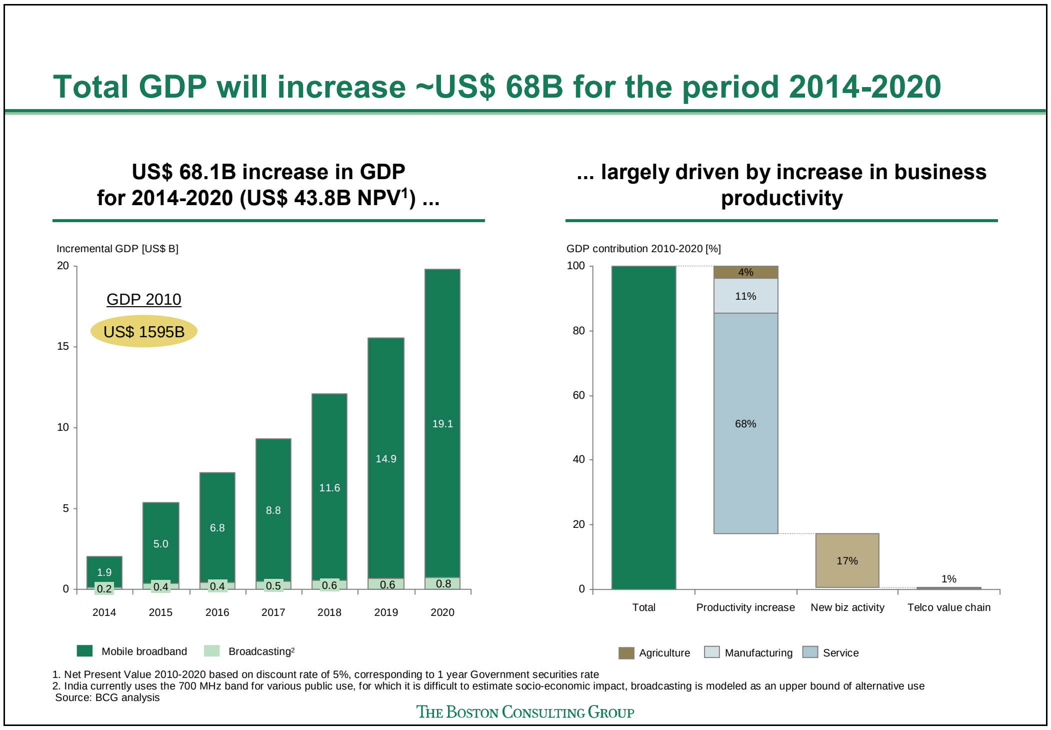

Exhibit 5.6 GDP increase

Most of this, around 83 per cent, will come from increased productivity across all sectors. The bulk of the increase in GDP, almost 68 per cent, would come from increased productivity in the service sector. This would see a productivity increase of 4.7 per cent by 2020, 0.4 per cent more than would have been observed without the allocation of the 700 MHz band to mobile. A further 11 per cent would come from higher manufacturing productivity. This sector would see an increase of 2.4 per cent by 2020, 0.2 per cent higher than the baseline.

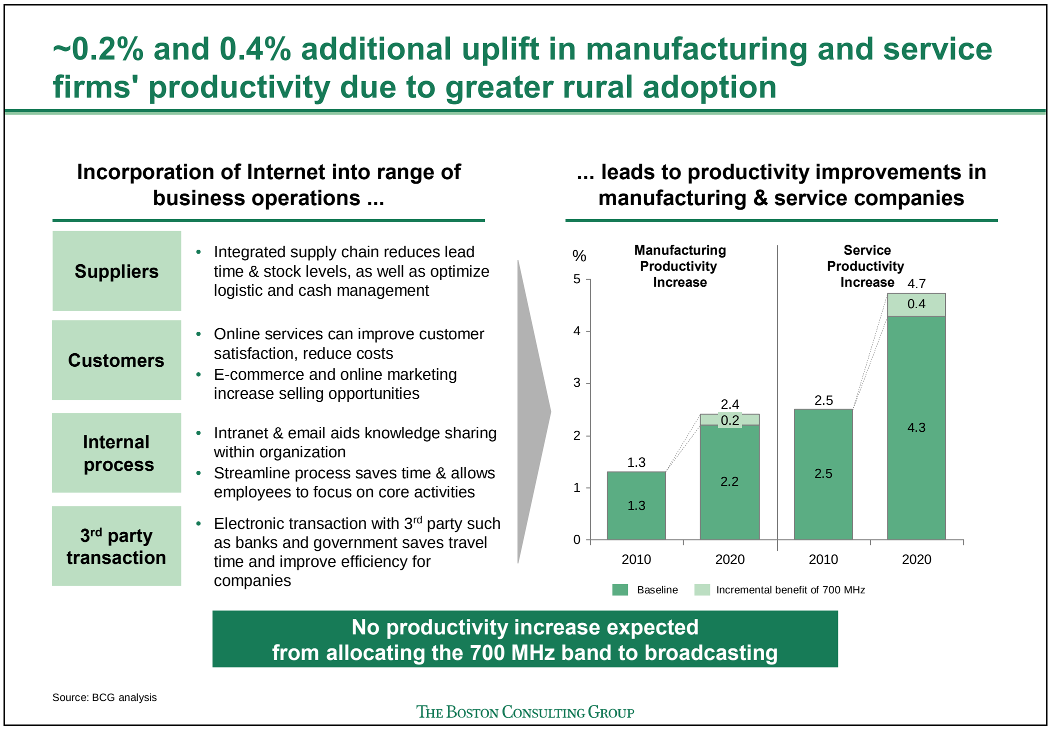

Exhibit 5.7 Productivity increase

New businesses account for another 17 per cent of the GDP increase. BCG estimate that by 2020, 138,000 new business activities – either fresh operations within existing companies or entirely new enterprises – would be created by 2020 in functions varying from e-commerce for existing businesses to reselling hardware and software, agricultural trading and ICT maintenance.

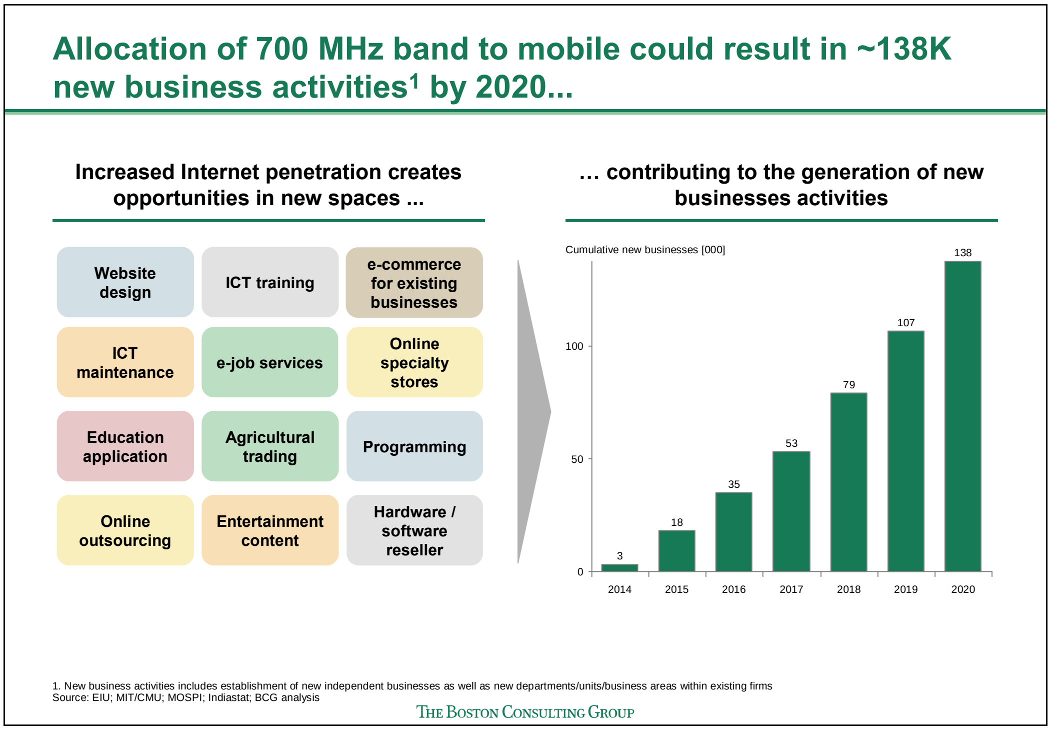

Exhibit 5.8 New business activity

These would generate more than 328,000 new jobs in 2020, many of them in rural areas as access to mobile broadband creates new business opportunities. This, again is a conservative estimate, excluding those created by increased productivity in additional firms, but still outweighs by far the 2,100 jobs that would be generated by allocating the 700 MHz band to broadcasting.

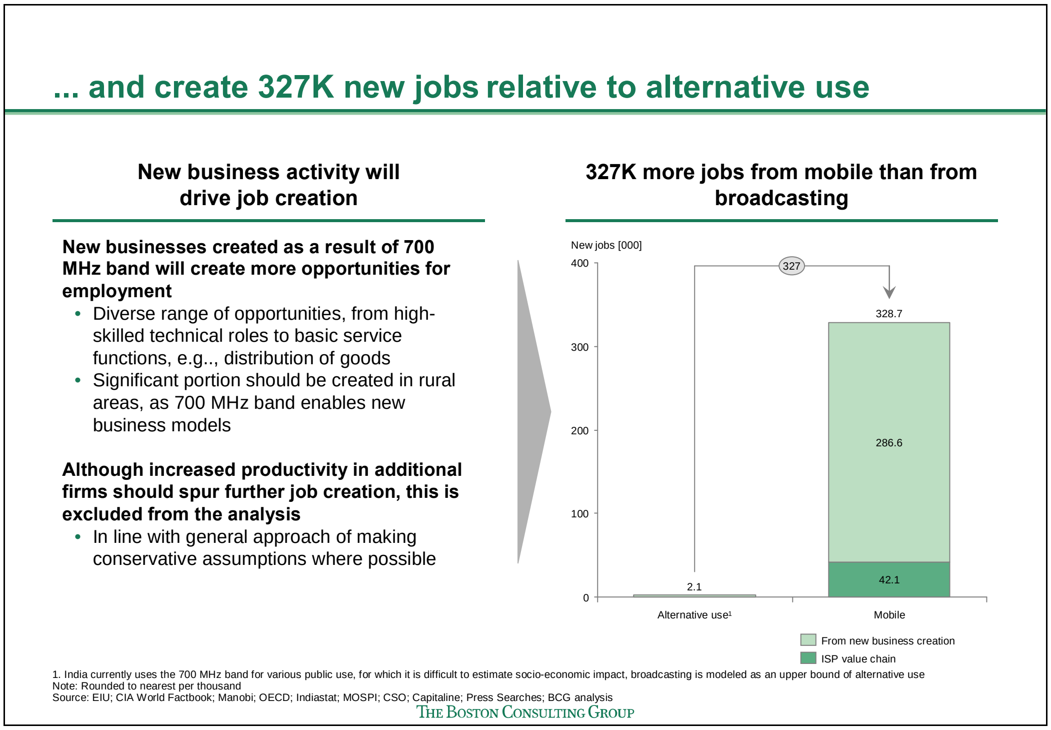

Exhibit 5.9 New jobs

By driving greater economic expansion, using the 700 MHz band for mobile would generate higher revenues for the Indian government. An extra $16.1B would accrue in tax income over the 2014-2020 period, slightly more than half of it from taxes on productivity and new businesses and most of the rest from corporation tax, compared to less than ten per cent of that - $1.5B – from the broadcasting option.

