Benefits of network competition and complementary policies to promote mobile broadband coverage

A REPORT PREPARED FOR THE GSMA

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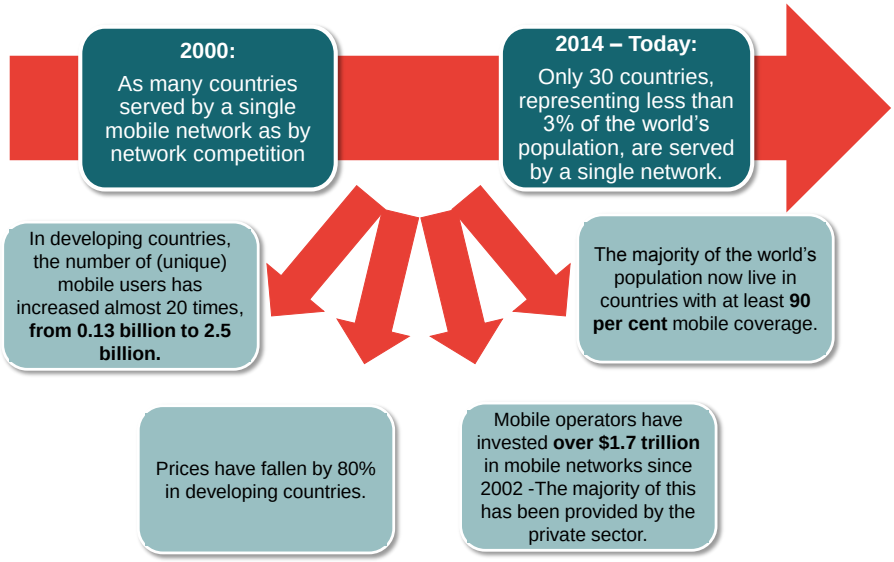
Executive Summary

In July 2014, Frontier Economics was commissioned by the GSMA to conduct a study on the merits and potential barriers of promoting mobile broadband coverage under the network competition model.

Network competition describes a market form in which more than one vertically integrated mobile network operator (MNO) competes for retail customers. Over the last three decades, this market structure has become predominant and has delivered significant consumer benefits. These benefits include widespread service availability, lower prices and faster rollout and mass take-up of new mobile technologies, in particular in developing countries (see **Section 2** of this report).

The global performance of the mobile sector since 2000 has resulted in staggering growth from 0.13 billion to 2.5 billion mobile users in developing countries alone. Mobile services are now available to the majority of the world's population. Average prices of mobile services in developing countries have fallen by approximately 80% in the same period, and mobile operators have invested over $1.7 trillion since 2002 (see **Figure 1** below).

Figure 1. Network competition in mobile has generated significant benefits to consumers



Source: Frontier Economics

We tested empirically the ability of the network competition model to deliver mobile coverage and take-up (see **Section 2.2** and **2.3**). The evidence from more than 200 countries over a 15 year period shows that network competition has driven mobile network coverage for 1G, 2G and 3G networks further and faster than has been achieved by single networks. After taking into account other factors, such as differences in GDP/capita, we find that;

- population coverage was **12 percentage points higher** in countries with network competition compared to countries served by a single network;
- 3G population coverage was **36 percentage points higher**[1]; and
- population coverage also increased three times faster in network competition countries.

We recognise that the benefits of network competition go beyond extending mobile coverage. Competitive markets are generally better than monopolies at promoting innovation. Using the same dataset as above, we also find that;

- having network competition increased **overall take-up by 7 percentage points** compared to having a single network; and
- network competition increased **3G take-up by 17 percentage points**, once other factors have been accounted for.

The main focus of this report, however, is mobile broadband coverage under the network competition model and complementary measures to promote this. Governments around the world recognise widespread broadband access as a facilitator of economic growth (**Section 3**). Multiple countries have introduced National Broadband Policies, which set ambitious targets for broadband coverage.

Mobile network competition is likely to play an important role in achieving these national targets. In particular, for rural and remote areas of a country where fixed networks are not viable, mobile will be the primary form of broadband access. Nevertheless, there may be areas of a country that are so uneconomic that even mobile network competition

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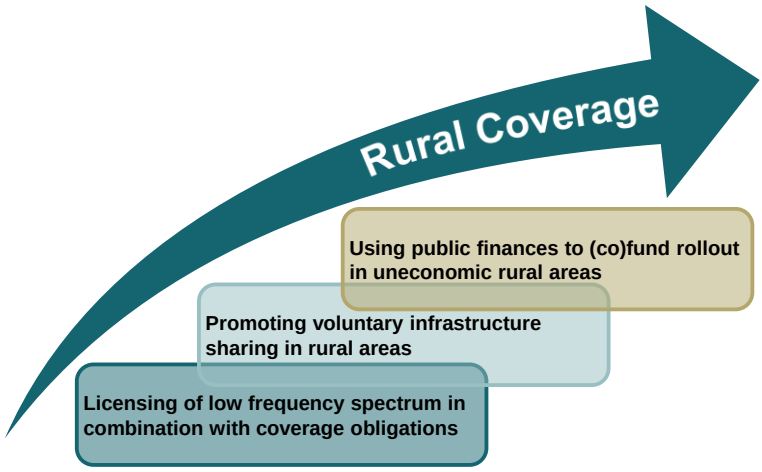
1 We recognise that results for 3G might be somewhat influenced by the relatively small sample size for single network countries today (we are using data from 2013, given that 3G is still a relatively new technology in many countries). We try to capture this to the greatest extent possible in our econometric analysis by controlling for different country specific factors.

may not achieve coverage, either within the required timeframe or at all. It may, however, be desirable for such areas to be covered because of the wider economic benefits of widespread broadband availability. Hence, some form of Government intervention might be needed to promote network rollout in these areas (**Section 4**).

We discuss three forms of supply-side intervention that the Government can use to promote rural coverage (**Section 5**). The Government can also adopt a combination of approaches, so that the combined effect of these different measures can optimize coverage outcomes.[2] Whilst in principle all of these forms of intervention can be designed to ensure that competitive neutrality is maintained in the market, the evidence suggests that in particular coverage obligations attached to new spectrum and voluntary network sharing are proven tools that Governments can use to promote rural broadband coverage and availability.

Figure 2. Complementary supply-side measures to promote rural coverage



Source: Frontier Economics

[2] The Government can also consider additional demand-side measures to promote rural coverage, but these are outside the scope of our report.

Licensing of new, low frequency spectrum in combination with coverage obligations

Coverage obligations set out the scope of coverage and the timescales in which it is to be achieved. In setting such coverage obligations, policy makers face a trade-off between additional coverage demanded above an expected market outcome and the proceeds that might otherwise be generated by the auction of a licence without such a condition.

Combining these coverage obligations with the licensing of new, low frequency spectrum appears to be an efficient approach given the propagation properties of this spectrum that help increase mobile coverage at a lower cost of network rollout.[3]

At the same time, there are likely to be benefits from using the competitive mechanism of a low frequency spectrum auction to achieve rollout targets, compared with an approach where the Government directly subsidises rural rollout. This approach can give operators flexibility in deciding when and where to roll out their network, as long as they achieve the coverage obligations within the given time frame.

In order to avoid distortions in the spectrum allocation process, operators need to be able to internalize the cost of additional coverage obligations in their business plans. This way, the imposed coverage obligations can be reflected in the operators' valuations of incremental spectrum.

Overall, the evidence suggests that requiring network rollout and coverage obligations as part of new mobile licences is a tested tool, successfully used both in Europe and in emerging markets.

Promoting voluntary infrastructure sharing

In many countries around the world, operators have voluntarily entered into commercially negotiated agreements to share certain parts of their network infrastructure. Sharing effectively represents a reduction in rollout costs for each operator, and in low-demand areas, this cost saving may be the difference between operators deciding to roll out and not rolling out.

However, in reality, there may be barriers to voluntary network sharing. These barriers effectively represent an additional cost which may result

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[3] We note that the use of coverage obligations is not limited to low frequency bands. Historically coverage obligations have also been imposed on high frequency spectrum to meet roll-out and other objectives. Nevertheless, sub-1GHz spectrum (e.g. 800 MHz and 700 MHz frequencies freed as a part of digital television switchover) presents a unique opportunity to achieve greater mobile coverage in a cost efficient way.

in some areas not being covered. The Government may be able to take steps to remove administrative and regulatory barriers, which, if it facilitates voluntary network sharing between mobile operators, would support expansion of mobile coverage in rural areas.

Using public finances to support rollout in remaining uneconomic areas

Even if the cost of rollout is reduced through measures to facilitate network sharing, there may still be some areas, typically uneconomic rural and remote areas, which will not be covered. In these areas, it may be possible for the Government to justify directly funding network rollout if it considers that the overall benefits (wider social and economic benefits, in addition to the revenues raised) from providing broadband access in such areas exceed the costs of doing so. We discuss the following means of public funding:

- One possible form of intervention would be for Governments to offer indirect public support in the form of **fiscal incentives** to promote rural coverage. These may include, for example, reducing the tax burden faced by operators rolling out network in uneconomic areas of the country, including reduction of import tariffs on certain types of network equipment used to serve these areas. We note that any such measures should be targeted to incentivise rollout in uneconomic areas. The more targeted they are, the more effective and less distortive they are likely to be.

- Secondly, the Government can award **public funds** directly to operators, where funds are allocated on the basis of a public tender. In low demand areas, the expected rollout costs exceed the expected margin that would be generated from offering services in the area. As a result, the area will remain uncovered in the absence of public funding. The Government could provide funding which acts to bridge the gap between costs and margins such that the area becomes viable to cover.

- Thirdly, there might be some remote areas which by themselves have enough demand to make rollout commercially viable, but the cost of extending the **backhaul network** might be too high. In these cases, Government can help to bring broadband connectivity closer to rural customers by supporting or co-funding the construction of backhaul links.

- Lastly, there is the provision of publically funded **network infrastructure** in uneconomic areas. This network intervention

doesn't necessarily lead to a full mobile network. We propose Governments take a minimal-intervention approach and work collaboratively with operators to define the right scope of public intervention. If Governments opt for a full public mobile network in uneconomic areas (what we define as a Rural Wholesale Network or RWN[4]), it should operate as a single regulated network (i.e. minimising the duplication of assets in rural and remote areas), whilst allowing for competition at the retail level. It would act as a wholesale provider only (i.e. not present in the retail market), providing network access to mobile operators, allowing them to serve the rural population. If designed properly, we would expect that any such network intervention in uneconomic areas would not face the significant challenges identified in relation to 'national' Single Wholesale Network (SWN) proposals.[5]

Ultimately, which of the above supply-side interventions leads to the best results depends on the situation in a particular country. Therefore they should not be viewed in isolation. It may be the case that a combination of the above options - coverage obligations, network sharing and some form of public support - are more effective in delivering coverage than any single measure on its own.

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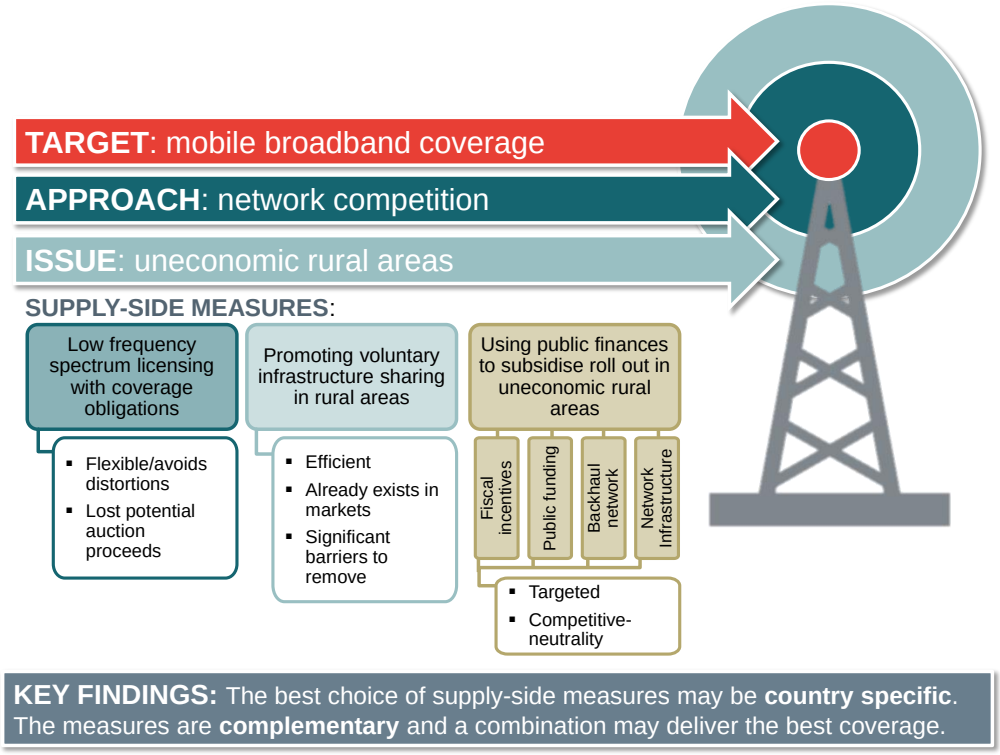
4 For brevity, we use the term RWN to refer to single wholesale networks in uneconomic areas only, where these areas are defined on the basis of the market analysis described in **Section 4** of this report, rather than rural areas more widely.

5 We discuss the main challenges of establishing and managing the national SWN in a separate report, Frontier Economics (2014): *Assessing the case for single wholesale networks in mobile communications*, available at http://www.gsma.com/publicpolicy/wp-content/uploads/2014/09/Assessing_the_case_for_Single_Wholesale_Networks_in_mobile_communications.pdf

Figure 3. Summary of our key findings



Source: Frontier Economics

1 Introduction

In July 2014, Frontier Economics (Frontier) was commissioned by the GSM Association (GSMA) to conduct a study about the merits and potential barriers of promoting mobile broadband coverage under the network competition model. Network competition describes a market form in which more than one vertically integrated mobile network operator (MNO) competes for retail customers. Over the last three decades, this market structure has become predominant and has delivered consumer benefits such as widespread service availability, lower prices and faster rollout of new mobile technologies.

We will show in this study the main mechanisms through which network competition has delivered significant benefits for consumers in terms of coverage and take-up of mobile services. We will then focus on the possible ways that Governments can intervene in mobile markets to further promote mobile broadband availability and network coverage.

We recognise that in many countries around the world, network coverage ranks very high on the political agenda. Universal broadband access is considered to have positive effects on social inclusion and general economic productivity. There are many ways in which rural coverage can be achieved under network competition and we will demonstrate that these options are successfully used around the world.

This study is structured as follows. In **Section 2** we show empirical evidence in relation to consumer benefits of network competition. We then discuss why Governments are keen on promoting mobile coverage in rural and remote areas in **Section 3**. In **Section 4,** we explain why some form of public intervention might be required to achieve the Government's broadband targets, in particular in uneconomic and rural areas. Finally, in **Section 5** we show that the Government has various complementary tools to promote rural coverage under network competition – thereby adding to the benefits discussed in **Section 2**.

2 Why is mobile competition good for consumers?

Network competition is a key driver behind customer benefits. In this section, we will briefly discuss the benefits of the shift from state monopolies to network competition worldwide during the last 15 years. We also show detailed empirical evidence around two of the main benefits network competition can deliver: **network coverage** and **innovation**.

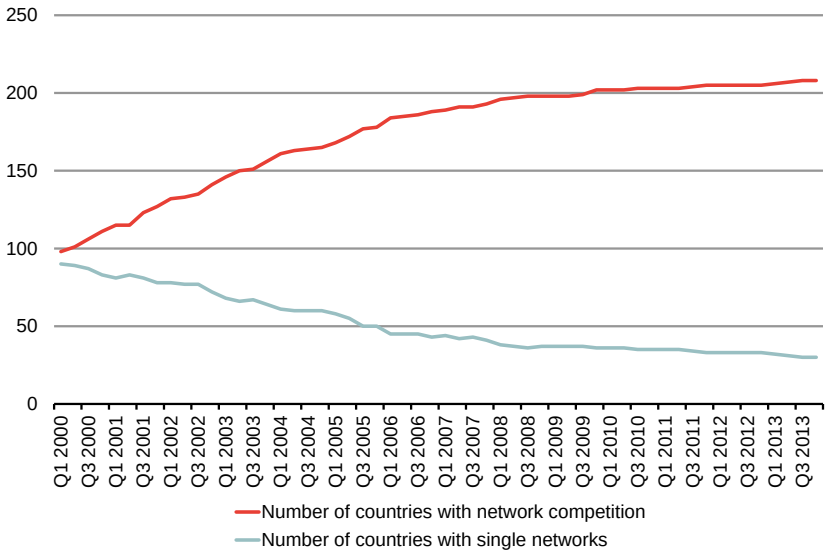
2.1 The performance of the mobile sector under network competition

Network competition is the most common model under which mobile markets around the world operate[6]. There has been a shift towards promoting liberalisation and competition between multiple MNOs over the past 30 years, due to the pressure exerted by policymakers. They consider it to be the best way of ensuring that the mobile sector delivers consumer benefits. Whilst in 2000 there was almost an equal number of countries with network competition and a single network, there are now only 30 countries with single networks and most of them are very small, representing less than 3% of world population (**Figure 4**)[7].

6 Network competition may involve the licensing from the outset of more than one mobile network operator to construct and operate a mobile network in a specific geographic area. Alternatively, it can involve the introduction of additional licensees to construct networks to compete with the original monopolist at some later stage in a market's development. Network competition may also change over time. In early phases, it involves the construction of competing, separate networks in urban and suburban areas. One operator may also become the first to cover uneconomic rural areas. In later stages, operators may then enter into voluntary sharing arrangements to rationalise costs and/or further extend coverage in some areas.

7 The total number of countries shown in each quarter changes slightly over time, because some countries did not have any mobile operators at the start of the millennium.

Figure 4. Number of countries with network competition and single networks

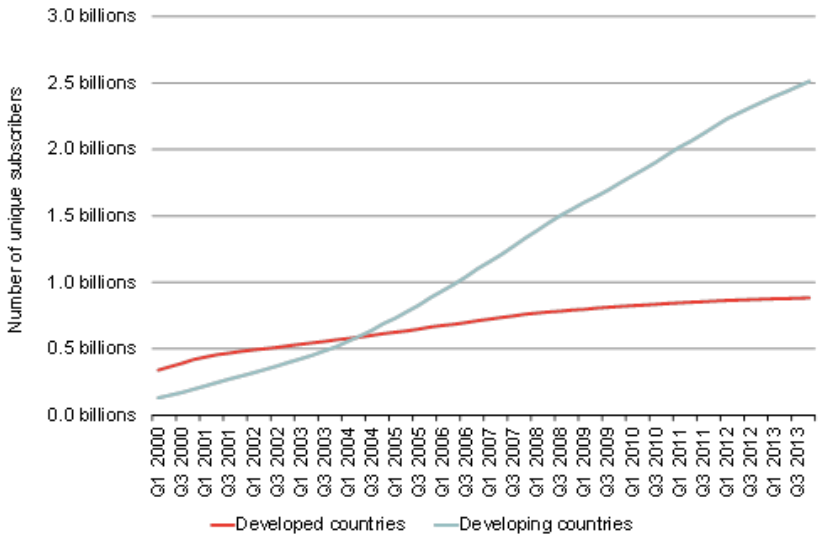


Source: GSMA intelligence database

This move towards network competition has delivered many favourable outcomes, summarised in more detail below.

Since 2000, **Figure 5** shows that the take-up of mobile services has almost trebled in developed countries, increasing from 339 million to 884 million in thirteen years. Developing countries have experienced even more staggering growth, with the number of users having increased almost 20 times, from 131 million to 2.5 billion. This trend is showing no signs of slowing.

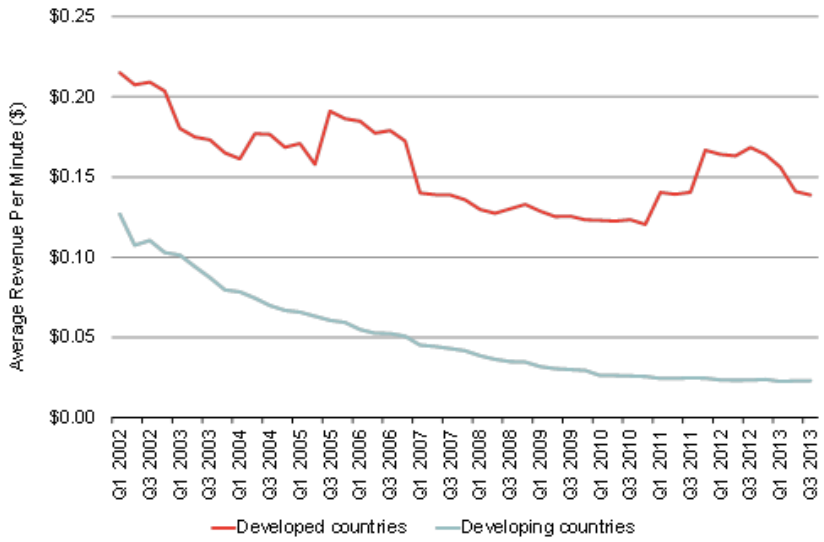
Figure 5. Take-up over time



Source: GSMA wireless database

Falling prices are among the factors explaining the sharp increase in take-up. In developing countries prices have fallen by 80%, as shown in **Figure 6**. Since 2002, average revenues per minute (ARPM) have fallen worldwide, particularly in developing countries that have experienced a fall from 13 cents per minute to 2 cents per minute. On the other hand, usage has increased significantly, meaning that mobile users are paying less and getting a great deal more.

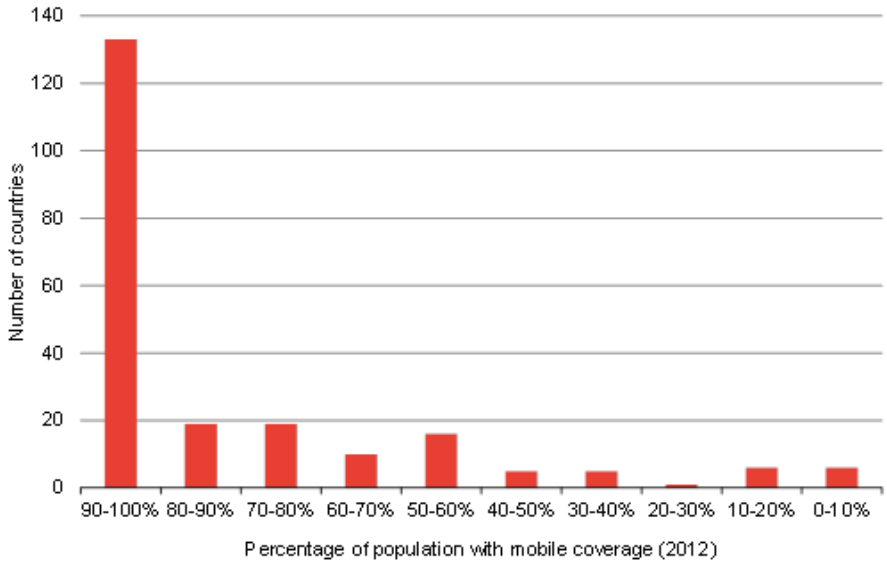
Figure 6. Average Revenue Per Minute (ARPM) over time



Source: GSMA wireless database

Another massive improvement has been made in mobile coverage. As of 2012, the majority of the world's population lives in countries with at least 90 per cent mobile coverage. Many of these countries are estimated to have 100 per cent population coverage (**Figure 7**).

Figure 7. Mobile coverage across countries (2012)



Source: GSMA intelligence database

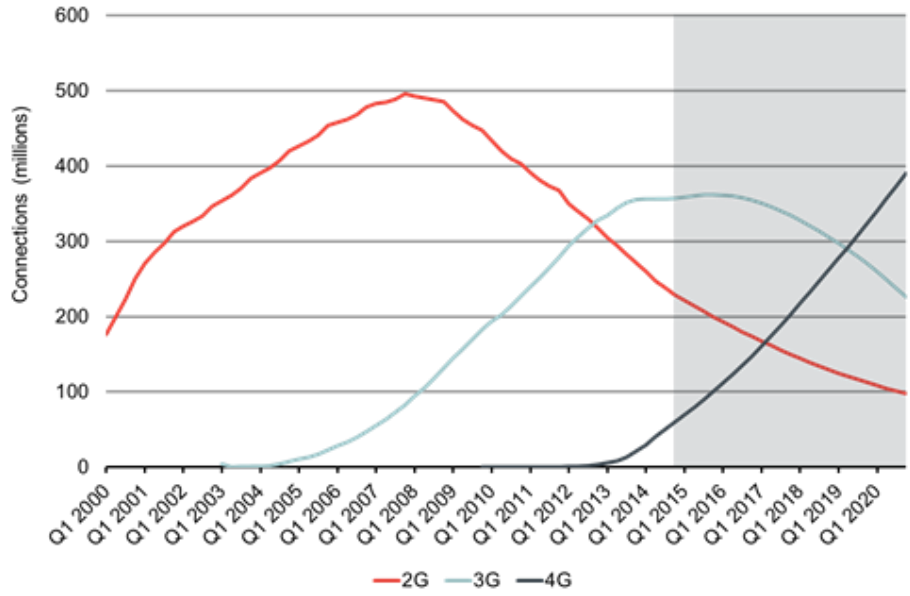
Figure 7 shows that in the vast majority of countries, mobile competition has led to close to universal coverage of voice services. It can be expected that the network competition model will also be able to provide nationwide coverage of mobile broadband services as low frequency spectrum is being freed up and networks are upgraded progressively from 2G and 3G to 4G (or 5G in the future). Operators in many countries such as the USA[8], Australia[9] and Singapore[10] have announced plans or are in the process of migrating their 2G customers to 3G and 4G networks. This would allow them to enjoy faster networks and more services with the same level of coverage. We indicate in **Figure 8** that technological progress in the mobile sector occurs in cycles and that mobile broadband will become the new standard as end users migrate to from 2G to next generations of mobile services.

8 http://www.business.att.com/enterprise/Family/mobility-services/machine-to-machine/m2m-applications/cd2migration/page=addl-info/

9 http://exchange.telstra.com.au/2014/07/23/its-time-to-say-goodbye-old-friend/

10 http://www.mobileworldlive.com/live-lte-asia-2014-singapore-singtel-shut-2g-network-2-3-years

Figure 8. Technology cycles in EU mobile markets



Source: GSMA intelligence database

Note: analysis relates to EU28 countries except for 4G connections which does not include Cyprus due to lack of data availability

The mobile sector plays an integral role in the wider economy. Globally, mobile network operators generate $1.1 trillion in revenues. This represents 1.5% of global GDP, which helps create jobs, increases tax revenues and boosts the local economy. Capital investment by mobile operators in mobile networks amounts to an estimated $200 billion per year.

Thus, the overall performance of the mobile sector on a global scale since 2000 has led to significant benefits to consumers. Much of this has been achieved by network operators competing with each other, since this has become the dominant model under which the industry is organised.

In the next few paragraphs, we show more detailed empirical evidence of how network competition has led to greater **coverage** and **innovation**.