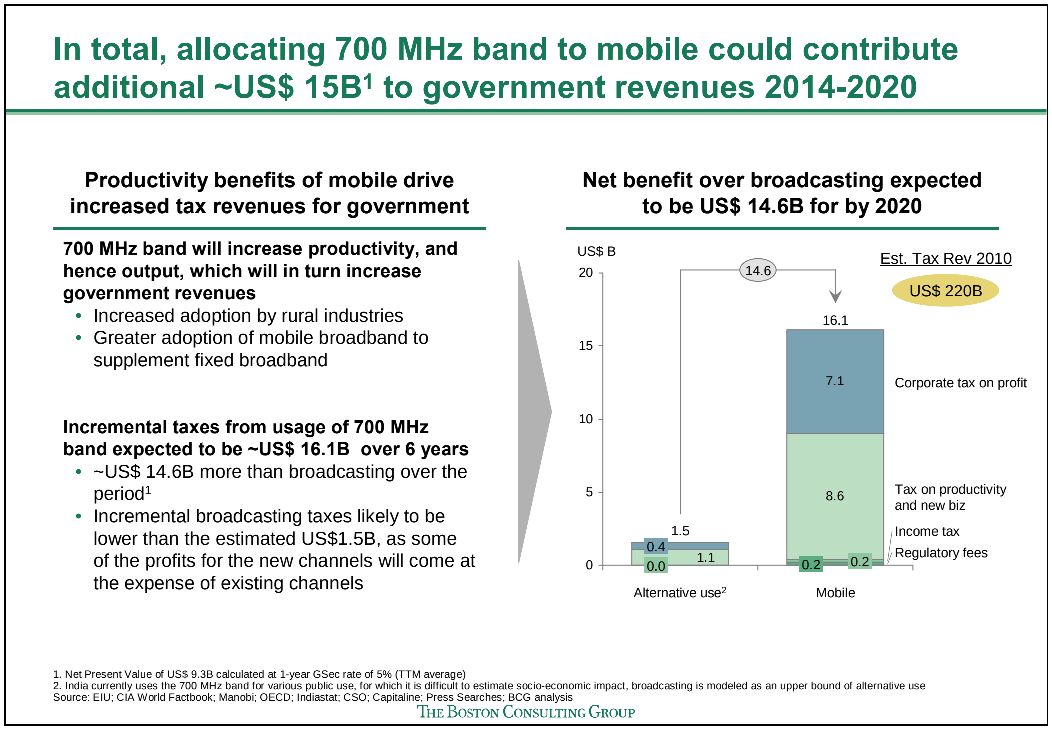

Exhibit 5.10 Governmental revenues

5.4 Social Benefits

While the potential economic benefits from allocating the 700 MHz band to broadband are clear, they are just one aspect of the potential benefits, as the social dividend from such a decision is also likely to be significant.

While India already derives some benefits from Internet access, such as basic IT literacy and access to remote markets, these would be vastly increased by allocating the 700 MHz band to mobile broadband. It would reach parts of India that are currently poorly served by Internet infrastructure, and unleash applications not currently supported – bringing benefits to individuals, companies and districts in those areas.

In particular, this use of the Digital Dividend would help progress towards the key socio-economic goals identified under India's 11th Five Year Plan. This aims for inclusive growth in order to attain the following goals :

- Education – reducing drop-out from elementary schools, increasing enrolment in higher education and improving adult, particularly female, literacy
- Health – reducing infant and maternal mortality, reducing malnutrition and anaemia among women and children and boosting rural healthcare facilities
- Income and Poverty – boosting agricultural GDP and increasing rural employment

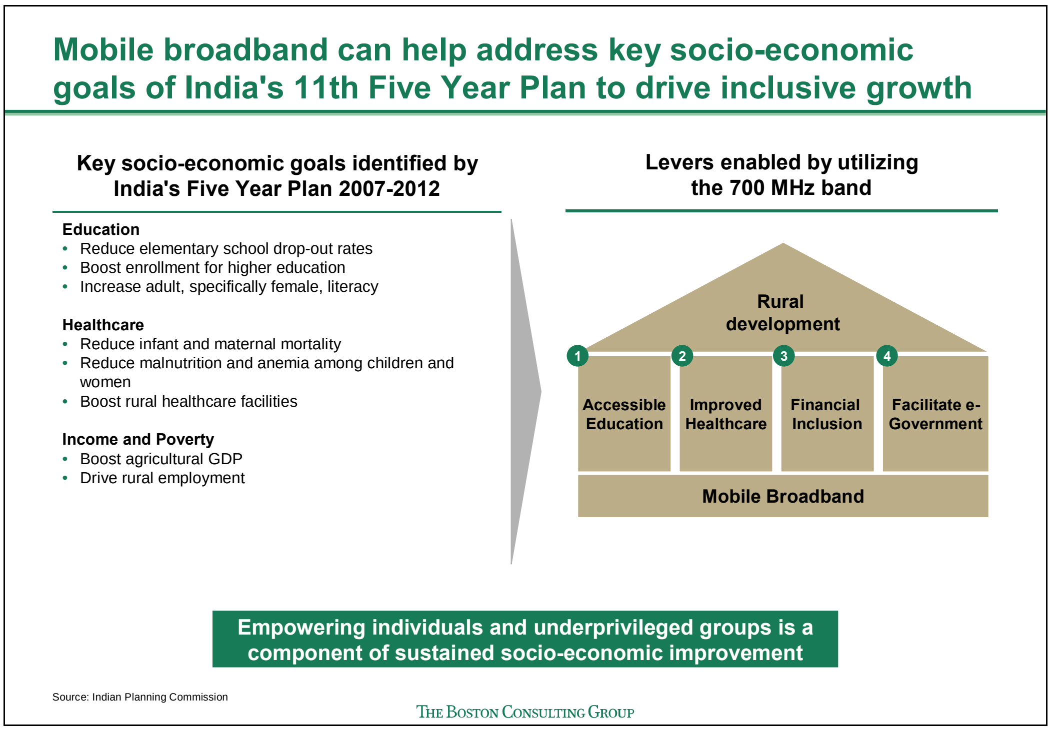

Exhibit 5.11 India's Five Year Plan

5.4.1 Education

Access to education is a serious problem for India. It has low literacy rates, which are most acute in rural areas and among women. Whereas 86.3 per cent of city-dwelling males in India are considered literate, less than half – 46.1 per cent – of females in rural areas are.

Many Indians do not complete even a basic education. The average time spent in education is only 10 years, nine for women. This compares to 13 years in Malaysia and

12 in Indonesia. Drop-out rates are high and there is low enrolment in secondary education. This creates problems when people move into the workforce, with education deficiencies – poor numerical, verbal and analytical skills and/or a skill set not aligned with industry needs – making many unemployable.

These problems are underpinned by poverty and inequality and deficiencies in the school curriculum. Many children, particularly girls, are taken out of school to work as farm labour, a tendency that has increased since the financial crisis and particularly afflicts groups already on the margins of economic life.

Rural schools are particularly handicapped by under-qualified teaching staff with high levels of absenteeism. They are underfunded, offer limited access to essential resources such as stationery and libraries, and sparsely distributed – leaving many children with long, difficult journeys. The curriculum is often outdated, with new changes and new content taking too long to work their way down the chain of schools and little dialogue between industry and educators over the skills needed by industry.

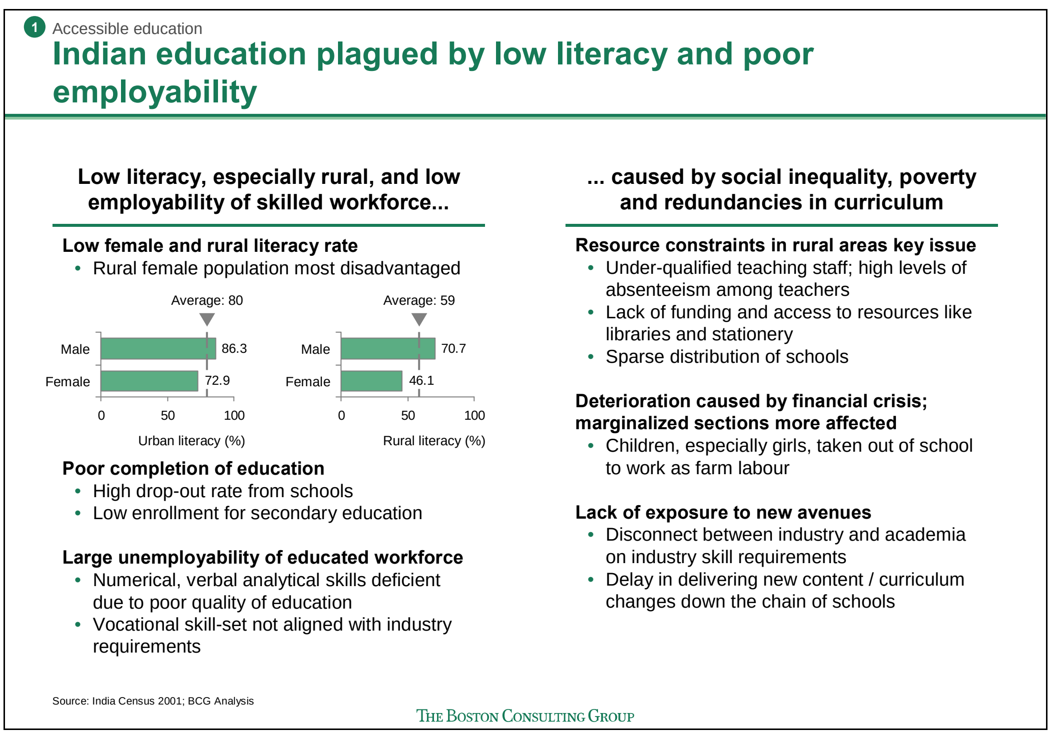

Exhibit 5.12 Educational challenges

Plans developed by India's Human Resource Development Ministry (HRD) for addressing many of these problems will benefit from widespread broadband penetration. Rolling out mobile broadband in the 700 MHz band is a very cost-efficient solution that is particularly well-suited to fulfilling this goal.

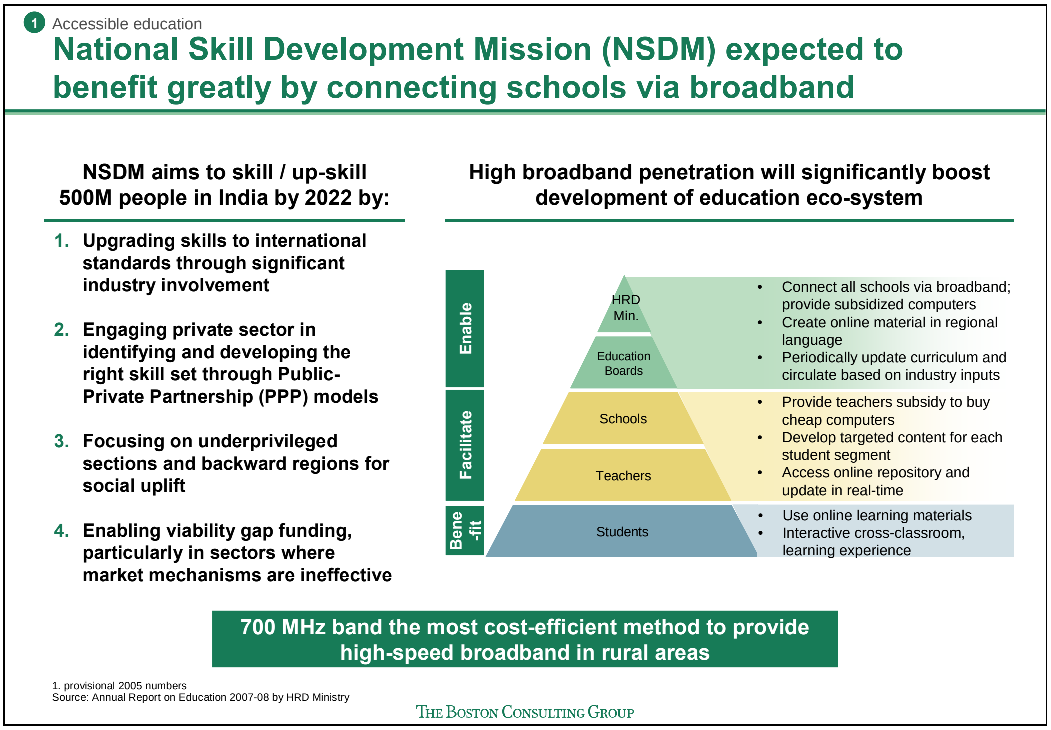

Exhibit 5.13 National Schools Development Mission

Broadband is also a key element in the National Schools Development Mission (NSDM), which is intended to improve the skills of 500 million Indians – equivalent to the entire workforce at present – by 2022. Industry will be heavily involved in upgrading skills to international standards, identifying and developing skill sets through public-private partnership models. The mission as a whole will focus on developing underprivileged sections and backward regions, supplying gap funding where market mechanisms are ineffective.

All of these aims would be enhanced by the wider educational benefits made possible by readily available broadband. Virtual platforms lower the cost of high-quality materials and make them available to all, irrespective of where they have been developed. Teacher training would be improved by continued online learning and access to up-to-date teaching aids.

Education would become more widely available and accessible. Virtual classrooms encourage the flow of information across groups. The physical and psychological barriers to learning for marginalised groups are lowered by bringing the classroom to them via broadband and inclusive, interactive learning processes which reduce social inhibitions

Adult literacy and vocational training would also be enhanced. Adult literacy would benefit from flexible schedules incorporating individual-specific syllabi in regional languages and the removal of the need for formal enrolment in programmes. Vocational training would both become more accessible in remote regions and more effective as industry input is incorporated into the online updates of the syllabus.