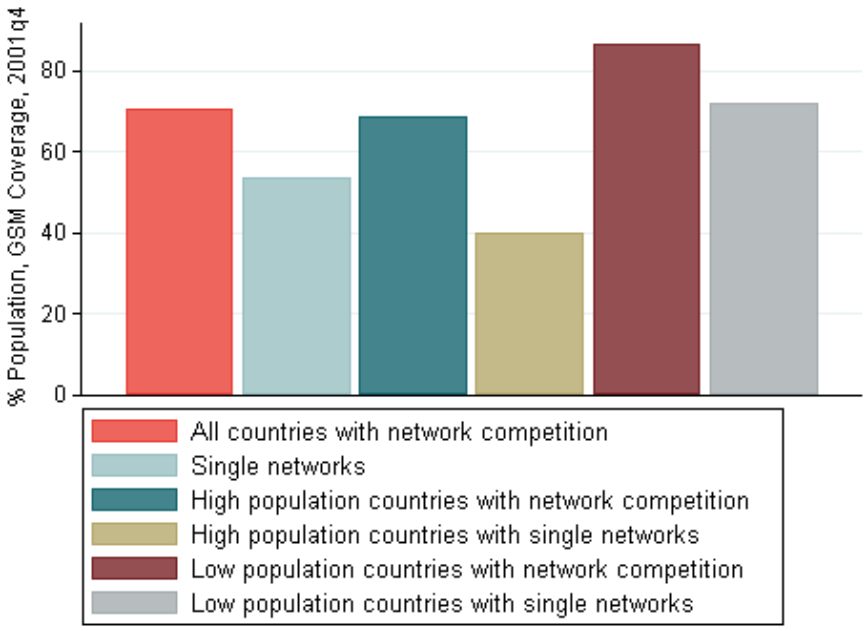
2.2 Empirical evidence on coverage performance

Competition among mobile operators tends to drive cost reductions which allow greater coverage to be achieved economically. This happens because competition forces firms to be more efficient in their use of existing technologies. In areas where it is not economically viable to sustain a network, there are other mechanisms, such as voluntary network sharing, that can help to extend coverage

(we discuss these in **Section 5.2**). This is why mobile coverage is significantly higher in countries with network competition, compared to those with a monopoly or single mobile networks.

Our view is supported by empirical evidence. We compare coverage in countries with single networks to countries with network competition. We have based our main analysis on data from 2001[11], as there were considerably more countries with single networks at that date than we see today. As illustrated in **Figure 9** below, overall population coverage is considerably higher in countries with network competition (70.4% compared to 53.4% when including all countries regardless of their size).

Figure 9. Total population coverage in countries with single networks and network competition



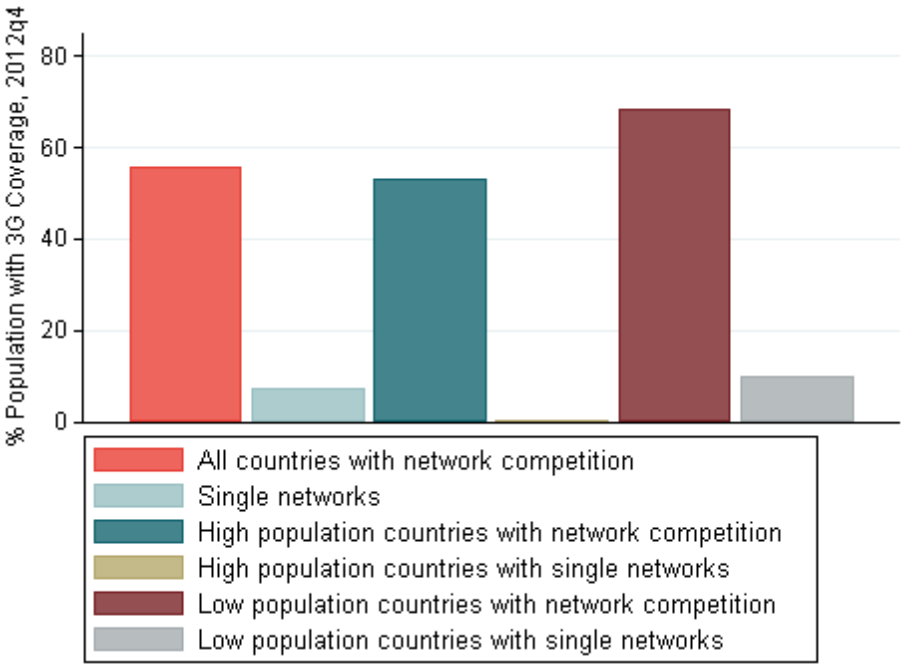
Source: Frontier analysis based on GSMA data

When looking at 3G coverage, the data indicates even larger differences between countries with network competition and single network countries, as shown in **Figure 10** below. 3G population coverage across the sample of network

11 The data quality gets considerably worse if going back before 2001, which is why we have chosen 2001.

competition countries was close to 60%, while data from single network countries indicated less than 10% population coverage.[12]

Figure 10. 3G coverage in countries with single networks and network competition



Source: Frontier analysis based on GSMA data

We have also undertaken a more detailed empirical analysis, looking at the impact of network competition on coverage, whilst controlling for different country specific factors (income levels, urbanisation, etc.). The results of our empirical analysis are summarized in a table included in **Annex 1**:

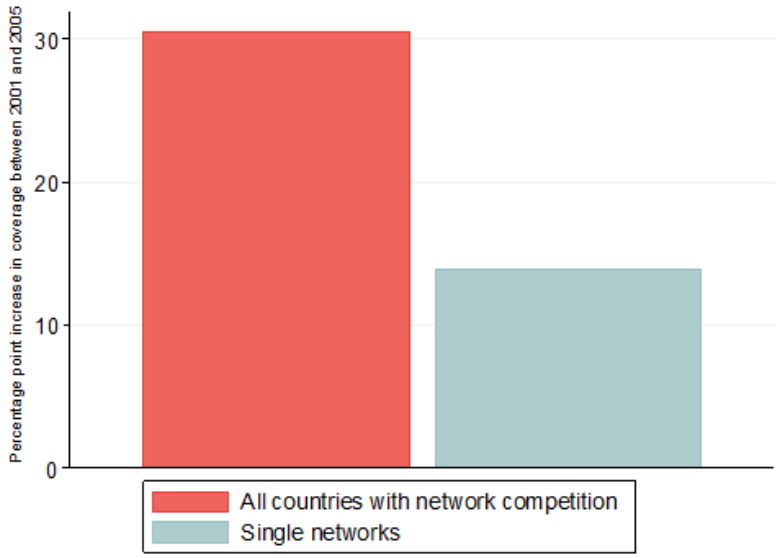
In particular, we find that compared to single network countries,

- having network competition **increases total population coverage by 12 percentage points** and increases area coverage by 15 percentage points; and
- having network competition **increases 3G population coverage by 36 percentage points** and **increases** 3G area coverage by 20 percentage points.

12 We recognise that these results might be somewhat influenced by the relatively small sample size for single network countries today (we are using data from 2013, given that 3G is still a relatively new technology in many countries). We try to capture this to the greatest extent possible in our more detailed econometric analysis by controlling for different country specific factors.

Finally, we have analysed the speed at which coverage increases over time. To do so, we have calculated the increase in coverage by 2005 on countries that had below 50% coverage in 2001. As **Figure 11** shows, coverage in countries with network competition **increased more than two times faster than in single network countries.**

Figure 11. Rate of increase in population coverage over time



Source: Frontier analysis based on GSMA data

Therefore, the empirical evidence clearly supports the view that network competition drives mobile coverage, both in terms of mobile voice technologies (1G and 2G) and mobile data technologies (3G).

2.3 Empirical evidence on innovation

Policymakers will also be concerned with goals other than maximising network coverage. For example, the benefits of mobile services in any national market are often determined by the rate at which new services are introduced. Even though mobile technologies are typically developed at an international level, the speed at which they become available to consumers depends crucially on national policies and market structures. Innovation determines the speed of adoption of new technologies in mobile networks. This has a major effect on the unit costs of services for consumers and for the ability of operators to extend network coverage.

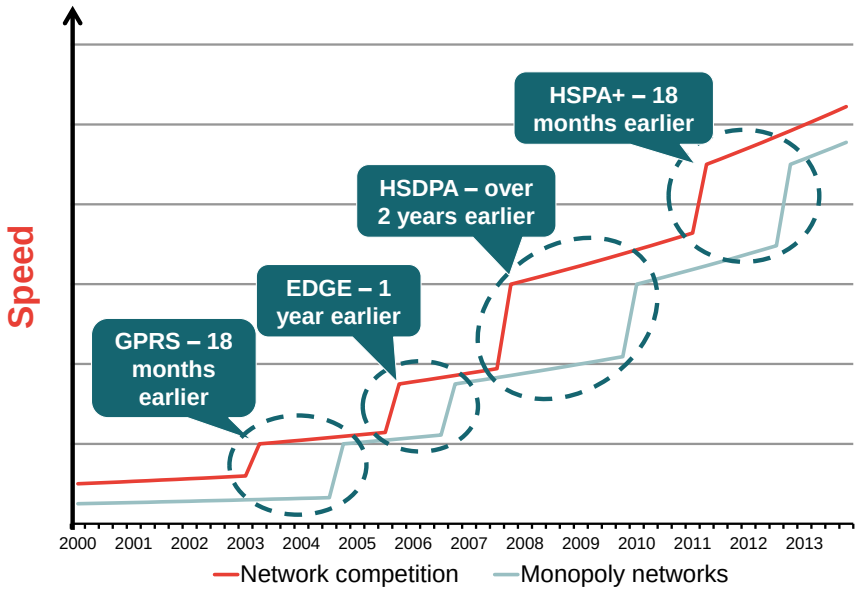
There are two reasons why competitive markets are generally better at promoting innovation than monopolies:

- **Competition** encourages operators to innovate as soon as possible. In competitive markets, bringing new technologies to market gives the chance to steal competitors' customers and hence earn higher profits than before. This will give operators an incentive to innovate in advance of their rivals. Also, there will be more firms who are searching for innovations and this increases the probability of an innovation being discovered.

- **Vertically integrated** operators can guarantee that both network and mobile terminal upgrades are coordinated to ensure efficient usage and reduce the risk of a "hold-up" problem. We refer to vertically integrated operators as MNOs that control both a wholesale and a retail business. Being vertically integrated means that the costs and benefits of both units are taken into account when making investment decisions. This ensures that incentives to invest are aligned. It also means that information collected at the retail level (such as consumption patterns and geographic spread of demand) can influence decisions at the wholesale level (such as network upgrade decisions).

The empirical evidence supports the view that network competition has driven innovation in mobile markets. **Figure 12** illustrates the median year in which a new mobile technology was first launched. This shows that network competition countries tended to be much faster to introduce new technologies. For example, HSDPA was typically launched over two years earlier in network competition countries, compared with single network countries.

Figure 12. Timing of technology upgrades



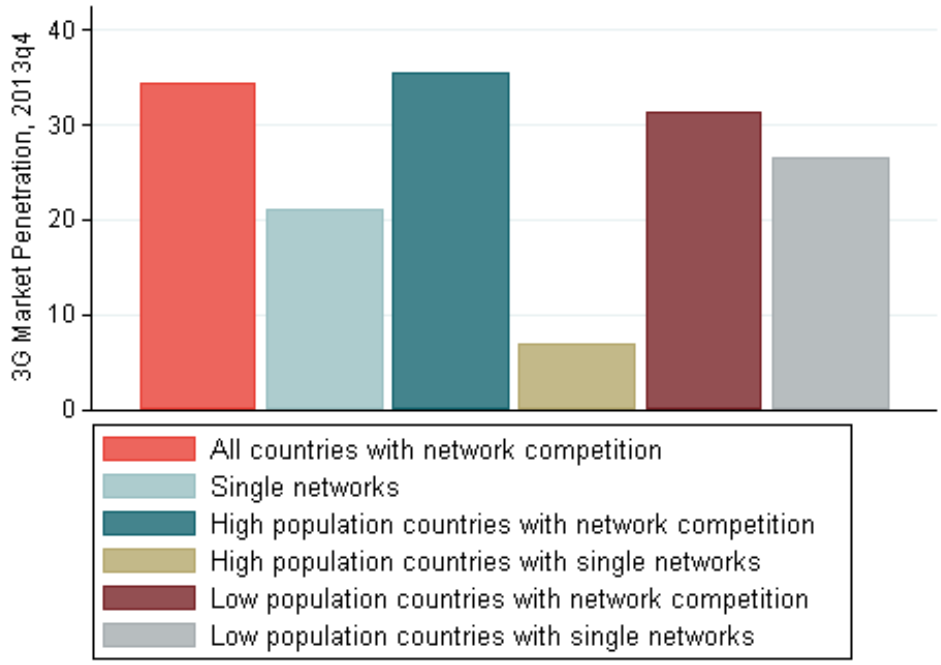
Source: Frontier analysis based on TeleGeography data

We also analysed the change in take-up in countries that have moved from single networks to network competition and found that overall take-up increased at a faster rate in the two years after the move to network competition (a 12.0 percentage point increase) than in the two years before (an 8.3 percentage point increase).

A similar pattern can be expected for next generation 'mobile data' services based on 3G and 4G technology. Indeed, we have considered how the take-up of 3G compares across countries using data from 2013, given that 3G is still a relatively new technology in some countries. As **Figure 13** shows, the 3G take-up is much higher in countries with network competition[13].

[13] However, we note that 3G/4G coverage would still be significantly lower than 2G coverage in a country due to the take-up depending on affordability of smartphones.