5.4.2 Health

Mobile broadband would also make a significant impact on India's health infrastructure, whose challenges can be clearly seen in the statistics. Rural areas in particular suffer through poor access to a sparsely distributed hospital network short on both qualified medical and nursing staff and advanced diagnostic and treatment facilities. The rural poor are excluded from quality treatment by the concentration of facilities in urban areas, creating the need to travel for consultation with specialists, and prohibitive drug prices. Nor has the system improved in line with the growth of India's overall wealth, with only 4 per cent of GDP spent on healthcare services and infrastructure.

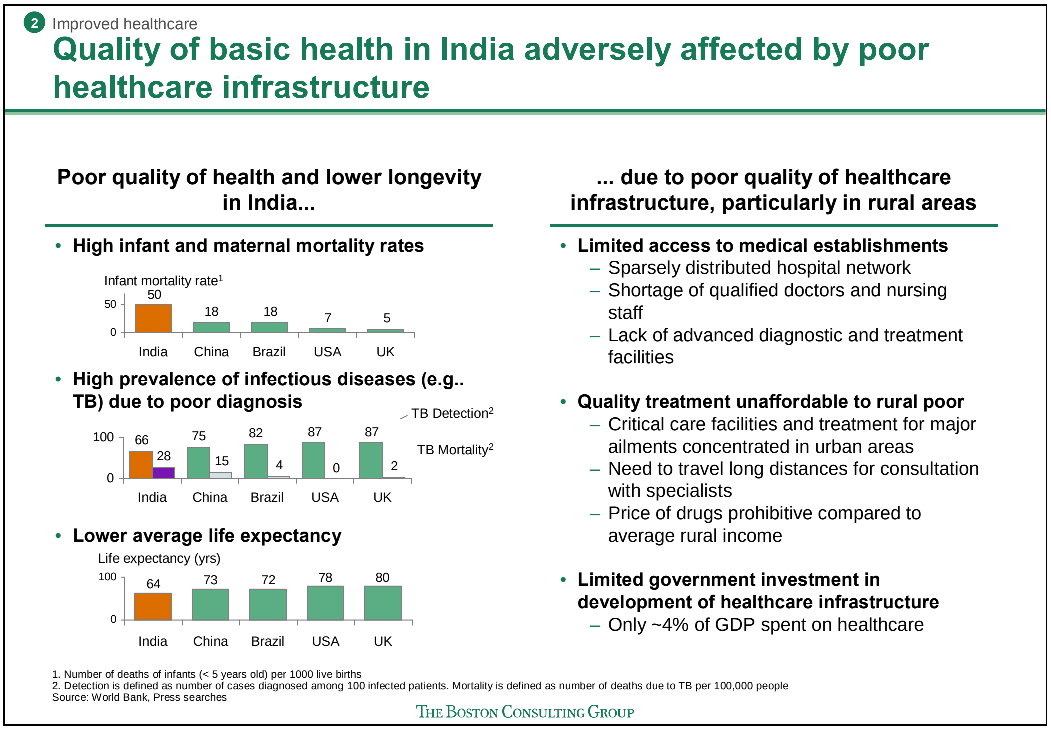

Exhibit 5.14 Basic health situation

The consequence of this is that India still has very high infant and maternal mortality rates, a high prevalence of infectious diseases because of poor diagnosis, and much lower life expectancy (64 years), not only relative to wealthy countries like USA (78) and UK (80), but also to peers in the developing world, like China (73) and Brazil (72).

Mobile broadband would enable the delivery of services to remote areas and more efficient treatment and management of diseases. Health workers would have better access to government and NGO resources and to online training on advances in treatment. Expert advice can be delivered to remote regions via mobile vans equipped with diagnostic facilities and Internet connections to specialists for online diagnoses. The online collection and analysis of health information would aid dissemination to health professionals and early detection of epidemics through systematic real-time data collection.

The urgent need to support initiatives with fast, inexpensive broadband connections is shown by the way initiatives are being constrained by the limited broadband infrastructure currently available in rural areas. Two good examples of this are the real-time monitoring system launched in Tamil Nadu through SughaVazhvu, and the online diagnosis pioneered in Himachal Pradesh through e-Sanjeevani.

- SughaVazhvu operates through micro-health centres operated by local community health workers well informed about health concerns in the district. They operate an electronic health record system, connected to a central database and accessed via a portal in the regional language, Tamil. These detailed records enable experts in leading institutions to offer diagnoses.
- e-Sanjeevani runs via healthcare centres set up in villages and Internet-enabled mobile vans with basic diagnostic equipment, both of which connect to a central medical 'hub' via the Internet. Web-based applications have been developed for the online collation of basic tests, while patients can connect to specialists in urban centres via video conferencing.

Both offer the prospect of significant improvements in health care in their respective states, but only when there is sufficient broadband penetration will they and other such initiatives be able to operate on the scale necessary to make the difference they promise.

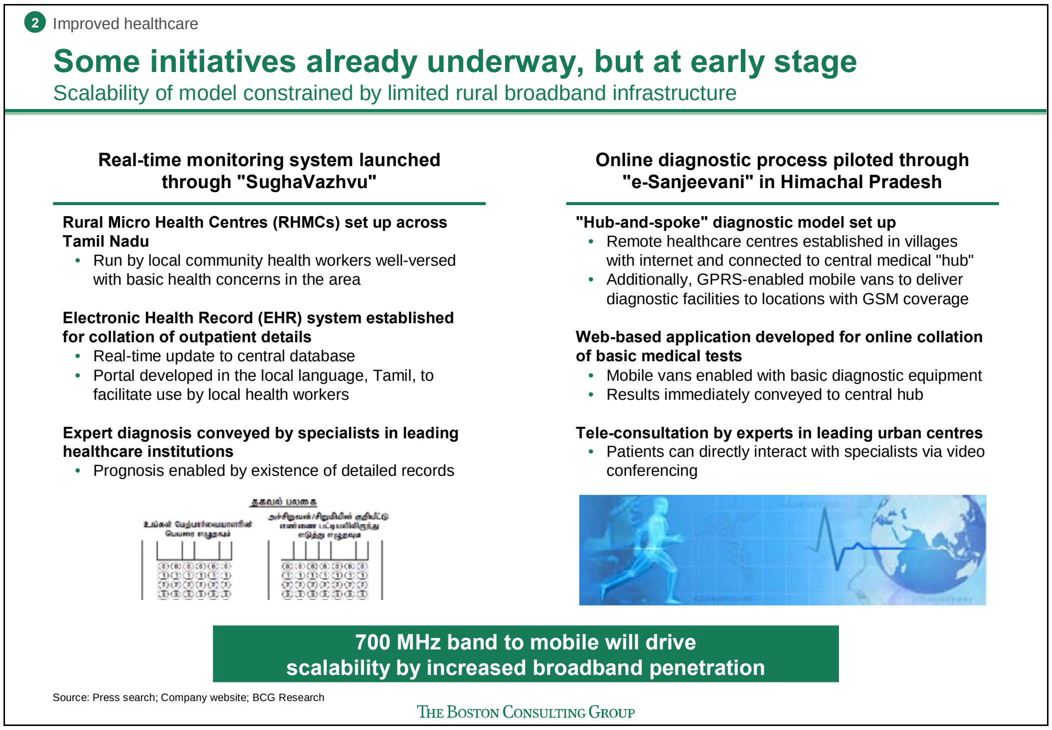

Exhibit 5.15 e-Health initiatives

5.4.3 Financial Inclusion

While the cities develop, India's rural majority continue to be affected by low household incomes, poor access to finance and high unemployment, all of which serve to create and perpetuate a wide income gap between urban and rural households. In 2009 the average household income in cities was more than twice as high as in rural areas.

Rural businesses are largely localised, with little access to wider domestic or global markets. They serve a market limited by the low household incomes from agriculture, which characterised by vulnerability to the vagaries of nature and low productivity because of limited mechanisation.

Most businesses are small scale, based on manual labour with low productivity levels and with limited opportunity to leverage economies of scale. They have limited access to financial services because of the sparse distribution of the bank network, low savings and insurance adoption rates and poor credit histories resulting from low, uncertain incomes.

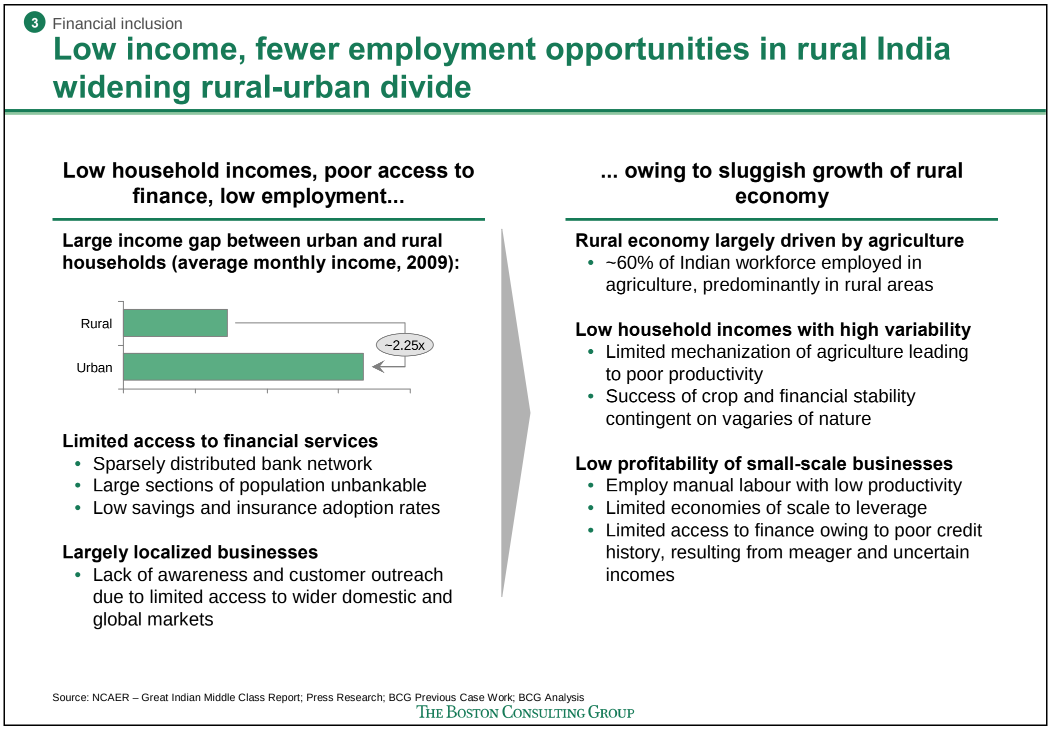

Exhibit 5.16 Rural-urban economic divide

Mobile broadband helps to address these limitations, with the potential to generate sustainable businesses capable of revitalising the rural economy. It offers businesses a means of selling into wider markets, of taking part in outsourced information technology work such as data entry, and the possibility of replacing unproductive manual labour with reliable electronic processes. Internet banking offers companies a convenient, safe and low-cost way to save and borrow money that can be as important as financial aid and access to credit. Insurance can offer protection against financial shocks while mobile accounts protect insurers against credit risks and transaction costs.

A fine example of how Internet-based business can underpin a self-sufficient local economy is provided in India by ITC's e-choupal, an online market and information system for farmers, which has provided support for around 4,000 previously marginalised farmers since it was set up in 2000.

The site develops localised content for each user, with smart card access tracking the specific interests of each farmer. Awareness is spread by mobile vans and virtual helpdesks. The online model provides immediate payment once a purchase has been recorded electronically, with transactions rewarded according to volume and value.

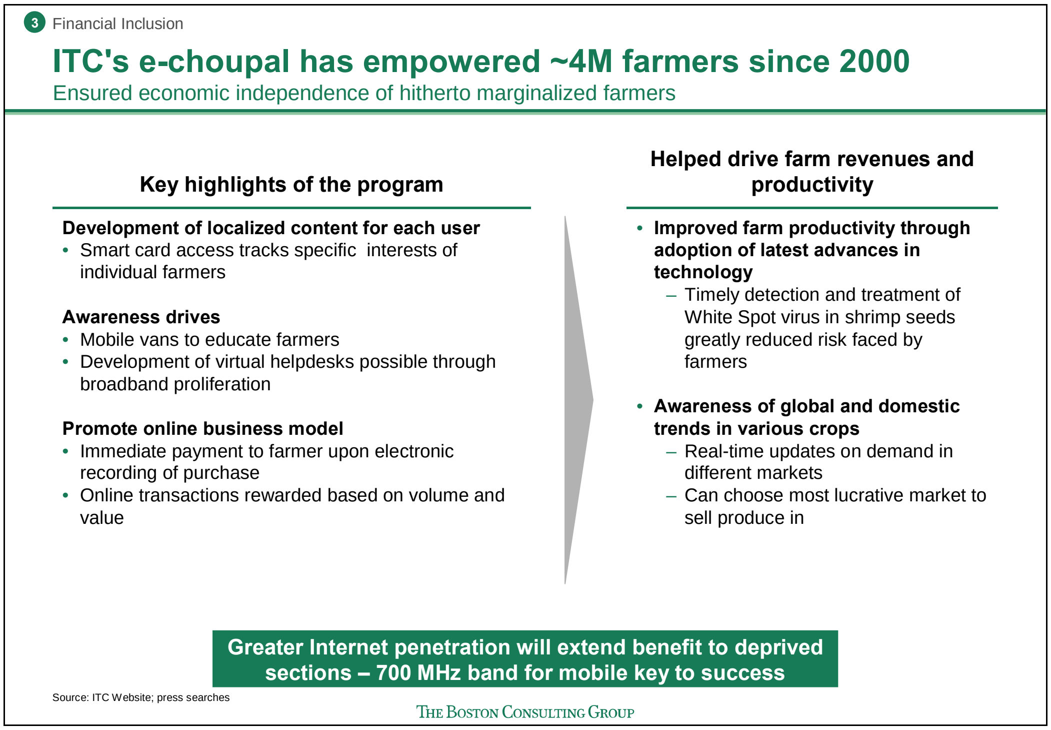

Exhibit 5.17 ITC's e-choupal

Like the health iniatives described earlier, e-choupal can already claim to have brought genuine benefits to rural India, but its full potential can only be attained when broadband is more widely accessible.

5.4.4 Facilitation of e-government

Mobile broadband could greatly increase efficiency in the provision of government services, especially in rural areas, and improve interactions between the government and businesses and consumers. Particularly in rural areas, a significant amount of resources are spent on basic paper-based filing, necessitating large staffs and high transportation and material costs. E-government could also improve the quality and availability of government services, reducing processing times and thereby helping to improve national competitiveness. Examples of services that have seen great improvement in efficiency and customer satisfaction are registration of land records and application procedures.

5.5 Regulatory Issues

Throughout this study, the estimates of benefits have been premised on an appropriate and supportive government policy. They are dependent on governments allocating the internationally harmonized frequency band 698-806 MHz, and implementing the Asia Pacific technical harmonization (the APT bandplan for FDD deployment in the 2X45 MHz based technical harmonisation) to ensure their consumers and society benefit from the economies of scale in handset and network equipment production. Countries which fail on either harmonized allocation of the frequency band or technical harmonization of the frequency band could risk losing out on the potential benefits.

Without access to the 108 MHz of bandwidth, effective rollout may become more difficult. There may be insufficient bandwidth for ensuring effective competition between mobile network operators, which may in turn reduce the range and quality of services, and may lead to increased consumer prices for subscriptions.

Without implementation of the technical harmonisation based on the 2X45 MHz APT bandplan, economies of scale in network equipment and handset production are lost. The 9th Meeting of the APT Wireless Forum (AWF-9), held from 13 to 16 September 2010 in Seoul, Korea, agreed on the planning of the UHF band. It adopted two band plans. One was based on the 2 x 45 MHz with a conventional duplex direction which is the bandplan supported by the GSM Association and its members and associates. The APT harmonised UHF bandplan for IMT is a 2X45 MHz bandplan within the 698-806 MHz band and with a lower guard-band of 5 MHz between 698-703 MHz and an upper guard-band of 3 MHz between 803-806 MHz.

Countries which are out of sync with the agreed band plans will lose out, because harmonization maximizes economies of scale, limits the risk of cross-border interference and improves overall usage quality. Especially for relatively small markets like Korea, Malaysia and Indonesia, but even for a market of the size of India, in the worst case scenario, handsets may not be available, or the range of models available to consumers will be very limited. In the "best case" scenario, failure to harmonize would raise handsets costs, which negates some of the benefits of the 700 MHz band based broadband. In addition failure to harmonize adds to the cost of establishing and maintaining the mobile network because of the need for technical adjustments, such as filtering solutions and other modifications to transmitters to adjust to non-harmonized band edges.

It is estimated that non-harmonization would reduce the projected benefits of 700 MHz band by 5-10%, thereby reducing the jobs, new businesses and taxes that could be generated by the Digital Dividend.

Beyond ensuring harmonized allocation of the 698-806 MHz band to mobile and implementing the technically harmonized bandplan to generate economies of scale, governments and their regulators need to provide a stable, supportive, predictable and transparent environment for operators and their investors and for equipment vendors and handset producers and their investors. Without this investment, overall efficiency and speed of rollout will be hampered. In particular, prices for spectrum fees should be set to ensure that rural areas get the low-cost provision essential for their needs.

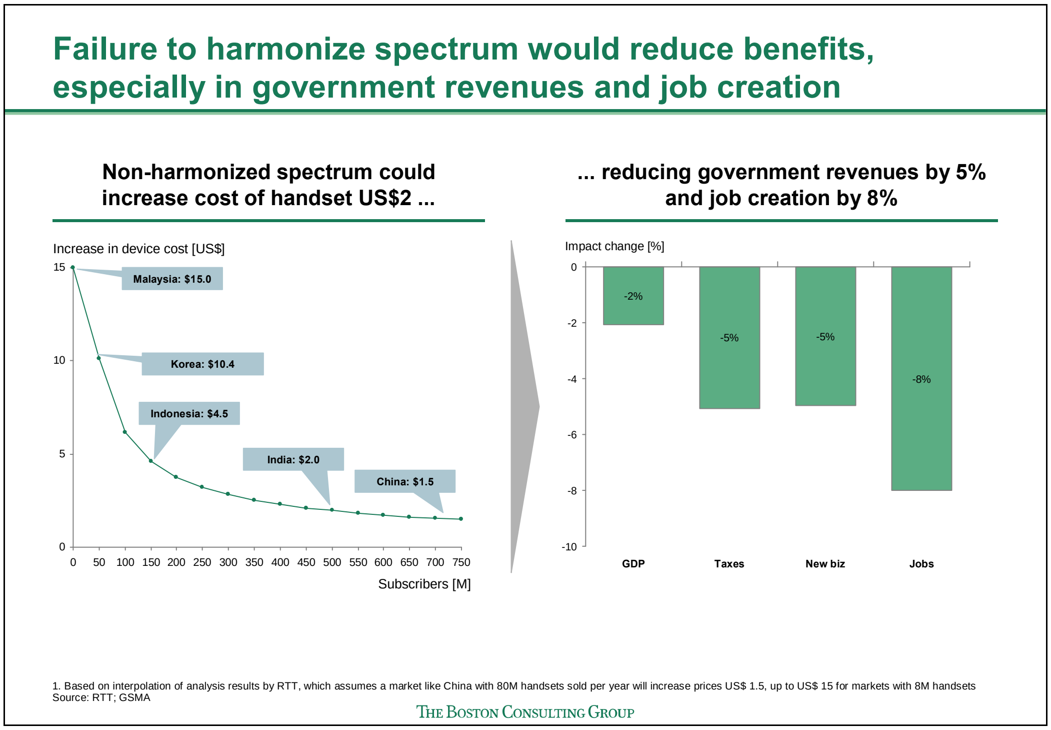

Exhibit 5.18 Impact of non-harmonization

APPENDIX - METHODOLOGY

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

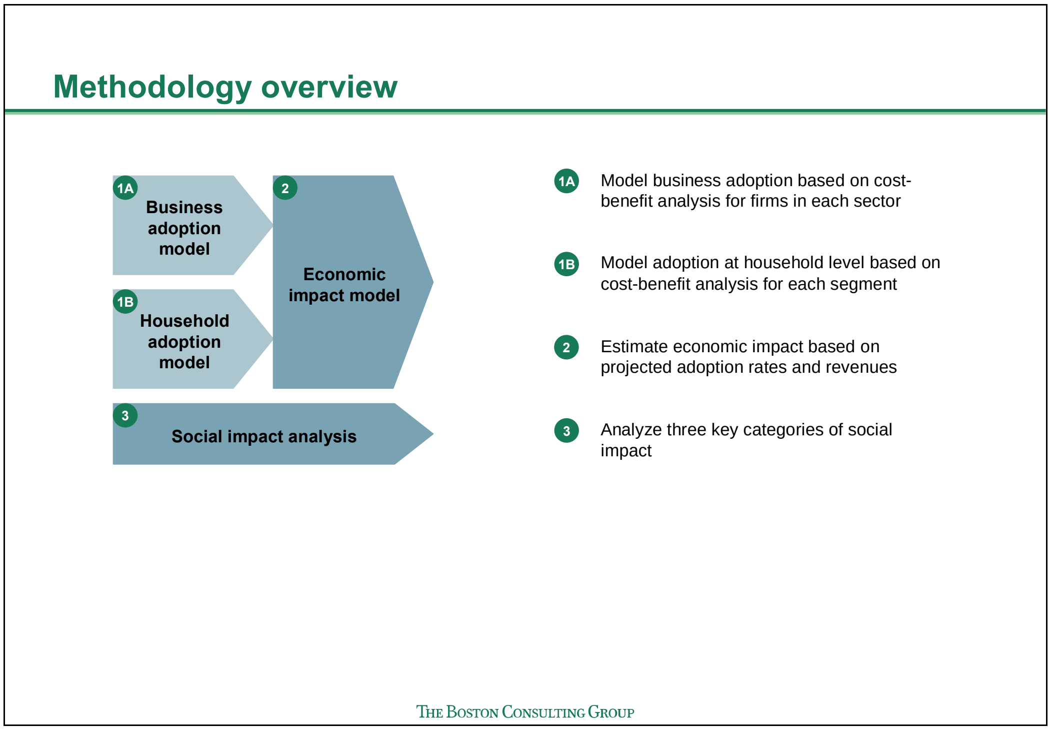

Exhibit A.1 Methodology overview

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

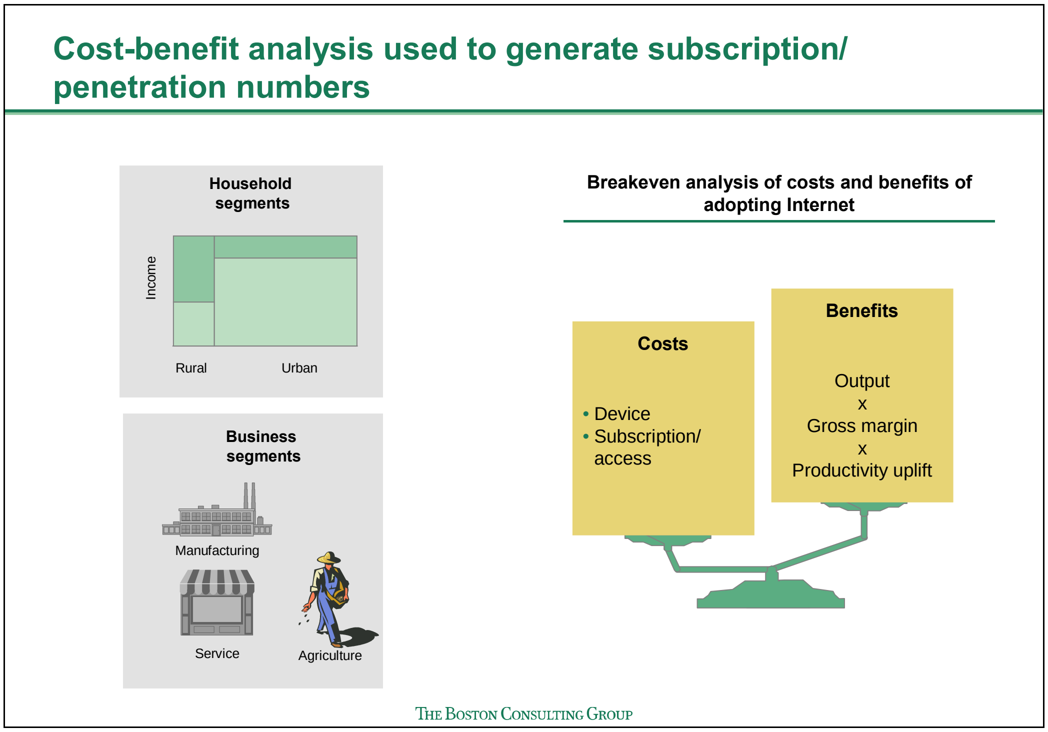

Exhibit A.2 Cost-benefit analysis

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.