Figure 13. Take-up of 3G in countries with single networks and network competition



Source: Frontier analysis based on GSMA data

We have also performed an econometric analysis to test the impact that having network competition has on take-up. Again, we have controlled for different demographic variables, including GDP per capita, population density, population size and the time since 2G was introduced. The results suggest that:

- Having **network competition increased overall take-up by 7 percentage points**; and
- Having **network competition increased 3G take-up by 17 percentage points** once other factors have been accounted for.

These findings are robust to different sensitivity checks, as shown in **Annex 1**.

2.4 Conclusion

In summary, network competition is the predominant mobile industry model worldwide. We have demonstrated that it has led to major benefits for consumers including: higher take-up, reduced prices, greater network **coverage** and faster **innovation** (rollout of new technologies). In the next section, we analyse the motives for why Governments are interested in promoting wider mobile coverage and extending it quickly to most uneconomic rural areas.

3 Why are Governments keen on promoting wider mobile coverage?

Broadband access is widely recognised as a facilitator of economic growth. In this section, we summarise some of the evidence to quantify this effect.

3.1 The benefits of broadband access

One of the reasons why Governments are keen on widening mobile coverage is that they recognise ICT services and broadband are becoming increasingly important in terms of economic growth.

There appears to be strong empirical evidence of the benefits of broadband on economic growth. Czernich et al. (2009)[14] analysed data from 25 OECD countries between 1996 and 2007, finding that a 10% increase in broadband penetration raises per-capita GDP growth by 0.9-1.5 percentage points. Koutroumpis (2009)[15] analysed 22 OECD countries between 2002 and 2007, finding that an increase in broadband penetration of 10% yields a 0.25% increase in GDP growth. Research on the impact of broadband on productivity has also identified positive effects. For example, Waverman et al. (2009)[16] determined the economic effect of broadband on the GDP of 15 OECD nations for the period from 1980 to 2007. They estimated that for every 1% increase in broadband penetration in high and medium impact income countries, productivity grows by 0.13%. Crandall et al (2003)[17] found a positive impact of broadband on job creation. They estimated the employment impact of broadband deployment aimed at increasing household adoption from 60% to 95% and requiring an investment of USD 63.6 billion. Their results showed the creation of 140,000 jobs per year over ten years and total jobs amounting to 1.2 million.

In light of the benefits of broadband internet, Governments around the world are developing national broadband policies (NBPs), which would typically set broadband coverage / availability targets and outline various measures that the Government plans to undertake to achieve these targets. As shown in the text box below, these broadband targets can be quite ambitious, indicating that there might

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14 Czernich, N., Falck, O., Kretschmer T., & Woessman, L. (2009), "Broadband infrastructure and economic growth", CESifo Working Paper No. 2861.

15 Koutroumpis, P. (2009), "The Economic Impact of Broadband on Growth: A Simultaneous Approach.", Telecommunications Policy, 33, 471-485.

16 Waverman, L. (2009), "Economic Impact of Broadband: An Empirical Study.", London: LECG.

17 Crandall, R., Jackson, C., & Singer, H. (2003), "The Effect of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy. ", Washington DC: Criterion Economics.

be a need for significant public intervention to help reach these targets in the required timeframe.

Text box 1: Examples of National Broadband Targets

Examples of National Broadband Targets

Among European countries, in 2009, the Federal Government in **Germany** defined the following targets in order to provide further impetus to broadband development:

- eliminating gaps in broadband penetration and providing nationwide broadband access by the end of 2010; and
- providing a total of 75% of households with Internet access with transmission rates of at least 50 Mbps by 2014.

In **France**, the Government planned that within four years, by 2008, every citizen would have access to broadband speeds of at least 512 Kbps at a maximum cost of 35 euros a month. Measures to achieve this objective include: the establishment of broadband centres of excellence, the examination of public investment in local authority broadband networks and the use of frequencies yielded by the digital dividend (790 to 862MHz) for broadband services.

We provide Japan, New Zealand, South Africa and South Korea as examples of non-European countries implementing challenging National Broadband policies.

In early 2006, in **Japan**, it was planned to eliminate all zero-broadband areas throughout the country and give households broadband Internet access by the end of March 2011, 90% of which would be through high-speed Internet connections.

In **New Zealand**, the Government put in place the Ultra-fast Broadband Initiative to accelerate the rollout of ultra-fast broadband to 75% of New Zealanders over 10 years by 2019. The Ultra-Fast Broadband would enable downlink speeds of at least 100 Mbps (megabits per second), and uplink speeds of at least 50 Mbps. The objective was supported by a Government investment of up to NZD 1.5 billion.

The Government in **South Africa** has set ambitious targets for broadband availability through its National Broadband Plan (South Africa Connect). In particular:

By 2020:

- 90% of the population to have access to 5 Mbps broadband; and
- 50% of the population to have access to 100 Mbps broadband.

By 2030:

- 100% of the population to have access to 10 Mbps broadband; and
- 80% of the population to have access to 100 Mbps broadband.

The plans also target that 100% of schools, health facilities and Government facilities will have access to 10 Mbps broadband by 2020.

A last example worth considering is the **South Korean** National Broadband Plan which is aimed at providing ubiquitous Internet access to all residents of the country, narrowing the urban-rural access gap. By 2010, the Government aimed at providing broadband multi-media services to 12 million households and 23 million wireless subscribers. By 2012, the goal was to raise average speeds to 10 Mbps with a maximum of 1 Gbps.[18]

3.2 Mobile networks are needed to achieve widespread, rapid broadband access

In many countries, particularly in the developing world, mobile networks act as a substitute for fixed networks, enhancing the economic growth potential of the country[19].

Many studies have tried to quantify the impact of the mobile sector on economic growth, particularly in developing countries. For instance, Lee at al. (2009) examined the effect of mobile phones on economic growth in Sub-Saharan Africa. They found that mobile availability is an important determinant of the economic growth rate, and that the marginal impact of mobile telecoms is greater in areas where fixed lines are rare. Waverman et al. (2005) concluded that 10 more mobile phones per 100 people would increase GDP per capita growth by up to 0.6 percentage points. Further studies suggest that this number is between 0.8 and 1.2 percentage points for developing countries. A GSMA study showed that the mobile sector contributed 3.7 per cent of GDP in Latin America.

As illustrated in **Figure 14**, it would typically be feasible to cover only a relatively small proportion of densely populated areas of the country by fixed broadband technologies such as xDSL and FTTx. This is because fixed networks require significant investment in the access network (for example trenching costs) and therefore need high subscriber density in order to recover these costs.

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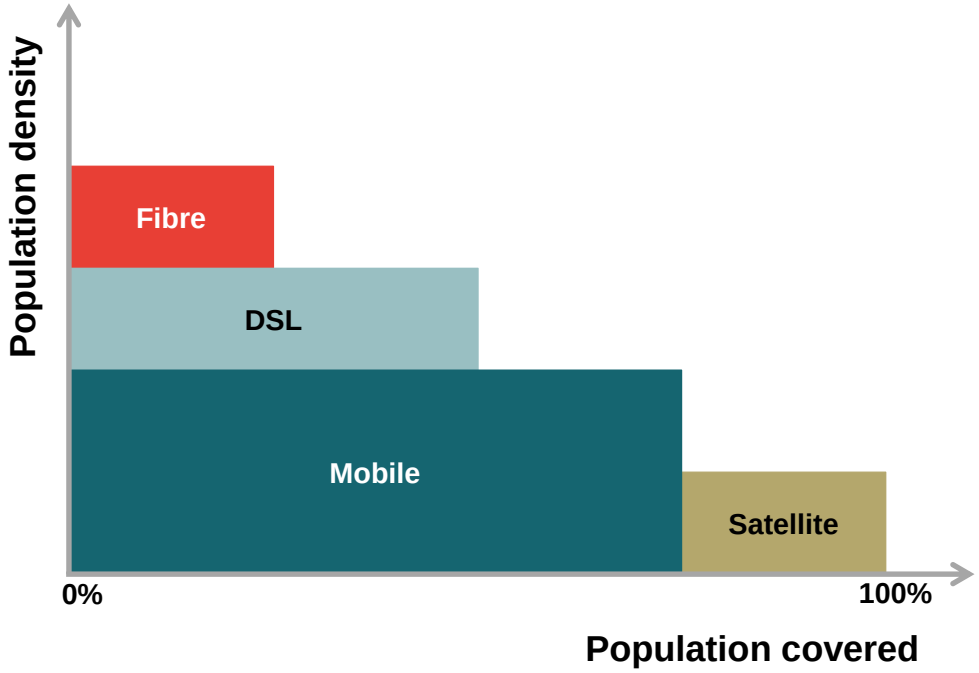
18 OECD (2011), "Working Party on Communication Infrastructures and Services Policy: NATIONAL BROADBAND PLANS".

19 Vodafone (see http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/public_policy_series_2.pdf)

Figure 14. Feasibility of different broadband technologies



Source: Frontier Economics

Mobile technologies will likely be able to reach the majority of the country's population including overlapping with fixed networks in high-demand areas. However, in particularly uneconomic, low demand areas, there may still be a small proportion of consumers whom it may not be viable to cover with mobile technologies.[20] In these areas, where the cost of the backhaul network is prohibitive, it may be more cost-effective to deploy alternative wireless technologies such as satellites. Satellites have traditionally been used in countries with large rural areas such as Australia. One of the most recent examples of the deployment of satellite services is Malaysia.[21]

We also note that telecommunications is a particularly fast-moving industry in technological terms. Therefore it is difficult to predict whether mobile or other

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20 The innovation in mobile network technologies is constantly expanding the area for which mobile networks are economically feasible solutions, see for instance http://www.mobileworldlive.com/ee-makes-world-first-claim-rural-coverage-debate?utm_campaign=MWL_20141202&utm_medium=email&utm_source=Eloqua&elq=1d690e3e921f4648a9eef8b5cc9b5c3a&elqCampaignId=2773

21 http://www.o3bnetworks.com/media-centre/press-releases/2013/o3b-signs-deal-with-maju-nusa-to-provide-ultra-high-speed-3g-backhaul-services-across-rural-malaysia

wireless technologies will be the most cost-effective solution to cover rural and remote areas in future.

3.3 Conclusion

Governments consider widespread broadband access a key driver of economic growth. This is evidenced by a range of National Broadband Policies around the globe. But we have also shown that these ambitious targets are unlikely to be achievable with fixed broadband technologies. This is because in sparsely populated areas, the cost of rollout might be prohibitively high. Mobile broadband is a viable option to extend coverage to the majority of these areas in addition to coverage in urban centres.

4 Intervention might be needed to promote mobile broadband coverage

In the previous section, we discussed how Governments have often set ambitious targets in relation to broadband coverage and that mobile networks might be required to achieve them. We showed in **Section 2** that network competition has an excellent track record in terms of extending voice, SMS and low-speed data coverage.

However, there are some areas in which even mobile networks may struggle to reach the more ambitious coverage targets which Governments aspire to. In this section, we discuss how to identify the areas in which some form of intervention might be needed.

4.1 Viability of mobile coverage

We believe that in order to intervene efficiently, Governments need to take a structured approach to analyse the discrepancy between its coverage targets and what market mechanisms can deliver in a certain time frame. For mobile broadband, for example, any given area in a country can be categorised as one of the following four types:

- **Areas which will be covered by network competition** – these are urban and suburban areas of high demand where mobile operators would expect to compete and comfortably make a profit by covering them (Area 1 in **Figure 15**).

- **Areas which can only be covered with some degree of network-sharing or a single network** – these are areas that lack the demand to support multiple national operators each rolling out their own networks independently, such that in the event of multiple operators rolling out, at least one would make a loss. Therefore, in these areas, operators may lack a clear business case for deciding to roll out independently. This lack of certainty may result in no operators rolling out, and the area remaining uncovered. However, the level of demand may be sufficiently high to support at least one network without public funding. This means that by engaging in some form of network-sharing, operators could remove the risk and uncertainty of rolling out independently and jointly cover the area instead (Area 2 in **Figure 15**); and

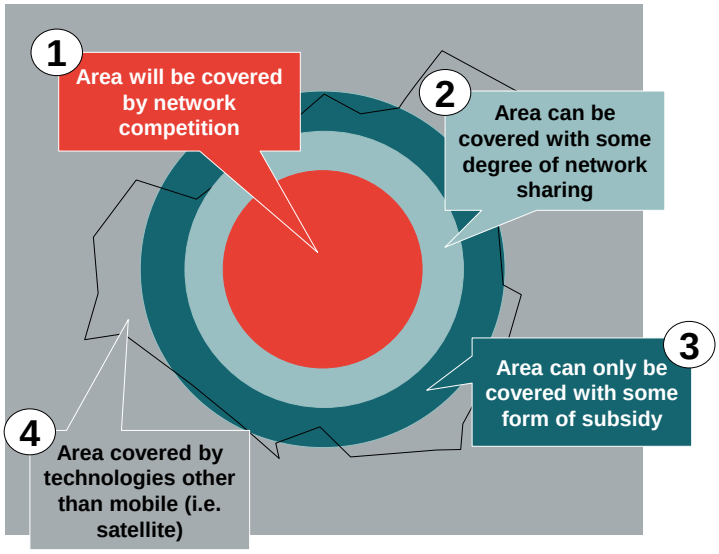
- **Areas which can only be covered with some form of public funding** – these are areas with relatively low levels of demand, such that even network-sharing is not a viable option for operators. Examples include sparsely-

populated rural and remote areas. In these areas, some form of public funding would be required for operators to consider rolling out (Area 3 in **Figure 15**).

- **Areas best covered by other technologies** – these are areas so remote that mobile technology is not the most efficient way of providing broadband coverage (i.e. these areas might be more efficiently served by other technologies) or where the provision of broadband services does not make economic sense even with a public subsidy (Area 4 in **Figure 15**).[22] [23]

We illustrate this in **Figure 15** below.