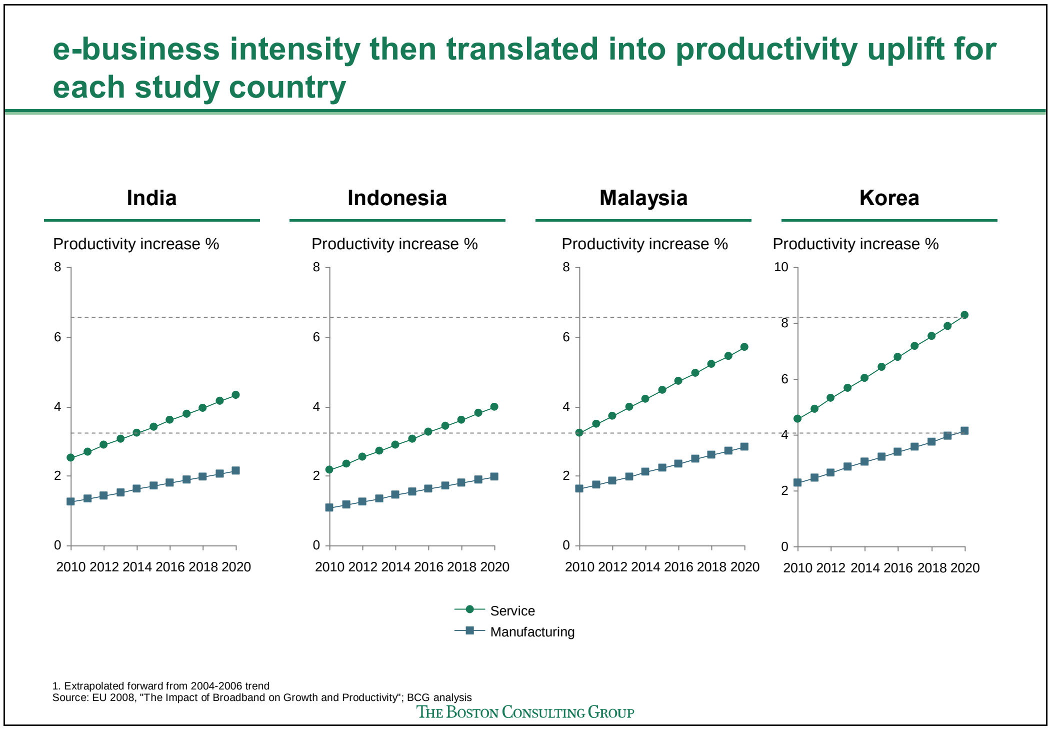

Exhibit A.3 Productivity impact

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[5], 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

[5] *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[6] 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.

[6] 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

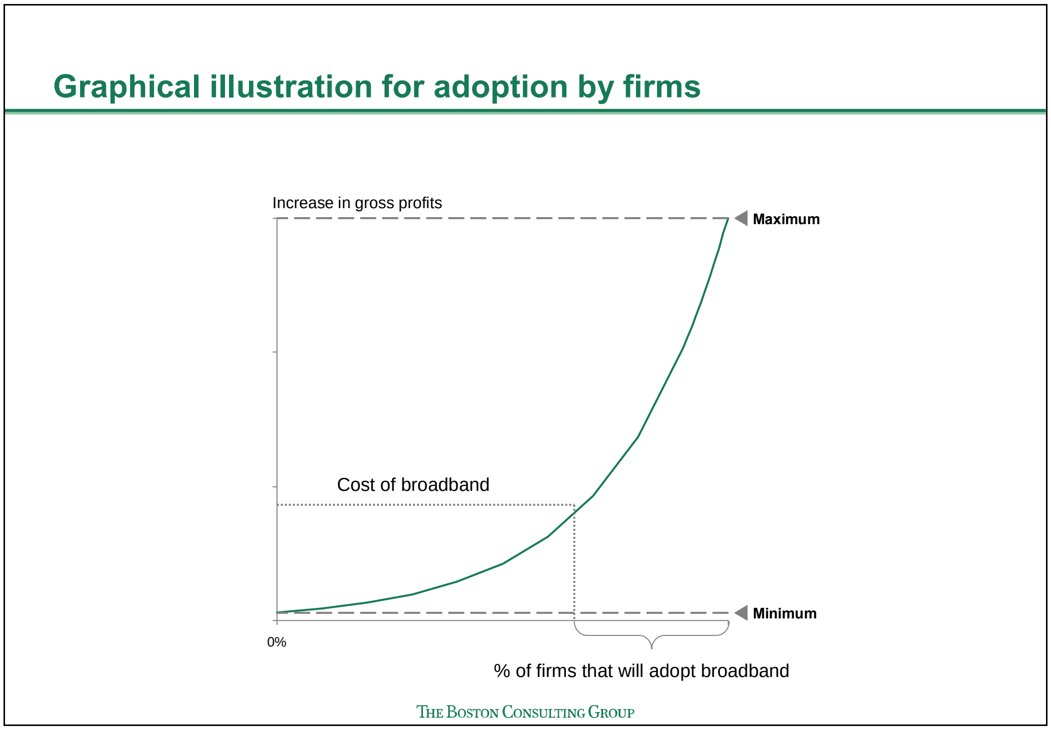

Exhibit A.4 Adoption by firms

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.

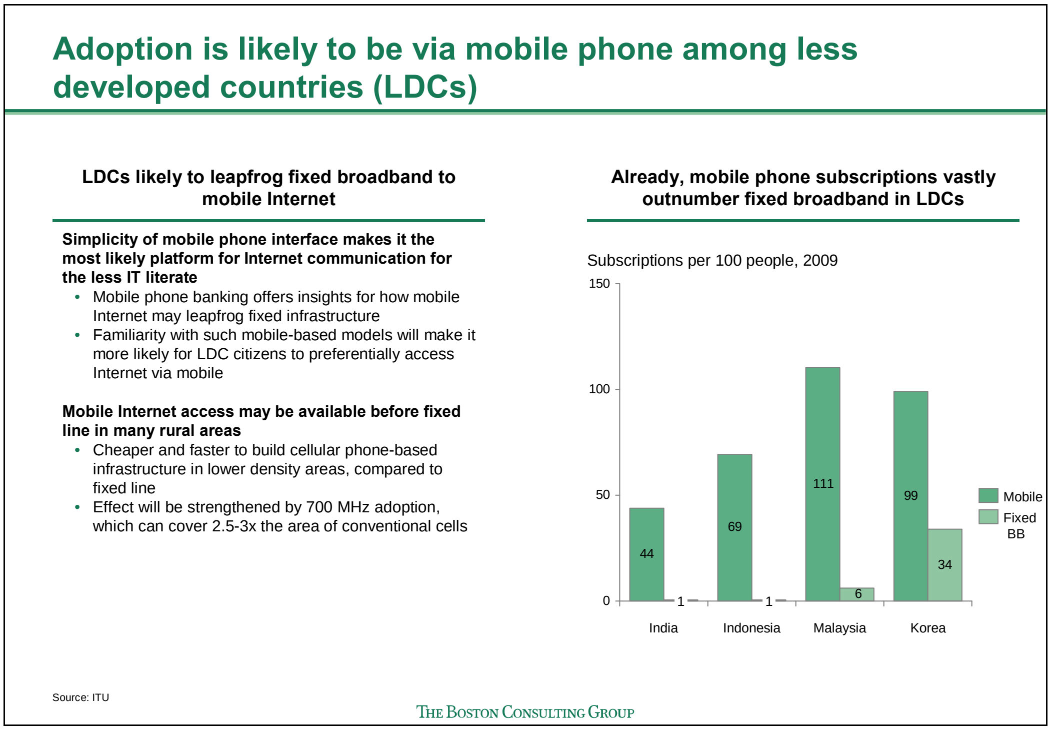

Exhibit A.5 Adoption platform for study countries

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[7]. 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.

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

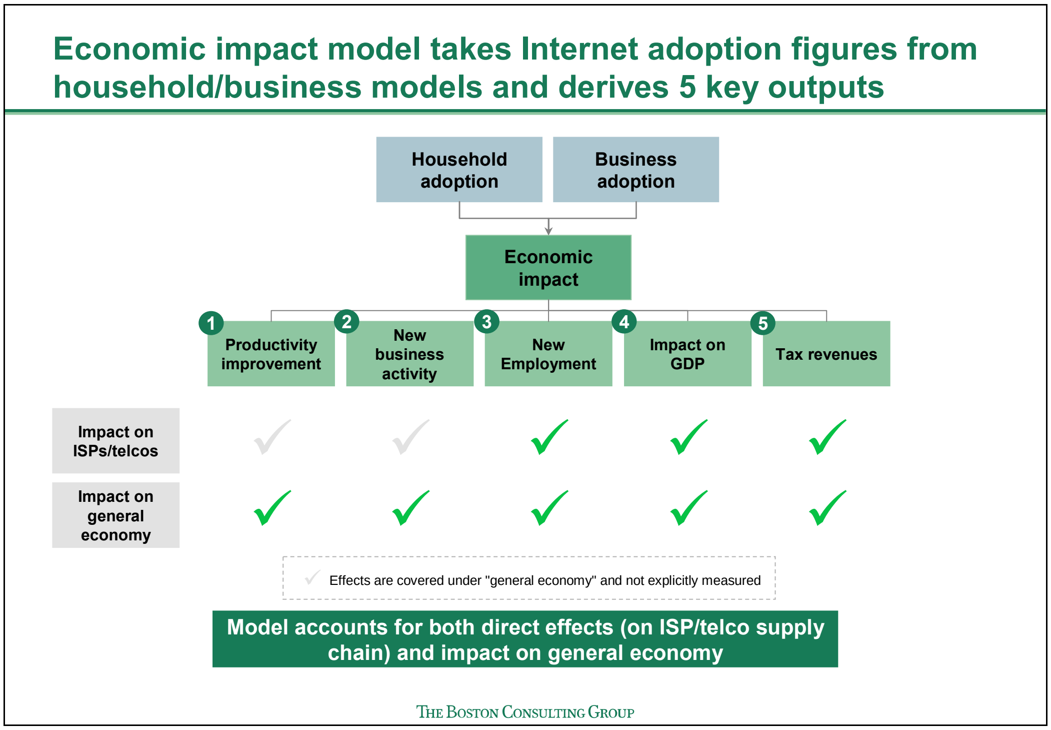

Exhibit A.6 Parameters of economic impact model

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.