Figure 15. Categorising areas by viability of mobile coverage.



Source: Frontier Economics

4.2 Steps for policy makers to follow

Areas 2 and 3 in **Figure 15** above cannot be covered by market mechanisms alone, so some kind of intervention might be needed. However, such intervention can be justified only if there are significant social benefits from achieving mobile broadband coverage wider than what would be delivered under network

22 This would imply that the cost of providing broadband service in a given remote area would exceed wider social benefits from increased broadband availability.

23 We recognise that this is a simplified illustrative approach as not all coverage gaps occur in rural areas. The network competition model is not always perfect, even when it makes economic sense, i.e. there could be spots with no coverage even in 'profitable' urban areas.

competition (or if intervention would achieve these goals faster than it would otherwise be possible).

If the Government feels that the cost of such intervention is lower than the expected benefits, it must clearly identify what kind of intervention[24] in which areas of the country is needed to achieve its national coverage targets.

Firstly, the Government needs to identify areas where network competition alone can provide mobile broadband coverage (Area 1 in **Figure 15**). This might bring a country close to achieving the target set by policymakers already.

Secondly, the Government needs to identify areas where only one network might be viable or where the lack of certainty prevents operators from rolling out (Area 2 in **Figure 15**). In these areas, **coverage obligations** attached to spectrum licences or network competition together with **network sharing** can deliver coverage.

Lastly there are areas in which some form of public funding will be required to promote broadband deployment (Area 3 in **Figure 15**), and the Government will need to identify an appropriate form of supply-side measures to decrease the cost of rollout in uneconomic areas of the country.[25]

4.3 Conclusion

Mobile networks might be the only way to achieve broadband coverage in some areas of a country where fixed networks are not viable. We have shown in **Section 2** the superior performance of network competition in terms of reaching high levels of coverage compared to other market structures. Competition among mobile networks therefore should be a good option to achieve the ambitious coverage targets set by Governments. But we recognise that there are some areas that are so uneconomic that *even network competition* may not lead to the required coverage and where some form of intervention might be needed – in particular, **coverage obligations**, **network sharing** or **public funding**. We discuss these mechanisms in the following section.

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24 The options include coverage obligations, network sharing and public funding. We discuss these in detail in Chapter 5

25 We will recognise the importance of demand side measures that can be used to complement any supply-side intervention, however the focus of our report will primarily be on supply-side intervention measures.

5 What are the tools Governments should use to promote mobile coverage in rural areas?

Given evidence on the success of the network competition model, Government intervention should aim to ensure that the Government's goals are achieved whilst seeking also to minimise distortion of a competitive market. Ensuring **competitive neutrality** is important to enhance economic efficiency and benefit consumers: "*where economic agents (whether state-owned or private) are put at an undue disadvantage, goods and services are no longer produced by those who can do it most efficiently*"[26]. Examples where operators can be put at an undue advantage over others include the allocation of spectrum at below market prices to a national Single Wholesale Network (SWN) or the provision of other forms of public support to some operators that other operators don't receive or cannot compete for on equal terms.[27]

In this section, we put forward proposals about how rural broadband coverage can be promoted, whilst at the same time the risks of distortion of competition in the mobile market are minimised. In particular, we discuss international best practice in relation to the following forms of supply-side intervention:

- licensing of low frequency spectrum in combination with coverage obligations;
- promoting voluntary infrastructure sharing in rural areas; and
- using public finances to (co)fund rollout in uneconomic rural areas.

See **Table 1** for an overview of which of the above three measures can be used to promote coverage in uneconomic areas.

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26 OECD (2013): "Maintaining a level playing field between public and private business for growth and development: background report". Meeting of the OECD Council at Ministerial Level.

27 This is discussed in Section **6.2** of Frontier SWN report:

http://www.gsma.com/publicpolicy/assessing-the-case-for-single-wholesale-networks-in-mobile-communications

Table 1. Areas in which the different tools can lead to improved coverage

Type	Area 2	Area 3
Coverage obligation	✓	✓
Network sharing	✓	
Public funding		✓

Area 2: These are areas which are viable for one network only
Area 3: These are areas in which it would be uneconomic for even one commercial network to roll out

Source: Frontier Economics

Areas where there is already competition (Area 1) need not usually be included in any of the proposed policy interventions to promote rural coverage. The only exception is voluntary network sharing, because these may extend to nationwide alliances between operators. As such, if operators choose to share their networks they might typically seek to realise CAPEX savings in all areas. Provided that the option of voluntary network sharing is open to all operators, and that network sharing agreements do not distort competition nor negatively affect incentives to invest, policies to promote network sharing should be welcomed by policy makers.

Coverage obligations don't affect Area 1, because rollout in the most profitable areas will occur in any case. Area 1 is also not affected by public funding, because this only applies to uneconomic areas where, otherwise, no rollout by commercial operators would occur. This way, the potential distortion to competitive neutrality from any Government intervention is minimised.

Measures recommended in this report focus only on supply-side intervention required to foster deployment of mobile broadband networks; this might not necessarily result in a significant increase in broadband adoption in uneconomic areas.[28] This is mainly the case if the willingness to pay for mobile broadband services, driven by perceived benefits from broadband, is below the cost of a broadband connection for a large share of end-users. In such a scenario, the Government can take additional steps to encourage broadband take-up by stimulating demand for broadband internet services, either through increasing the

[28] According to Florence School of Regulation (2011): Broadband Diffusion: Drivers and Policies ('The FSR study' hereafter), commissioned by Independent Regulators Group, the literature on ICT and new technology adoption suggests that '*simply reducing the immediate and direct cost of access to broadband connections through supply-side policies may not be enough to stimulate broadband subscriptions'*, page 62.

purchasing power of rural customers (e.g. handset subsidies) or by stimulating perceived benefits of broadband (e.g. more local content).

We believe that supply- and demand-side intervention should complement each other and that the Government will need to apply the right mix of different policy measures to i) maximise the probability of achieving its broadband targets, ii) minimise the financial costs and iii) minimise the risk of distorting competition in the market.

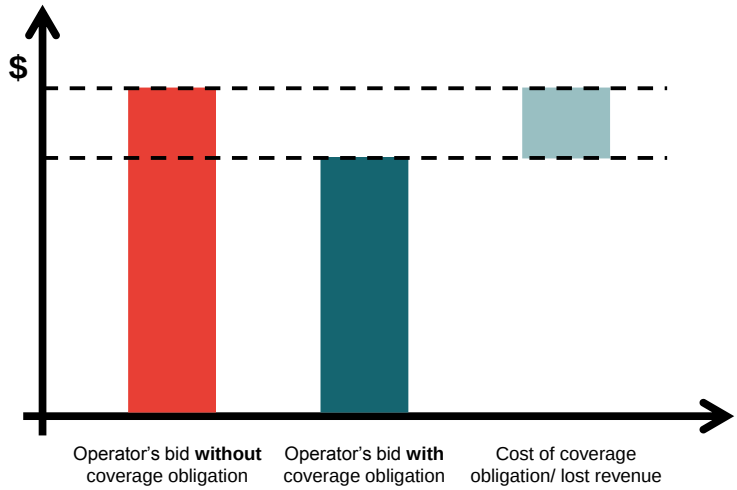
The focus of this report, however, is specific supply-side measures that we discuss in more detail below.

5.1 Licensing of new, low frequency spectrum in combination with coverage obligations

The first form of public intervention we will focus on is coverage obligations, typically introduced as conditions in operating licences, which are commonly awarded through a competitive tendering process (spectrum auctions or beauty contests). Coverage obligations set out the scope of coverage and the timescales in which it is to be achieved.

In setting such coverage obligations, policymakers face a trade-off between coverage and the proceeds that might otherwise be generated by the auction of a licence without such a condition. This is because potential licensees will be willing to pay less for a licence with more extensive coverage obligations, as coverage obligations require licensees to cover areas in which no economic case for rollout can be made. The difference between what an operator is willing to pay for a licence without and a licence with an obligation can therefore be seen as lost revenue to the Government or the amount the Government is contributing to support the rollout of services in areas that would not be served, absent the obligation. We illustrate this in **Figure 16**.

Figure 16. Illustration of cost of obligation



Source: Frontier Economics

Taking into account that operators will bid less for licences that include a coverage obligation, Governments might be tempted to set reserve prices to guarantee a minimum return from the auction. While in principle this is a legitimate concern, regulators should abstain from setting reserve prices that are too high, because this might discourage bidders and make the auction less competitive. In an extreme case, spectrum blocks might be left unsold or unused as has occurred in India and Australia.[29] Therefore, if stringent coverage obligations are imposed, regulators may also need to reflect this in the level of the reserve price.

5.1.1 Benefits of achieving greater coverage through spectrum auctioning and coverage obligations

We will cover the competitive tendering of public funds in more detail in **Section 5.3.1**. In what follows, we discuss the benefits of combining the tendering of spectrum with the tendering of coverage obligations in one single auction:

- **Simplicity** – it is easier for operators to internalise the transfer from profit making areas to uneconomic areas and adjusting their bid value accordingly if the two tenders are combined into one auction. Therefore, the winning bid is more likely to reflect the true value of the spectrum band that is auctioned.

[29] http://mph.gsma.com/publicpolicy/wp-content/uploads/2013/07/Mobile_Policy_Handbook_2013-English.pdf

- **Efficiency** – there might be some efficiency gains from combining coverage obligations and frequency allocations. This is because operators are likely to need to adjust/reconfigure their network both to efficiently use newly allocated spectrum and to meet the coverage obligation at lowest possible costs. It might therefore be more cost efficient to do this reconfiguration only once. If coverage obligations are imposed separately (and with a time lag compared to the spectrum auction) operators will have to reconsider the configuration of their different spectrum bands twice.

- **Cost minimisation** – if the auction process is competitive, the net cost of the coverage requirement (the auction proceeds forgone) will be minimised.

- **Positive externalities** – applying a coverage obligation to one operator only can result in other operators also increasing their coverage. This is because operators might try to minimise the competitive advantage of the licence holder due to his superior coverage.

5.1.2 Specification of the coverage obligation

There are a number of variations regarding how a coverage obligation can be specified (for example, whether it focuses on population or geographic coverage, how the provision of a mobile data service within the coverage area is ensured, etc.). The exact drafting of a coverage obligation will need to vary between markets according to the demand and cost characteristics of the market concerned. We discuss some of the points to consider below.

Choice of spectrum band

Low frequency spectrum has certain characteristics that make it especially useful for extending coverage. This is due to the fact that as a result of its wavelength, it propagates better over long distances compared to high frequency spectrum. High frequencies are useful in cities because they can carry a large amount of data over short distances and are thus suitable for extending network capacity in densely populated urban areas. [30]

Low frequency spectrum is generally well suited for extending coverage in rural areas because it requires fewer cells for equivalent coverage. This means lower infrastructure investment and therefore the cost of rollout is lower for mobile operators. For these reasons, recent spectrum auctions in Europe and the US

[30] We note that the use of coverage obligations is not limited to low frequency bands. Historically coverage obligations have been imposed on high frequency spectrum on many occasions to meet specific regulatory objectives.

would typically attach more stringent coverage obligations to sub-1GHz spectrum (700, 800 and 900 MHz spectrum) compared to higher frequency bands.[31]

Regulators might either require that operators use a specific spectrum band to fulfil the coverage obligation or to leave it to the operator to decide which frequency bands to use. The latter might be the preferred option as it gives the operator more room to find the most cost efficient solution.

Outdoor vs. indoor coverage

Coverage targets can either be defined in terms of outdoor or indoor coverage. Indoor coverage is difficult to measure as it is dependent on the characteristics of buildings, such as the thickness of walls. There are substantial practical challenges associated with testing indoor coverage in a way that takes account of the wide variety of building types for monitoring purposes. It might therefore be preferred to specify a level of outdoor coverage instead.

This is the approach Ofcom has chosen in the last 4G auction.[32] In particular they attached the requirement to reach 98% coverage outdoors and *"at some indoor locations within the vast majority of residential buildings"*. According to Ofcom, requiring 98% coverage outdoors would ensure that there is a sufficient level of indoor coverage.

Geographic / Population reach of coverage

Coverage obligations usually state what percentage of surface area or population of the country needs to be covered by the licensee.

In terms of **Figure 15**, coverage obligations can be used to achieve rollout in Areas 2 and 3 (in Area 1, they are not needed as rollout will occur anyway). When setting the level of coverage, the regulator needs to have an idea about the relative sizes of Areas 2 and 3 (and how many licensees are subject to this obligation – see **below**).

- Covering Area 2 is economically viable for at least one operator, so the coverage obligation is unlikely to impose a huge financial burden if it only applies to one licensee. Therefore the challenge for the operator who is subject to the obligation lies in achieving coverage subject to the specified time frame (see **below**).

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31 Out of the 16 most recent EU spectrum auctions, 10 either involved coverage obligations on low, but not on high frequency spectrum, or the coverage obligations on low frequency bands were stricter than on high frequency bands

32 http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/statement.pdf

- However, Area 3 is so uneconomic that rolling out there is loss-making. So if the level of required coverage is set such that a large part of Area 3 needs to be covered, operators will factor this in during the bidding process. This may decrease the revenue generated during the auction, or in an extreme case, leave spectrum with coverage obligations unsold, in particular if reserve prices are set prohibitively high. In such a case, the direct use of public funds might be a preferred approach to coverage obligations in reaching Area 3 (see below).