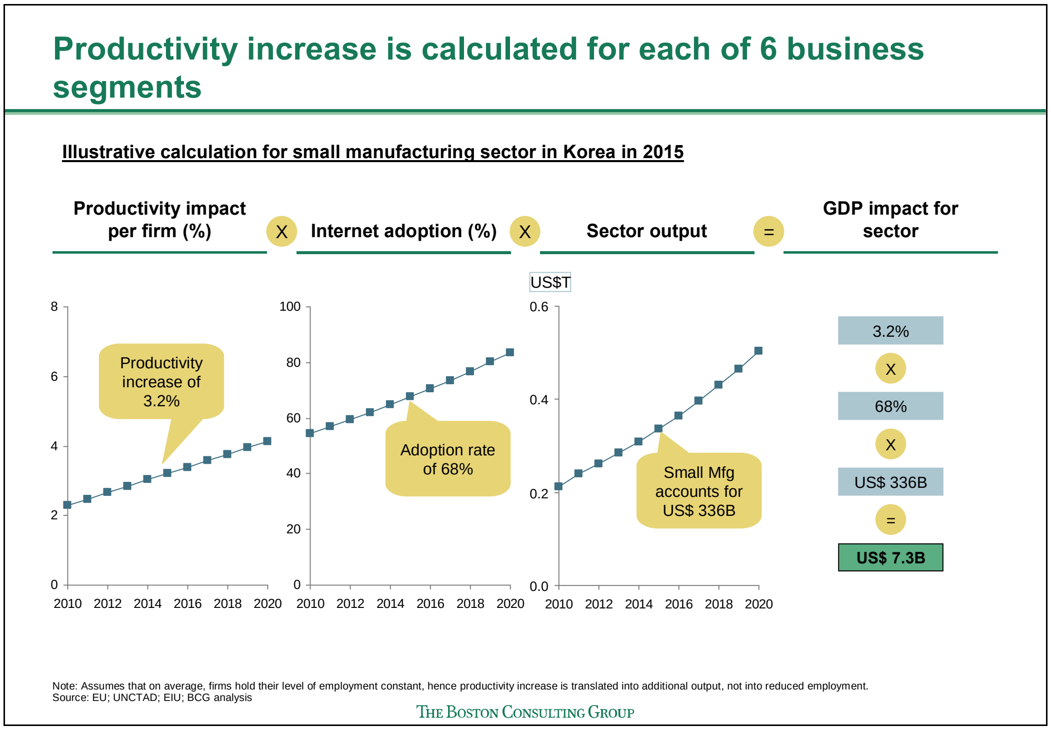

Exhibit A.7 Productivity impact calculations

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

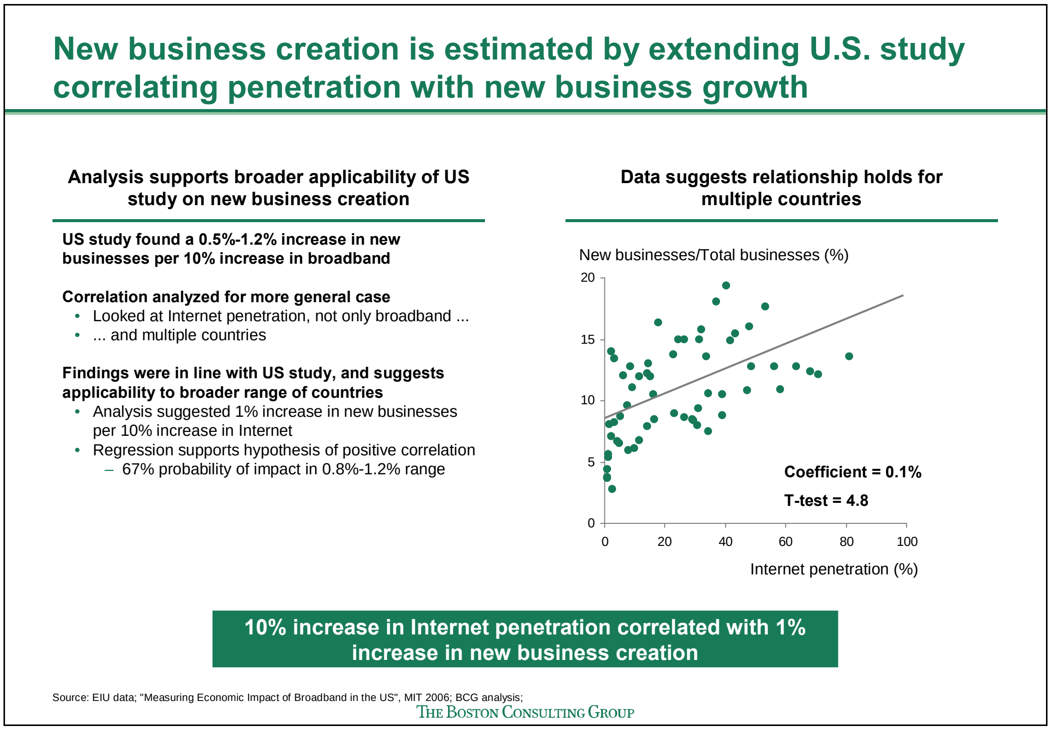

Exhibit A.8 New business creation

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.

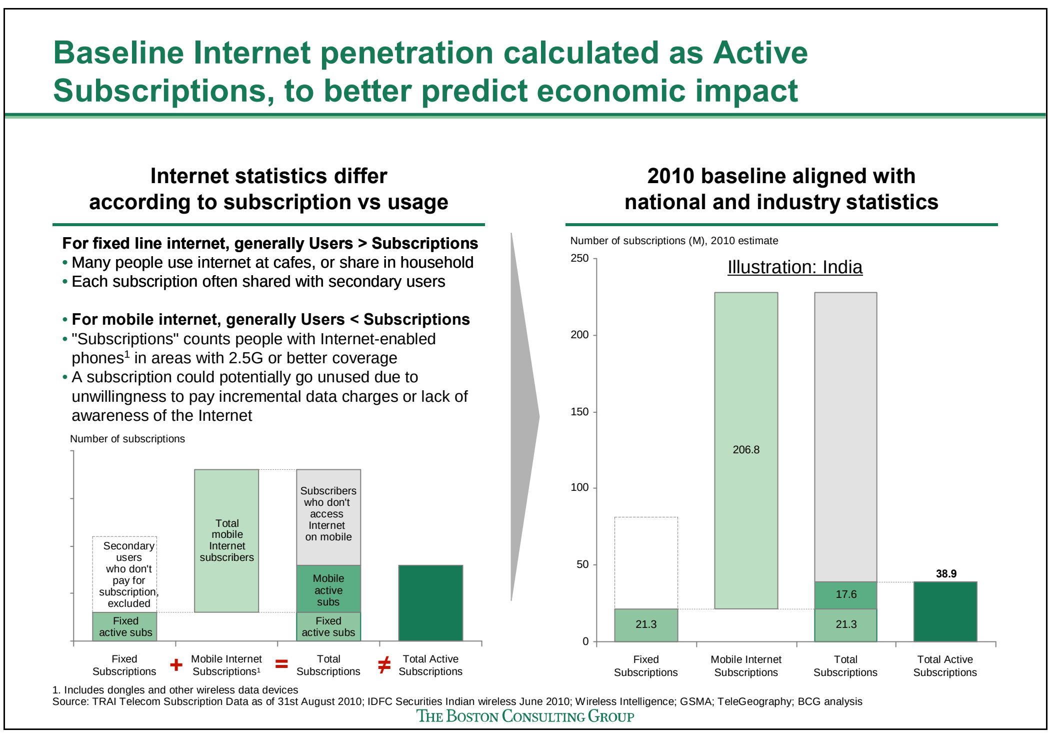

Exhibit A.9 Active Subscriptions

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.

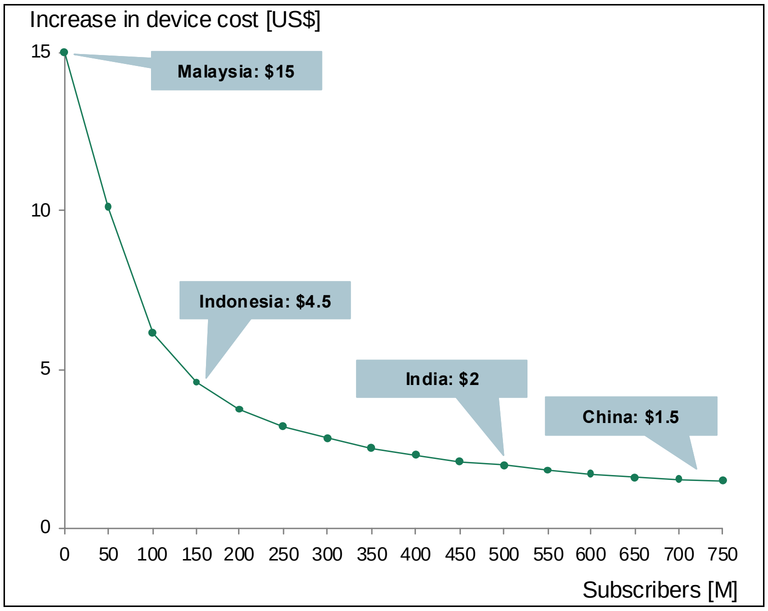

Exhibit A.10 Device cost increase due to non-harmonization

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.

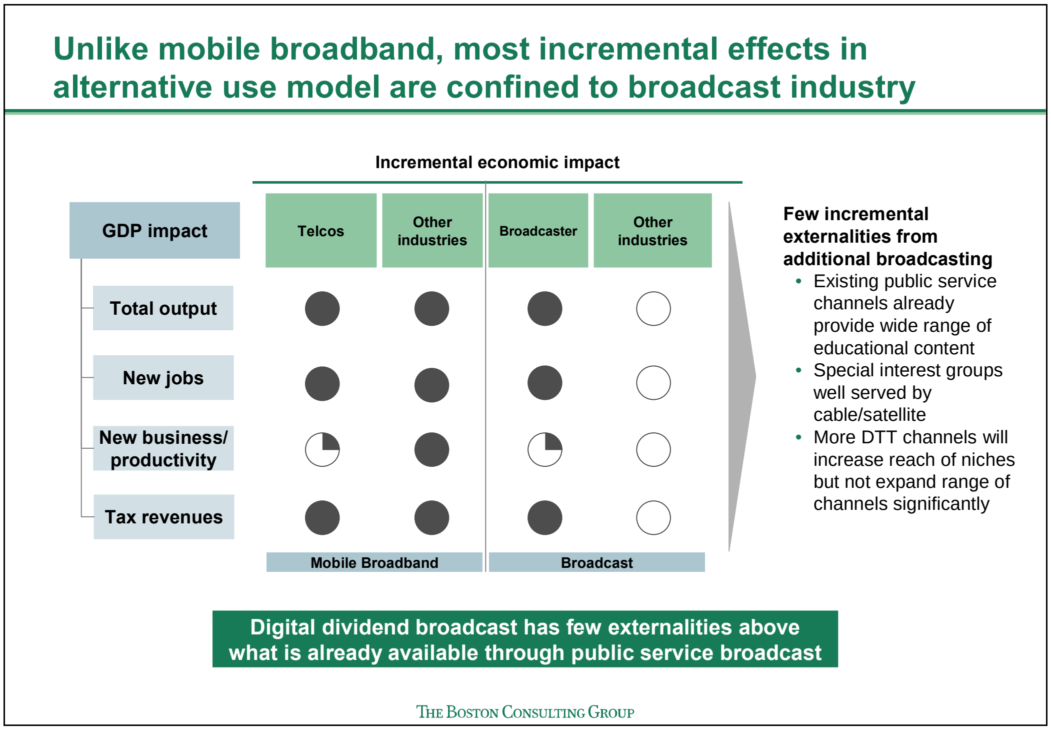

Exhibit A.11 Economic impact of broadcast vs. broadband

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.

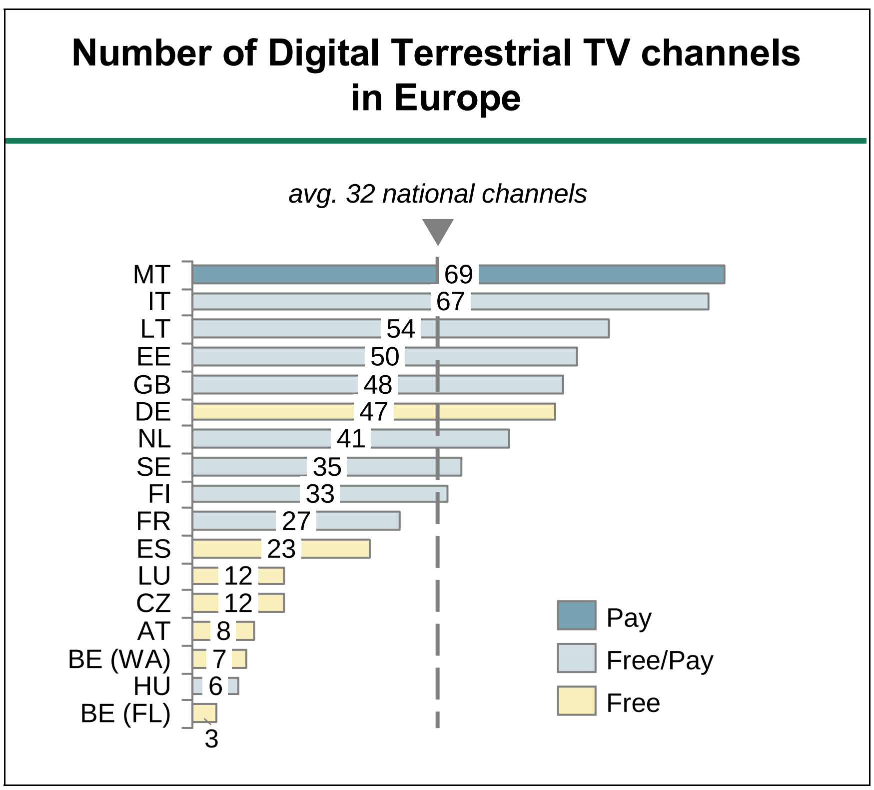

Exhibit A.12 Number of DTT channels in Europe

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[8] 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 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.

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

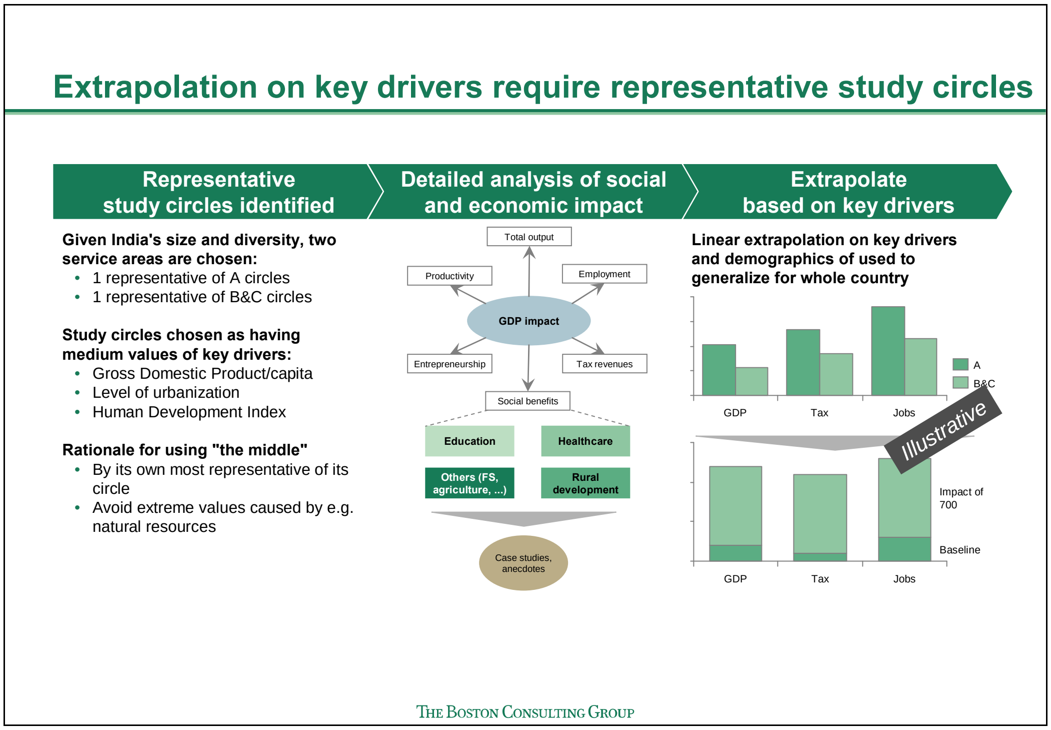

Exhibit A.13 Extrapolation methodology

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.

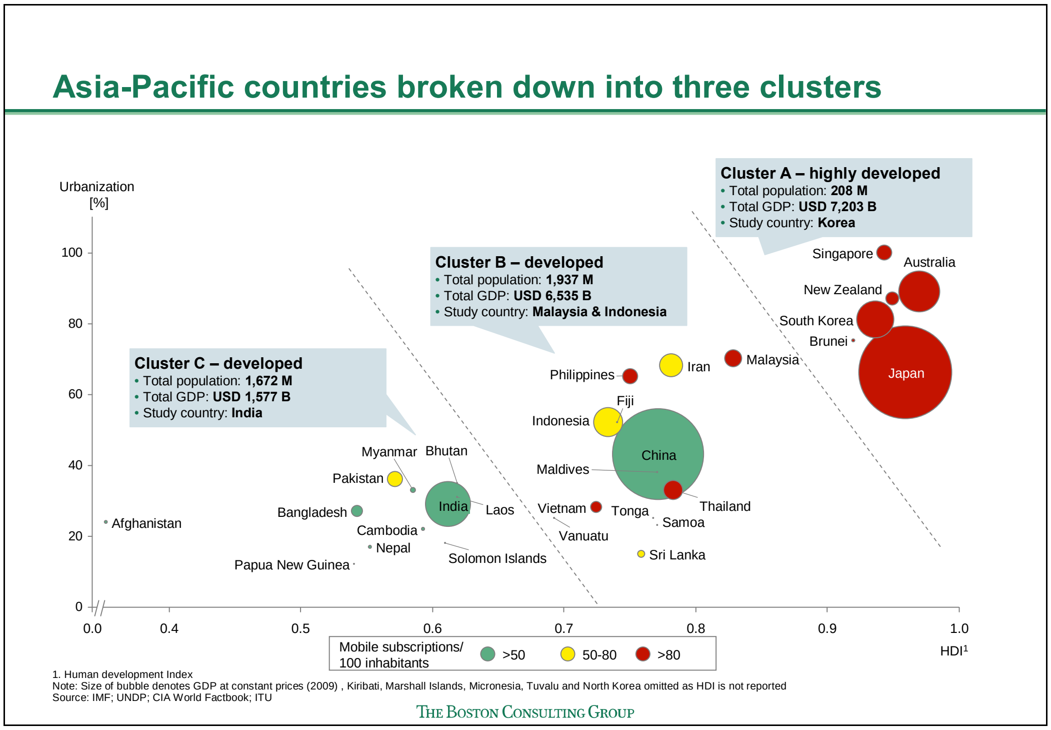

Exhibit A.14 Clustering of Asia-Pacific countries

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.

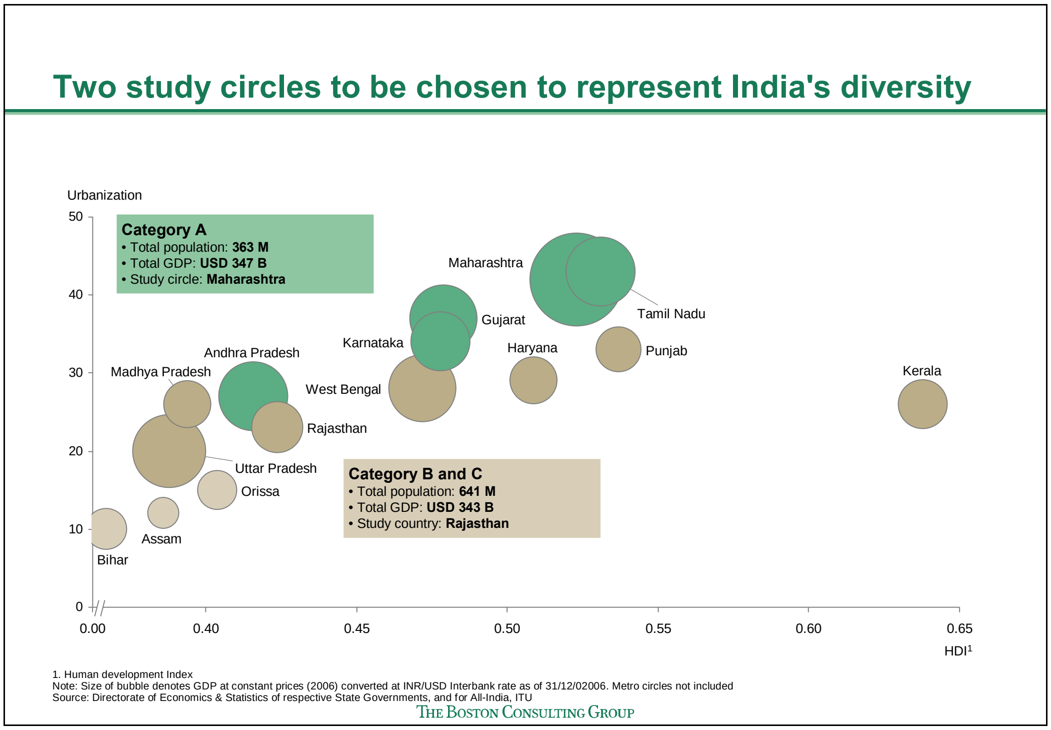

Exhibit A.15 India study circles

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.

Extrapolation from study countries based on level of urbanization and current mobile penetration

Inverse average of urbanization and penetration used as uplift factor...

Illustration: Uplift factors for Cluster A

	Urb.	Penetr.	Uplift factor
Korea	1.00	1.00	**1.00**
Australia	1.10	1.15	**0.89**
Brunei	0.93	1.08	**1.00**
Japan	0.81	0.91	**1.16**
New Zealand	1.07	1.11	**0.92**
Singapore	1.23	1.42	**0.75**

... to estimate socio-economic impact for entire cluster of countries

GDP impact based on impact/GDP ratio

$$\sum_{Countries} \frac{\text{GDP uplift study country}}{\text{GDP of study country}} * \text{country GDP} * \text{uplift factor}$$

Governmental revenue based on tax/GDP ratio

$$\sum_{Countries} \frac{\text{Tax uplift study country}}{\text{Tax of study country}} * \text{country tax} * \text{uplift factor}$$

Jobs created based on uplift ratio

$$\sum_{Countries} \frac{\text{Jobs created study country}}{\text{Total job increase study country}} * \text{annual job increase} * \text{uplift factor}$$

New business creation based on job uplift

$$\sum_{Countries} \frac{\text{New biz created study country}}{\text{Total job increase study country}} * \text{annual job increase} * \text{uplift factor}$$

1. Indexed to study country. For Cluster B, countries indexed to average of study countries Malaysia and Indonesia, for India towards average of Maharashtra and Rajastan
Source: IMF; UNDP; CIA World Factbook; ITU; BCG Analysis

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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

Cluster A	Cluster B[1]	Cluster C[1]
Australia: 0.89	China: 1.51	Afghanistan: 1.11
Brunei: 1.00	Fiji: 1.18	Bangladesh: 1.22
Japan: 1.16	Indonesia: 1.00 (study country)	Bhutan: 0.88
New Zealand: 0.92	Iran: 1.05	Cambodia: 1.23
Singapore: 0.75	Malaysia: 1.00 (study country)	India: 1.00 (study country)
Korea: 1.00 (study country)	Philippines: 1.02	Laos: 0.89
	Samoa: 1.52	Myanmar: 1.73
	Sri Lanka: 1.96	Nepal: 1.70
	Thailand: 1.05	Pakistan: 0.79
	Tonga: 2.05	Papua New Guinea: 2.78
	Vanuatu: 2.01	Solomon Islands: 2.66
	Vietnam: 1.27	

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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Capitaline: http://www.capitaline.com
CIA World Factbook: https://www.cia.gov/library/publications/the-world-factbook/
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Economic Planning Unit of Malaysia: http://www.epu.gov.my
Economist Intelligence Unit : http://www.eiu.com
Euromonitor : http://www.euromonitor.com
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Indiastat: http://www.indiastat.com
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International Telecommunications Union: http://www.itu.int
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Service Canada: http://www.servicecanada.gc.ca/eng/home.shtml
Source for Change: http://www.sourceforchange.in
Statistics Malaysia: http://www.statistics.gov.my
Telecom Regulatory Authority of India: http://www.trai.gov.in
Telkomsel: http://www.telkomsel.com
TheCarrot website: http://thecarrot.com
UITP: http://www.uitp.org/publications/Mobility-in-Cities-Database.cfm
United Nations Development Program: http://www.undp.org/
Vault: http://www.vault.com/wps/portal/usa
World Health Organisation: http://www.who.int

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Annexure- 2

CEPT Report 31Annex 5 'Spectrum utilisation of FDD, TDD and mixed FDD/TDD frequency arrangements'

A5.1 Introduction

This annex considers the effectiveness of mixed FDD/TDD frequency arrangements, compared with a reference of an FDD band-plan containing only paired blocks and with band plans containing TDD only.

In the first step, the number of available 5 MHz blocks is calculated. However, a viable Mobile/Fixed Communication Network requires more than a single 5 MHz block. Therefore, in the second step, the amount of spectrum that can be fully utilised by Mobile/Fixed Communication Networks is calculated. However, the spectrum that cannot be fully utilised will not remain unused. Therefore, in the third step the overall effectiveness of potential spectrum use is estimated.

A5.2 Analysis of Number of available blocks

Figure A5.1 shows the eight most optimal frequency arrangements for FDD, TDD and mixed FDD/TDD for the frequency range 790-862 MHz. Table A5.1 shows the total number of available blocks plus the usable spectrum in the centre gap, for these options.

The following assumptions are made for the mobile service in the numerical calculations:

- Block size: 5 MHz
- Unsynchronised TDD operators
- Restricted –block between TDD and either uplink or downlink: 5 MHz
- Guard bands of 7 MHz and 12 MHz (however, note that the 7 MHz guard band is not consistent with the conclusions of ECC TG4)

The following assumptions are made for the use of spectrum within the band-plan by other applications:

- For the spectrum to be useful for another application, there has to be some consistency in the spectrum available across Europe:
  - For most potential applications, the practical tuning range of equipment is limited.
  - The FDD centre gap and the TDD guard band above 790 MHz would be consistent, but the restricted blocks would be country specific (and may be dependent on the result of the licence award process).
- A 5 MHz restricted block would not be useful for other applications:
  - There would not be sufficient useful spectrum (e.g. to create a viable market for equipment).
- The other applications will probably not use packet based transmission:
  - for full utilisation of the spectrum, the emissions limit for coexistence would therefore need to be for the scenario where probability of packet collisions cannot be taken into account (see ECC Report 131, section 4.1)
  - A typical FDD base station and or terminal will meet this limit within the centre gap at an offset of around 4 MHz from the band edge (see PT SE 42 (09) 005).
  - A TDD base station is also likely to need to meet this limit at an offset of 4 MHz from the channel in order to meet the likely block edge mask at 5 MHz offset (assuming that they are similar to the BEM for 2.6 GHz defined in CEPT Report 19).