International experience indicates that coverage obligations are typically set on a population basis, rather than an area basis, to minimise the risks of inefficient network investment in areas where there is no demand for mobile services.[33] Nevertheless, when setting coverage targets, the regulator might also consider setting certain minimum requirements for particular regions, as a complement to requirements on overall population coverage. In the UK, for example, Ofcom decided to impose a coverage obligation of 95% for England, Wales, Scotland and Northern Ireland (in addition to reaching 98% coverage in the UK as a whole). In Germany and the Czech Republic, the regulator identified a list of 'underserved areas' (in combination with overall population coverage obligations) where operators had to provide basic broadband coverage before they could start rolling out in profitable urban areas.

In relation to what percentage of population/ area is to be covered through the obligation, the regulator may also need to specify a QoS (Quality of Service) target. This can for example be specified in terms of average speed in terms of Mbit/s. It seems advisable to set relatively conservative QoS targets in more rural areas at the outset. This will focus operators' efforts on attaining basic coverage in these areas and give them more time to achieve faster broadband speeds over a period of time.

Absolute vs. relative reference

The reach of a coverage obligation can be defined with an **absolute** or **relative** reference. The former would specify coverage to where, for example, 98% of the population lives according to the latest census data. The latter might require coverage in, for example, at least 90% of areas where there is currently 2G coverage. In the UK, Ofcom has chosen to use absolute references in the latest 4G auction on the grounds that this is easier to define.[34] It also enables prospective bidders to evaluate the cost of fulfilling the obligation with a higher level of confidence.

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33 In the last 4G spectrum auctions across Europe, regulators established national coverage obligations targets for the winners of the spectrum. Coverage obligations in 9 out of 10 analysed cases were set on a population rather than an area basis. The Netherlands was the only country to mandate a coverage obligation by area.

34 http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/statement.pdf

Number of operators

As mentioned **above**, an additional important question to consider is to whom any coverage obligation should apply. Here, there are two broader options for Governments to consider:

- **All operators:** The same coverage obligations could be imposed on all operators. This will lead to network competition throughout the served area but could lead to inefficient duplication, which network sharing or 'first mover' coverage would otherwise avoid. Thus, it will also impose higher costs on the sector than the second approach and, hence, also on the Government because of decreased revenues from the spectrum auction.

- **One operator:** Licence coverage obligations could be imposed only on a sub-set of operators or on a single operator (or there could be asymmetric coverage obligations, with one licence having more stringent obligations than the others). The licence with a coverage obligation may also include additional spectrum rights compared to those with no obligation, to support that licensee in meeting its obligations. Or there may be additional obligations imposed on the licence holder, for example the requirement to grant wholesale access to other operators (see **below**).

Ofcom, for instance, considered in the last 4G auction whether to impose coverage obligations on several operators. In the end, they decided to apply obligations to only one licence and without wholesale access obligations on the following grounds:

- It is not necessary to impose obligations on several operators as competition will encourage operators without the obligation to accelerate their rollouts anyway; and

- Even if in rural areas there might only be one network present, it is unlikely that consumers in these areas are to suffer substantially higher prices due to a lack of competition. This is because operators usually charge uniform prices to consumers across the UK.

Additional rights and obligations attached to the licence

Given the particular market structure in question, the regulator might consider attaching further rights or obligations to certain licences. One example of this is the obligation to grant wholesale access in uneconomic areas. This applies mainly in the case where a coverage obligation is imposed on a single operator who might then be the only operator in rural areas.

Nevertheless, the regulator considering imposing this additional obligation should carefully consider the costs and benefits of this measure.

- Firstly, while the obligatory wholesale access allows others to use the network in a given area, and hence facilitating competition, it is not obvious that this would lead to significant benefits for consumers. In particular, if there is effective competition between multiple networks in urban areas and prices (and other terms of mobile service) are nationally averaged, then one would expect outcomes in rural areas covered by one network operator (that is subject to coverage obligation) to remain competitive, even in the absence of any wholesale access obligations.

- Secondly, wholesale access obligations could potentially decrease the value of spectrum for operators by limiting the revenue that the Government can raise from auctioning the spectrum with coverage obligations and increasing the risk that the spectrum might be left unsold.

For instance, in the 4G spectrum auction, Ofcom considered imposing such obligations. However it decided against this because of the following difficulties:

- to design such an obligation in a way that doesn't undermine commercial incentives;
- to specify details - in particular within which areas the obligation applies; and
- consumer experience in roaming areas has been poorer.

Therefore, while there might be a rationale for imposing additional wholesale access obligations on the licence with a coverage obligation, the regulator needs to take into account potential risks and costs related to this additional obligation.

Timing issues

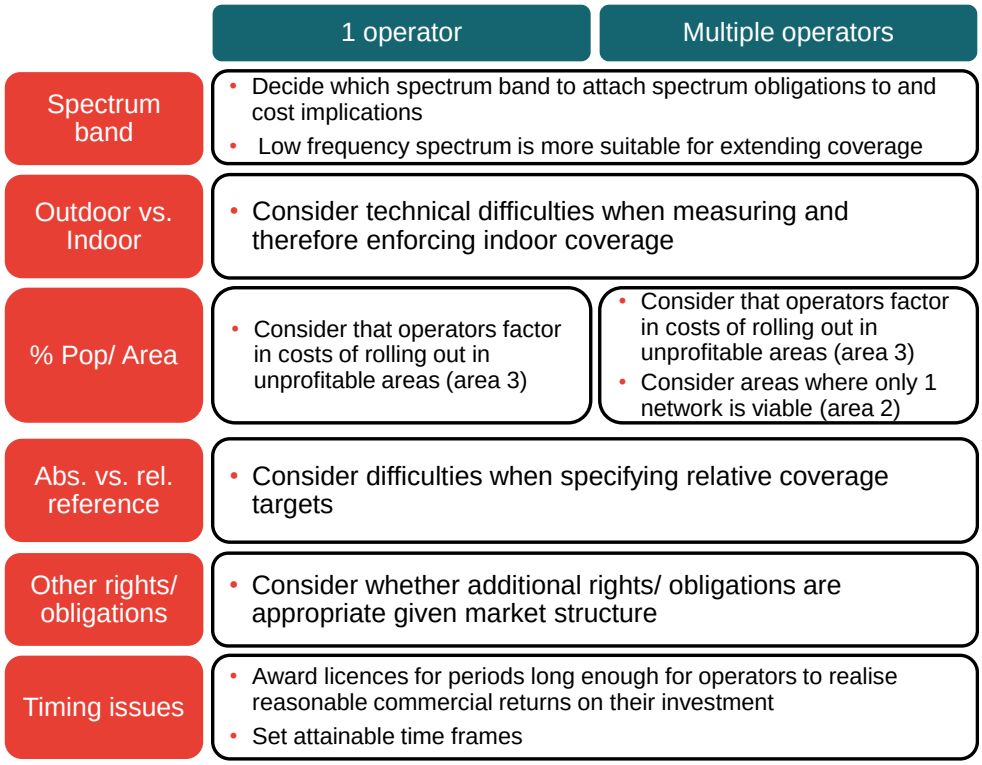
Despite the fact that network competition leads to rollout of new technologies substantially faster than other market structures, regulators in some countries envisaged the rollout of 3G to occur even faster. So, in 4G auctions, one of the reasons why coverage obligations are quite common is to speed up the rollout to rural areas.

When setting the **time frame** in which rollout should occur, the regulator has to take into account the characteristics of the national mobile market. There is a trade-off between setting goals that are ambitious enough, but are at the same time realistically attainable by market participants. If the requirements are too tight, they might prevent some operators from bidding for these licences which would make the auction process less competitive.

Regulators should also take into account the **length** of licences. Rollout in uneconomic areas involves large investments at the start whereas revenues might be relatively low due to low population densities. It might therefore take more time to earn a sufficient return to justify rollout in rural areas compared to urban areas.

In order to increase the likelihood of operators earning a sufficient return on their investment, more extensive coverage obligations may require relatively longer licence periods.[35]

Figure 17. Summary of key specifications of coverage obligations



Source: Frontier Economics

Enforcement and other considerations

- A proposed coverage obligation should be specified in detail. It is very important for bidders to understand the practical implications of accepting the coverage obligations in terms of cost and feasibility. It is also a relevant prerequisite for a meaningful discussion about the geographical extent of the coverage obligation.

- In relation to the above, the specification of the coverage obligation also needs to provide potential licensees with certainty about how achieving coverage

35 In the recent UK auction, Ofcom even specified an initial period during which the grounds for revocation are limited.

targets will be enforced and non-achievement will be penalised. In particular, when making their bids, operators need to take into account what happens if coverage targets are not achieved due to force majeure events.

- One tested way of enforcing coverage obligations is the use of performance bonds. These are bonds issued by the holder of the coverage obligation at the start of the licence. The Government has the option to monetise the bond if the obligation is not met as specified.

- Regulators should consider if the obligation should be technology and band neutral. This would allow the licensee who has the coverage obligation to deliver the specified service in whichever way is most cost effective.

5.1.3 Examples of coverage obligations

The approach of regulators mandating network rollout and coverage obligations when they issue new mobile licences is a well-tested tool to promote mobile coverage in more remote areas of the country and is successfully used worldwide. We summarise some examples in **Text box 2.**

Text box 2: Examples of coverage obligations

Examples of coverage obligations

There are numerous examples worldwide where coverage obligations have been successfully used in combination with competitive auctioning of spectrum.

- **Germany:** In 2010, 800 MHz licences required that operators roll out to rural areas first, before rolling out to urban areas (which might already receive mobile broadband services over a 3G network in another frequency band). Within less than two years, all licensees had met their coverage obligations in specified districts and were allowed to use the frequencies they purchased in the 800 MHz band in all federal states.[36]

- **Sweden:** In 2011, an obligation was placed upon one licensee in the 800 MHz auction to provide service of at least 1 Mbps or better to a list of stated addresses (identified as being broadband 'not spots', lacking any other form of broadband connection). The obligation included a commitment from the

36 AETHA (2011), "Case studies for the award of the 700MHz/800MHz band: Germany". Available at: http://www.gsma.com/spectrum/wp-content/uploads/2011/11/700MHz-800MHz-band-Germany.pdf

winner to spend SEK300 million (EUR34.2 million) on covering homes and businesses in rural areas of the country.[37]

- **UK:** The 4G auction only included a coverage obligation for one block of 800 MHz spectrum. O2 obtained 2x10 MHz of 800 MHz spectrum with a coverage obligation to "provide a mobile broadband service for indoor reception to at least 98% of the UK population (expected to cover at least 99% when outdoors) and at least 95% of the population of each of the UK nations - England, Northern Ireland, Scotland and Wales - by the end of 2017 at the latest". O2 expects to meet the national coverage obligation by 2015, two years earlier than required.[38]

- **Chile:** In 2013, in what was a mixture between an auction and a "beauty contest" (a 'hybrid' method), the terms of references indicate that bidders had to specify their coverage plans if they were awarded a spectrum block. There were also certain minimum requirements such as a commitment to cover 1,281 rural locations. To date, Chile has already successfully achieved 30% of the forecast. Taken together, the obligations are expected to lead to 4G coverage of 98% thereby ending the digital divide in Chile.[39]

- **Brazil:** 3G services were launched in November 2007. 3G coverage obligations were imposed on winners of the auction, such as:

  - Coverage of all the municipalities without any mobile technology within 2 years;
  - Coverage of all the municipalities with populations above 100,000 inhabitants with 3G within 5 years;
  - Coverage of 50% of the municipalities with populations between 30,000 and 100,000 inhabitants with 3G within 5 years; and

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37 Radio Spectrum Policy Group (2011), "RSPG Report on Improving Broadband Coverage". Available at: http://rspg-spectrum.eu/_documents/documents/meeting/rspg26/rspg11_393_report_imp_broad_cov.pdf

38 OFCOM (2014), "4G radio spectrum auction: lessons learned". Available at: http://www.nao.org.uk/wp-content/uploads/2015/03/4G-radio-spectrum-auction-lessons-learned.pdf.

OFCOM (2012), "The Office of Communications: Annual Report and Accounts". Available at: http://www.ofcom.org.uk/files/2013/07/Ofcom_Annual-Report_AD600_ACC-2_English.pdf.

39 ITU (2014), "Post Connect Americas Summit Report". Available at: http://www.itu.int/en/ITU-D/Conferences/connect/Documents/Post%20Connect%20Americas%20Summit%20Report%20(English).pdf.

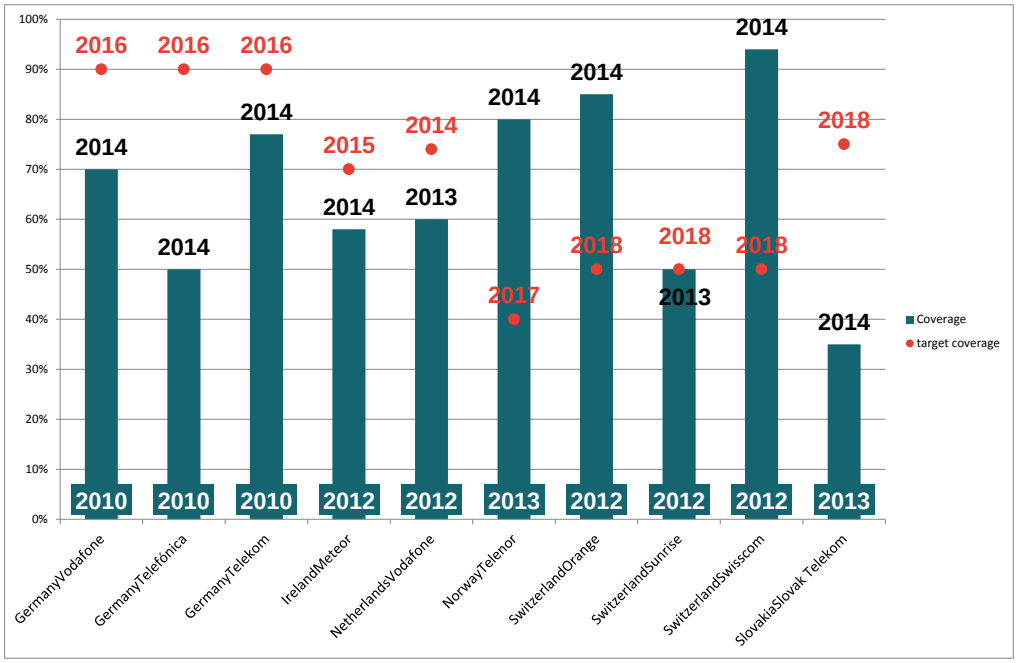
- Coverage of 15% the municipalities with populations below 30,000 inhabitants within 8 years.

We understand that after 5 years 100% of Brazilian municipalities already had mobile coverage.[40]

Most European mobile operators who have coverage obligations imposed on them have been successful or are on track to fulfil what regulators mandated. **Figure 18** below shows that the Swiss operators and Telenor in Norway have already satisfied their obligations before the required deadline. Optimus in Portugal is the only one to show a delay. All the other mobile operators are on track to meet the coverage levels set by their Governments.

40 ITU, "The Brazilian experience on spectrum pricing modeling: The 3G and 4G license". Available at:https://www.itu.int/ITU-D/finance/work-cost-tariffs/events/tariff-seminars/Mexico-13/pdf/Sess5_Silva_spectrum-en.pdf

Figure 18. Success of coverage obligations set on European mobile operators



Note: Here we illustrate the level of coverage so far reached by each operator who won the licence. Also, the graph specifies the year of the auction where the coverage obligation was issued, the target year within which the obligation has to be met and its level.

Source: GSMAi and national telecommunications regulators

5.1.4 Conclusion

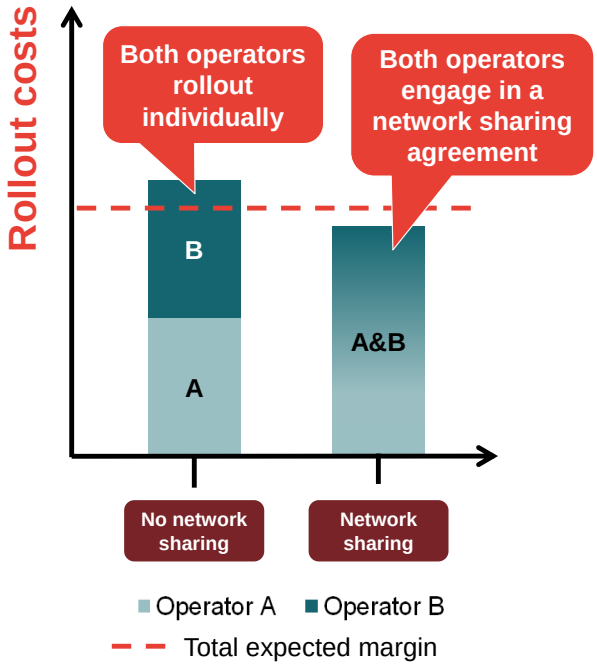
Competitive tendering of low frequency spectrum in combination with coverage obligations is successfully used worldwide. Whether or not and to what extent coverage obligations should be imposed depends to a large degree on the circumstances in the market in question as there is no one-size-fits-all solution. We discussed some of the key features that need to be considered when specifying a coverage obligation nationally. Regulators should be flexible enough to take these into account when specifying coverage obligations.

5.2 Promoting voluntary network sharing in rural areas

In the previous section, we discussed the benefits of Government intervention by licensing low frequency spectrum in combination with **coverage obligations**. Now we illustrate that encouraging **voluntary network sharing** is another policy measure for the Government to extend coverage to rural areas.

It may be the case that in rural areas, there is insufficient demand to support multiple operators rolling out independent networks. However, there may be enough demand to support one operator (or a combination of operators involved in network sharing) rolling out.

Figure 19. Network sharing agreements may lead to increased coverage



Source: Frontier Economics

Figure 19 provides a simplified example of a low-demand area that cannot support multiple operators rolling out independent networks (i.e. Area 2 using our terminology). In this example, if both operators were to roll out, then at least one operator would realise a loss. As a result, both operators may respond to the uncertainty by deciding to not roll out, in which case the area would remain uncovered. However, it is possible that through network sharing, the operators may be able to share infrastructure and save costs by avoiding duplication and removing the uncertainty that it is profitable to jointly roll out.

Operators who engage in network sharing may experience lower OPEX and CAPEX as a result compared to other operators. While this may in principle present a competitive advantage over other operators, network sharing could still minimise risks of distortions to **competitive neutrality** on the following grounds:

- there is evidence of multiple networks in a country engaging in network sharing within a network competition model (for example in the UK);
- network sharing arrangements are generally reviewed by competition authorities to ensure that they do not lead to a diminishing or distortion of competition (by the sharing operators gaining an unfair advantage over others); and
- if appropriate, competition authorities could in principle consider whether it is desirable to require some form of additional arrangement to address competitive distortions.

As network sharing arrangements reflect commercial arrangements between mobile network operators, without any public funding or favourable treatment, they should in general be more consistent with the principle of competitive neutrality, compared to policies that involve a significant risk of a competitive distortion, such as the establishment of a national SWN.

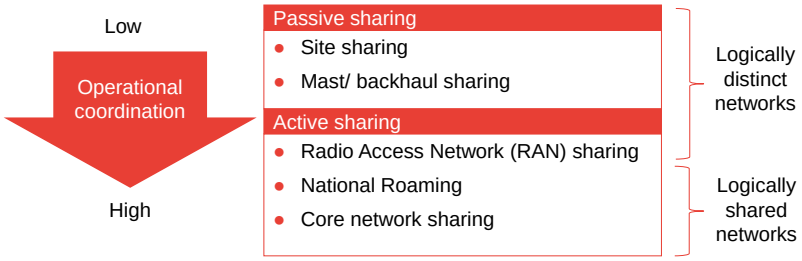
In the rest of this section, we set out:

- different types of network sharing; and
- examples of obstacles that may prevent operators from engaging in network sharing – which the Government can therefore aim to tackle.

5.2.1 Types of network sharing

Network sharing can take several forms but always involves a certain part of a mobile network being used by more than one MNO. The options range from sharing only passive elements (like the site or masts) to sharing active elements such as antennas or the core network. Different types of network sharing are listed in **Figure 20** below.

Figure 20. Overview of types of network sharing



Source: Frontier Economics

- **Site Sharing:** This concerns the sharing of the compound on which masts and any backhaul equipment of a substation are installed. It is the most basic form of network sharing as operators only share acquisition and maintenance of the site but erect their own masts and backhaul equipment. However, this form of sharing can lead to cost savings of up to 10%[41] and make rollout in rural areas more viable. In urban areas there might sometimes be no other choice than to co-locate sites due to limited space. Most agreements include the sharing of sites, for example in Australia, Cyprus, Germany and Pakistan[42]. The degree to which sites are shared differs significantly across countries, but can reach up to 50%, as was the case in Austria in 2009[43].

- **Mast / backhaul sharing:** MNOs can take this a step further by sharing passive components, such as the masts on which antennas are located, but maintaining their own antennas and separate Node Bs/ BTS[44] and RNC/ BSC[45]. There are estimates of potential overall cost savings for an MNO of up to 15%[46]. If backhaul equipment is shared, additional cost savings of up to

41 Vodafone: Network Sharing in Vodafone (http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/06/Vodafone1.pdf)

42 GSMA Mobile Infrastructure Sharing (http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf)

43 BEREC-RSPG report on infrastructure and spectrum sharing in mobile/wireless networks (http://rspg-spectrum.eu/_documents/documents/meeting/rspg25/rspg11-374_final_joint_rspg_berec_report.pdf)

44 Node Bs include radio frequency transmitters and receivers used to communicate with mobile devices and are used in UMTS networks. Base transceiver stations are the GSM equivalent of Node Bs.

45 Radio network controller (RNC) and base station controller (BSC) control several Node Bs/ BTS (for example manages the handover between them) and acts as an aggregator.

46 GSMA Mobile Infrastructure Sharing (http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf)

another 15% are possible[47]. We note that in some countries, such as India, there are third-party infrastructure providers (such as Tower Companies - see below) that specialise in the provision of shared infrastructure. These companies do not themselves operate mobile networks but lease shared infrastructure to MNOs. An increasing number of countries are permitting this approach, one of the most recent examples being Myanmar.

- **RAN sharing:** This form of sharing includes active parts of the network such as antennas, Node Bs/ BTS and RNC/ BSCs in addition to the site and mast. This means that operators share their entire infrastructure up to the point where it connects to the core network. However, they maintain separate logical networks and their own separate spectrum. Sharing of the RAN (including passive and active elements of the network) can lead to potential total cost savings of up to 30%[48].

- **Core Network sharing:** This is the most involved form of infrastructure sharing as MNOs give each other access to network elements such as the core transmission ring or logical network elements such as VAS platforms or the OMC[49] (operation and maintenance centres). Transmission ring sharing occurs if an operator has spare capacity on its lines and can be of great value for new entrants who have not yet rolled out their own infrastructure. Total cost savings achievable tend to be lower than those of RAN sharing, because the RAN usually accounts for a larger part of network costs than the core network[50].

- **National roaming:** Roaming is distinct from other forms of network sharing as it doesn't involve shared investments in infrastructure. Instead, under roaming agreements, MNOs are allowed to route traffic on each other's networks. It is therefore not necessary for an MNO to operate its own access network across the country to achieve certain levels of coverage. We include

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47 Coleago Consulting: Network Sharing business planning (http://www.coleago.co.uk/fileadmin/user_upload/Downloads/Network%20Sharing%20Overview%20Coleago.pdf)

48 BEREC-RSPG report on infrastructure and spectrum sharing in mobile/wireless networks (http://rspg-spectrum.eu/_documents/documents/meeting/rspg25/rspg11-374_final_joint_rspg_berec_report.pdf)

49 Coleago Consulting: Network Sharing business planning (http://www.coleago.co.uk/fileadmin/user_upload/Downloads/Network%20Sharing%20Overview%20Coleago.pdf)

50 GSMA Mobile Infrastructure Sharing (http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf)

it as a form of network sharing, because it has been proposed by MNOs and permitted by regulators as part of network sharing agreements in the past.[51]

Operators tend to either enter one of the above sharing arrangements or to opt for a different organisational form of network sharing. e.g. by creating a **Tower Company** ("Tower Co").[52] In broad terms, there are two types of Tower Cos:

- **Operator-owned Tower Cos** - this category consists of companies created by hiving off assets of telecoms companies into subsidiaries.
- **Independent Telecom Tower Cos** - this category consists of companies that are not owned or managed by telecom operators and build, own and lease towers to them.

As with the other forms of network sharing mentioned above, the goal is to achieve cost efficiencies by removing duplication of infrastructure. To the extent that cost efficiencies can be achieved by the creation of Tower Cos, they can potentially have a positive impact on coverage and might therefore be of interest to national regulatory authorities.

5.2.2 Examples of voluntary network sharing

In many countries around the world, operators have **voluntarily** entered into commercially negotiated agreements to share certain parts of their network infrastructure.

According to a 2011[53] survey among European regulators, in the vast majority of countries, operators have engaged in such agreements *voluntarily*.[54] In some countries such as the Netherlands, France and Lithuania, network sharing is *mandated*. In other countries like Portugal, Italy, Finland and Switzerland and also outside of Europe like India[55] and Pakistan[56], network sharing is *encouraged* by the

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51 Please note that there is an important distinction between national roaming as part of a voluntary network sharing agreement and roaming obligations forced upon MNOs by national regulating authorities, e.g. as a measure to promote new entry.

52 The term "Tower Co" was coined because historically these companies tended to lease only towers to operators. But in general their activities are not restricted to towers but may extend to other types of mobile infrastructure.

53 http://www.irg.eu/streaming/BoR%20(11)%2026%20BEREC-RSPG%20report%20on%20spectrum%20sharing_final_110629.pdf?contentId=547195&field=ATTACHED_FILE

54 Examples include but are not limited to Hungary, UK, Romania, Denmark, Sweden and Germany

55 http://www.ictregulationtoolkit.org/en/toolkit/notes/practicenote/3157

56 http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

authorities by means of including infrastructure sharing as one of the evaluation criteria in bid submissions, offering legal incentives and simplifying civil work procedures as well as publishing best practice guidelines[57] and recommendations.

The sharing of infrastructure effectively represents a reduction in rollout costs, and in low-demand areas this cost saving may be the difference between operators deciding to roll out and not rolling out. We analysed the example of N4M ("Net4Mobility") which is a joint venture between Telenor and Tele2.[58] The two operators started sharing their 2G and 4G network and spectrum pool in 2008. The network sharing agreement led to CAPEX savings of up to 46% and OPEX savings up to 29%. See the following **Text box** for further successful examples of voluntary network sharing around the world.