<u>The term "guard block" does not preclude the use of such spectrum by other applications</u>

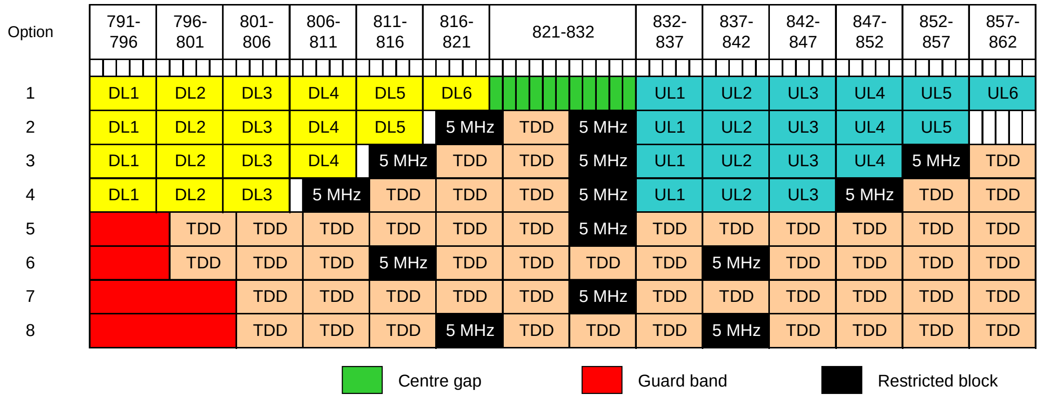


Figure A5.1 Possible band-plan options

Options 5 and 7 represent the best outcome for two TDD networks and options 6 and 8 represent the best outcome for three TDD networks (with 7 MHz and 12 MHz guard bands respectively). It is not possible to support more than three TDD networks within the 790-862 MHz band.

It is assumed that a centre gap or guard band of 8 MHz or more is suitable for other applications such as PMSE. However, this does not take account the impact of fragmentation of the spectrum across Europe on the viability of developing equipment.

Available spectrum																
(No. of blocks)	**Option 1 FDD**		**Option 2 Mixed**		**Option 3 Mixed**		**Option 4 Mixed**		**Option 5 TDD**		**Option 6 TDD**		**Option 7 TDD**		**Option 8 TDD**	
	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz
FDD	12	60	10	50	8	40	6	30								
TDD	0		1	5	3	15	5	25	12	60	11	55	11	55	10	50
Useful Mobile Blocks	12		11		11		11		12		11		11		11	
Total Mobile Spectrum		**60**		**55**		**55**		**55**		**60**		**55**		**55**		**50**
Centre Gap		11														
Guard Band										7		7		12		12

Table A5.1: Available spectrum

A5.3 Amount of spectrum that can be fully used

Table A5.2 analyses the amount of useful spectrum for the eight options illustrated in Figure A5.1, with the following illustrative assumptions for the spectrum needed to support a Mobile/Fixed Communication Network in the UHF band:

FDD: Minimum of 2 X 10 MHz

TDD single frequency re-use (1-F): 20 MHz contiguous

TDD 2-frequency re-use (2-F): 2 X 10 MHz

TDD 3-frequency re-use (3-F): 3 X 5 MHz

Number of blocks that can be fully utilised																		
(Max no. of networks)	**Option 1 FDD**		**Option 2 Mixed**		**Option 3 Mixed**		**Option 4a Mixed**		**Option 4b Mixed**		**Option 5 TDD**		**Option 6 TDD**		**Option 7 TDD**		**Option 8 TDD**	
	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz
FDD	3	60	2	50	2	40	1	20	1	20	0		0		0		0	
TDD (1-F)	0		0		0		0		0		0		0		0		0	
TDD (2-F)	0		0		0		0		1	20	0		2	40	1	20	1	20
TDD (3-F)	0		0		1	15	1	15	0		4	60	1	15	2	30	2	30
Total fully utilised Spectrum		**60**		**50**		**55**		**35**		**40**		**60**		**55**		**50**		**50**
Guard band or centre gap	11											7		7		12		12

Table A5.2: Number of blocks that can be fully utilised

A5.4 Effectiveness of spectrum usage

The analysis in the previous section only considered spectrum that could be fully utilised by mobile broadband TDD and FDD networks. However, the spectrum that could not be fully utilised would not remain unused. The analysis in Table A5.3 is an assessment of the overall effectiveness of spectrum utilisation, if effectiveness is measured purely by the quantity of spectrum available. The following assumptions are made:
FDD, 2X10 MHz; TDD (1-F), 1 X 20 MHz; TDD (2-F), 2 X 10 MHz; TDD (3-F), 3 X 10 MHz: 100%

FDD, extra 2X5 MHz; TDD (3-F), 3X5 MHz: 67%
(5MHz channels have lower trunking efficiency and throughput)

Residual spectrum: 33%
(can only to provide extra capacity in certain sectors, not evenly across network).

Restricted blocks: 5%
(The main value of UHF spectrum is for wide area coverage, but restricted blocks can only be used for small coverage areas due to the power limitation).
Other applications in FDD centre gap: 50% for first 4 MHz and 100% above (see the assumptions in section A5.2).
Other applications in TDD guard band: 50% (see the assumptions in section A5.2).

The figures of 67%, 33% and 5% are examples, but are considered reasonable assumptions for the effectiveness of use of spectrum. Similar conclusions would be reached for a wide range of values.

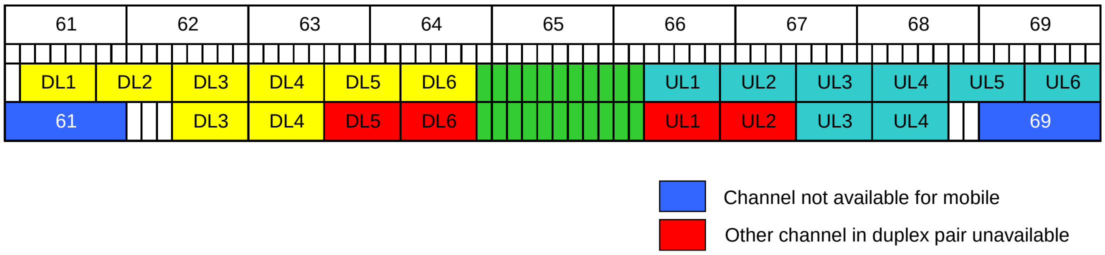
Effectiveness of spectrum utilisation (equivalent to MHz fully utilised)																		
(Max no. of networks)	**Option 1 FDD**		**Option 2 Mixed**		**Option 3 Mixed**		**Option 4a Mixed**		**Option 4b Mixed**		**Option 5 TDD**		**Option 6 TDD**		**Option 7 TDD**		**Option 8 TDD**	
	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz	No.	MHz
FDD	3	60	2	40	2	40	1	20	1	20	0		0		0		0	
TDD (1-F)	0		0		0		0		0		0		0		0		0	
TDD (2-F)	0		0		0		0		1	20	0		2	40	1	20	1	20
TDD (3-F)	0		0		0		0		0		2	60	0		2	30	0	
TDD (3-F) (X 0.67)	0		0		1	10	1	10	0		0		1	10	0		2	20
Extra 2X5MHz (X 0.67)	0		1	6.7	0		1	6.7	1	6.7	0		0		0		0	
Residual Blocks (X 0.33)	0		1	1.6			2	3.3	1	1.6	0		0		1	1.6	0	
Restricted blocks (X 0.05)	0		2	0.5	3	0.75	3	0.75	3	0.75	1	0.25	2	0.5	1	0.25	2	0.5
Equivalent effectiveness of spectrum usage		**60**		**48.8**		**50.75**		**40.75**		**49.05**		**60.25**		**50.5**		**51.85**		**40.5**
PLUS effectively usable centre gap or guard band		**9**										**3.5**		**3.5**		**6**		**6**

Table A5.3: Effectiveness of spectrum utilisation (equivalent to MHz fully utilised)

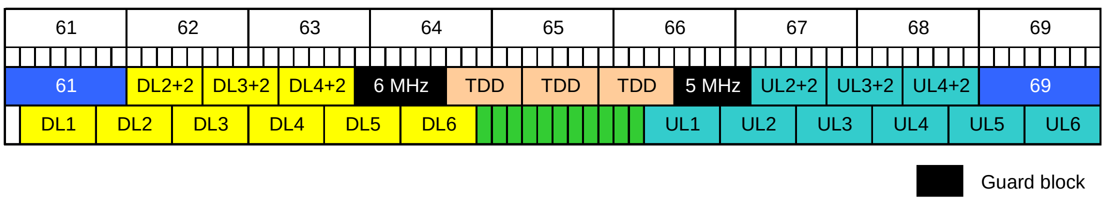
In the above analysis, the usable spectrum in the centre gap has not been added directly to the mobile spectrum, because it is not possible to directly compare the effectiveness of spectrum use of the two applications. Nevertheless, it is clear that the use of the centre gap increases the overall effectiveness of the use of the 790-862 MHz band.

A.5.5 Mixed FDD/TDD in the case that part of the band is not available within a country

Where part of the band is not available for two-way mobile, an FDD only arrangement might not be the optimal use of spectrum because each unused downlink FDD channel has a corresponding unused uplink FDD pair, as illustrated in the example below:

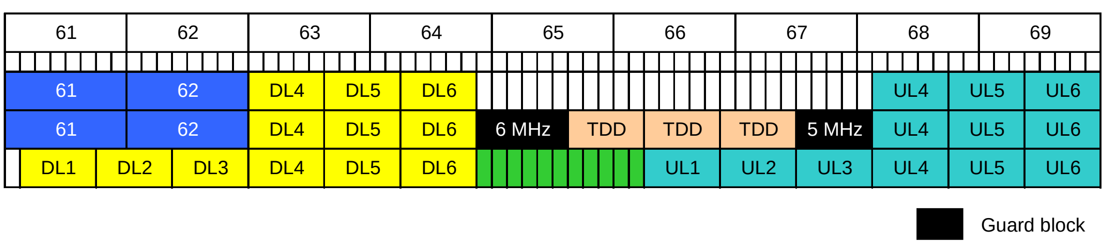


However, adding TDD could provide a means to utilise the spectrum that would otherwise be left empty. The following example is based on a 2 MHz offset for FDD channels and use of TDD in channels whose corresponding FDD pair is not available:



Different assumptions for the size of guard blocks would alter the number of TDD channels that could be included in such an arrangement. Decisions on guard blocks in these circumstances would be on a national basis

In cases where the unavailable channels are at one end of the band, there could be additional gains in efficiency from the use of a mixed FDD/TDD arrangement as shown in the following example:



In this example, using the above assumptions, the usable spectrum in the first row is 16 + (2×15) = 46 MHz and only one operator could be supported. In the second row the usable spectrum is 16 + (2×15) + 15 = 61 MHz and two operators could be supported. Without the flexibility for mixed FDD/TDD, the only efficient option in such cases is an all-TDD plan.

A.5.6 Conclusions

In every considered mixed FDD/TDD band-plan for the full 790 – 862 MHz band, there is less spectrum available compared with a FDD band plan or full TDD band plan and therefore spectrum is used more efficiently by Mobile/Fixed Communication Networks in a FDD band-plan or TDD band plan than in the mixed band-plan examples.

Additionally, the centre gap of a FDD band-plan and the guard band of a TDD band-plan are wide enough for use by other applications.

In cases where the full band is not available, it is not efficient to leave FDD channels unused; mixed FDD/TDD arrangements can provide a means to utilise this spectrum without forcing regulators to adopt a TDD-only arrangement.

For two TDD networks and a 7 MHz[1] guard band, the spectrum utilisation is equal to the FDD case, apart from the utilisation of the centre gap. For two TDD networks and a 12 MHz guard band, the spectrum utilisation is less than the FDD case but more than the mixed FDD/TDD examples. For three TDD networks, the spectrum utilisation is comparable to the mixed TDD/FDD examples.

[1] The guard band could be decided on a national basis (see section 2.3). CEPT Report 30 contains analysis of the TDD guard band considerations for fixed or portable DTT reception.