57 http://www.lvm.fi/docs/en/964900_DLFE-11791.pdf

58 Frontier Economics' estimate based on http://www.telenor.com/wp-content/uploads/2013/09/03_CMD_2013_Telenor_Europe_FINAL.pdf

Text box 3: Examples of network sharing arrangements

Examples of network sharing arrangements

- **Malaysia -** Malaysia has been on the forefront of network sharing in South-East Asia. Celcom and Digi have an infrastructure alliance based on site, mast and backhaul sharing. Celcom engaged in a domestic roaming agreement with U Mobile from as early as 2007. The deal helped U Mobile to achieve national coverage before rolling out its own 3G network and provided Celcom with a new stream of revenue.[59] Celcom has been engaged in sharing of active elements (including spectrum) with Altel since 2013. Altel seeks to achieve national coverage until it has rolled out its own 4G network.[60] Maxis has been sharing infrastructure and spectrum with REDtone since in 2012 claiming that it will enable them to fast track their rollout of 4G services. Network sharing is a response to the Malaysian Government's call for mobile operators to avoid duplication of infrastructure and is expected to lead to reduced capital expenditures and more efficient use of spectrum**.**

- **India:** The Indian telecoms regulator TRAI[61] published recommendations on network sharing in 2007. Amongst others, it cited the benefits such as greater coverage, cost reductions and faster rollout.[62] TRAI also approved the use of a universal service obligation fund (USOF) in support of the scheme. The fund was set up in such a way that (up to three) operators received subsidies if they decided to share passive infrastructure.[63] There were two rounds of public tenders during which 8,000 and an additional 11,000 masts were shared respectively. Tower sharing is very prominent in India today with over 80% of towers in the country owned and managed by operator-owned companies.[64] One of those companies is Indus Towers, a joint venture between Bharti, Vodafone and Aditya Birla Telecom. The main reasons for the creation of this joint venture were reduced capital and operational expenditures and the acceleration of the rollout of new technologies - particularly in rural areas.[65]

- **Ghana:** In 2010, the three operators – Tigo, MTN and Vodafone – have sold their transmission towers to other specialized business entities. In particular, American Tower Corporation (ATC) agreed to acquire a stake in almost 2,000 of MTN Ghana's transmission towers. They would create a joint venture company, TowerCo Ghana, with ATC responsible for managing the assets.[66] Ghana has a majority of its towers (around 63%) owned by independent telecom Tower Companies.[67]

In the next section, we discuss some obstacles that may prevent operators from engaging in network sharing and we present some remedies that the Government can adopt in order to tackle these issues.

5.2.3 Barriers and concerns about network sharing agreements

In principle, network sharing can lead to cost savings which may result in some low-demand areas becoming commercially viable for operators to cover.

However, in reality, there may be barriers to voluntary network sharing and these barriers effectively represent an additional cost which may result in some areas not being covered. This is particularly relevant for rural areas, where voluntary network sharing can have a positive impact on coverage increase. Also, we recognise that there are potential regulatory and competition issues that may arise from network sharing agreements, and we cover a few examples below.[68]

Table 2 below lists some examples of potential barriers to network sharing and regulatory / competition concerns. Potential solutions and safeguards are also provided.

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59 Operator response to Frontier data request

60 http://www.soyacincau.com/2014/04/23/altel-to-invest-rm1b-in-5-years-to-roll-out-lte-network/

61 Telecommunications Regulatory Authority of India

62 http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

63 http://www.ictregulationtoolkit.org/en/toolkit/notes/practicenote/3157

64 http://www.icra.in/Files/ticker/Telecom%20_notel.pdf

65 http://www.coleago.co.uk/fileadmin/user_upload/Downloads/Network%20Sharing%20Overview%20Coleago.pdf

66 Tower Exchange (2012), "Are three towercos in Ghana too many?"

67 AT Kearney, " The Rise of the Tower Business";

ICRA Rating Feature (2011). "Indian Telecom Tower Industry: Consolidation Round the Corner"

68 We recognise that these regulatory / competition concerns are more likely to affect network sharing agreements in economic / urban areas of the country.

Table 2. Typical barriers to voluntary network sharing agreements, regulatory and competition concerns that may arise, and potential remedies

Barrier / concern	Potential remedy
Shared ownership may cause delays if one operator needs permission from another to make on-site changes	Oblige operators to maintain planning independence - e.g. European Commission's 2003 decisions in the UK and Germany, both regarding network sharing agreement between O2 and T-Mobile [69] [70]
Administrative barriers – e.g. planning permission	Simplify bureaucratic procedures – e.g. in the Netherlands, no planning permission is required for deploying small antennas
Possible collusion due to information exchange	Limit the degree of information sharing between operators - e.g. implemented by the German regulator RegTP in its 2001 general guidelines concerning network sharing. Also referred to in the European Commission's 2003 decisions on the O2 / T-Mobile network sharing in the UK and Germany

Source: Frontier Economics

There are two issues in particular that regulators may take into account when considering Tower Cos as a means to fostering rural coverage:

- **Coordination** – this might be a potential concern to regulators in the case of **operator-owned Tower Cos**. Similar to network sharing agreements, if operators set up a joint Tower Co some information about network rollout will be shared in order to realise cost savings. Regulators might be concerned that this coordination extends beyond what is envisaged and that operators use their joint activities to tacitly collude. As discussed in **Table 2** this risk can be mitigated by limiting the amount of information sharing that is allowed between operators.

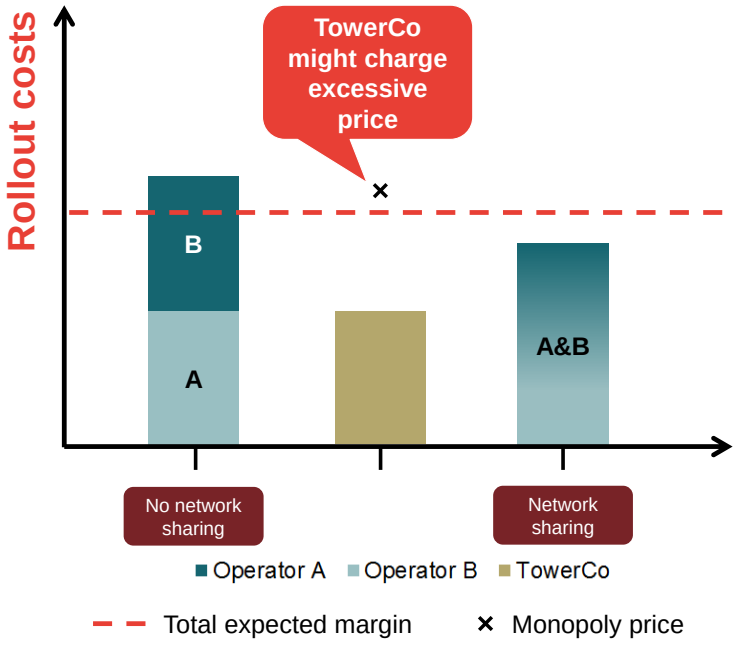
- **Excessive pricing** – in the case of independent Tower Cos, there is the risk that excessive pricing prohibits rollout in uneconomic areas if there is a lack of competition. In an extreme case, where there is only one Tower Co

69 Case COMP/38.369: T-Mobile Deutschland/O2 Germany: Network Sharing Rahmenvertrag (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32004D0207)

70 Case COMP/ 38.370 —O2 UK Limited / T-Mobile UK Limited (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1396368263143&uri=CELEX:32003D0570)

providing access to sites and towers in a country, the profit-maximising price that the monopoly Tower Co sets might be too high in rural areas for operators to make use of this service. We illustrate this in **Figure 21**. Network sharing between some operators can lead to cost savings that are sufficient to allow rollout in rural areas

Figure 21. The risk of excessive pricing under independent Tower Cos



Source: Frontier Economics
Whilst cost savings might in principle be lower for a monopoly Tower Co[71], it might be the case that the price the Tower Co charges is too high to make it worthwhile for an operator to roll out in some areas.

5.2.4 Conclusion

Network sharing is a well-tested model which is used in many countries around the world. There is a clear commercial rationale for operators to voluntarily enter such agreements which is to save costs. To the extent that network sharing reduces the cost of rolling out, it can be pivotal in the decision of whether or not to cover remote areas. Moreover, if the right safeguards are in place, competition will not be affected negatively and competitive neutrality will be maintained. Regulating authorities should therefore take a positive stance on network sharing and

71 Assuming that all operators in the market use the Tower Co such that per operator capital expenditures are minimised.

encourage operators to engage in such agreements as it has the potential to provide greater mobile coverage.

5.3 Using public finances to support rollout in uneconomic areas

So far we have considered how licensing low frequency spectrum in combination with **coverage obligations** and promoting **network sharing** agreements can improve coverage in rural areas. We have found that these measures are useful to extend coverage to areas where currently at least one network is viable, but where due to uncertainties, rollout might not take place in a timely manner (Area 2 in **Figure 15**).

As we discussed earlier, public intervention might be necessary to fund network rollout in order to reach the most uneconomic rural areas (Area 3 in **Figure 15**).

There are a number of alternatives the Government can adopt in order to approach this issue, but all of them require its financial participation, either directly or indirectly, in covering at least some of the cost of rollout in these areas.

In this section we will focus on four main alternatives (ordered from least to most disruptive):

- use targeted fiscal incentives to induce rollout;
- use competitive tendering of public funds to directly co-finance network rollout in uneconomic areas;
- (co)-financing the construction of national links, bringing connectivity closer to the end user and decreasing cost of access network rollout in remote areas; and
- some form of network intervention in underserved rural areas. This involves the direct provision of public infrastructure in uneconomic areas to be shared by commercial operators.

The above options can be implemented in a way that is consistent with the principle of **competitive neutrality**. Indirect public funding, such as using **fiscal incentives,** for example, in the form of tax rebates will leave competitive neutrality unaffected as this is available to all operators. Also, a **competitive tendering** process, if designed appropriately, will be able to avoid providing any operator with any undue advantage. Thirdly, (co-)financing the construction of **backhaul links** will maintain competitive neutrality, provided that all operators have access to it with no undue discrimination, and that backhaul links are funded in the areas where such funding is necessary for their deployment (as we explain in **Section 5.3.3**). Lastly, as public **network intervention** occurs only in areas which are not served by commercial operators, it doesn't interfere with the competitive market.

Giving all operators access to the shared public infrastructure without any undue discrimination should ensure that no one operator is favoured over another.

5.3.1 Targeted fiscal incentives

In this section, we discuss how Governments can consider using **fiscal incentives** to promote coverage by making it feasible for operators to roll out in otherwise uneconomic areas.

There are a number of channels through which fiscal measures can influence rollout decisions of operators. These include, for example, taxes in relation to the operation of tower sites or energy consumption and import tariffs on network equipment. What they have in common is that they impose an additional cost on operators which might be pivotal in some investment decisions and therefore lead to some rural areas not being covered because no economic case can be made.

Mobile operators in fact often face *additional* tax burdens compared to many other sectors of the economy, which would be expected to reduce the economic case for expanding coverage – e.g. Bangladesh, Nigeria, Turkey, Algeria and Ghana[72] as well as many Latin American countries such as Argentina and Mexico[73] are such examples.

If Governments wish to promote coverage by using targeted fiscal measures they need to take into account the following:

- **Targeting –** there should be a direct link between the chosen measure and the desired outcome – wider coverage. In practice, this means that if, for example, a regulator chooses to use corporate income tax rebates to promote rural coverage, these should only apply to revenues generated in uneconomic areas rather than to the company as a whole. The more direct this link, the bigger the impact will be.

- **Efficiency –** designing and monitoring any such scheme might incur a significant cost if it is too complex. So while any fiscal incentives should be as closely linked to the ultimate policy goal as possible, regulators should pay

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72 In **Bangladesh**, mobile operators are subject to a special corporation tax rate 10% higher than all other sectors except for tobacco. Also, we understand from the GSMA there is a regulatory duty of 5% imposed on approximately a quarter of all imported network equipment. In **Ghana** and **Nigeria**, various fees on mobile operators raise the cost and administrative complexity of rolling out networks. In Nigeria, there are local business taxes of on average N 30,000 per site, town planning fees amounting to an average of N 650,000 per site and annual civil aviation taxes of N 50,000 per site. In Ghana, on the other hand, fees for fibre rollout in amount approximately to $ 4,000/km.

73 http://www.gsma.com/publicpolicy/wp-content/uploads/2012/12/GSMA-2012-Latin-America-Tax-ReportWEBv2.pdf

attention to choose measures that can be administered easily such that the cost of the scheme doesn't outweigh its benefits.

- **Transparency –** if any tax rebate scheme is offered it should be well defined so it is clear to operators at the outset which geographic areas it will apply to and which taxable items it is targeting. This is essential to avoid any potential disputes.

In the following text box, we show how the above can be implemented in practice, using the example of Malaysia.

Text box 4. Fiscal incentives in the case of Malaysia

Fiscal incentives in the case of Malaysia

A recent budget of the Malaysian Government[74] included the following measures to incentivise investment in mobile broadband coverage:

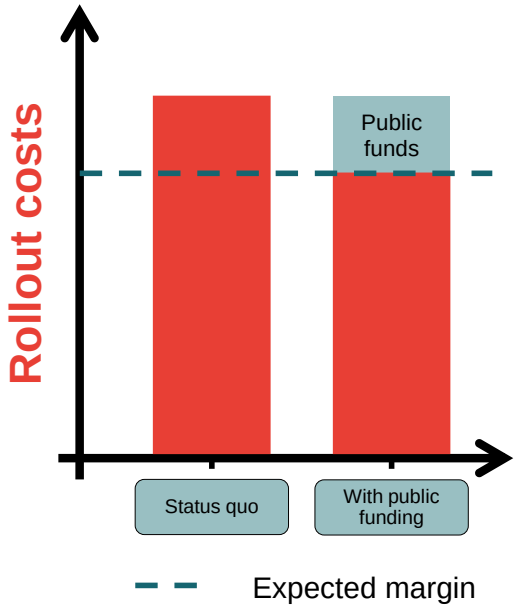
- "Last Mile Broadband" network investment incentive. This provides a tax exemption for up to 70% of corporate income tax on qualifying (rural broadband) expenditure which has been used to deploy a faster access network.
- Exemption from import duty and sales tax for broadband equipment and consumer access devices for the provision of broadband services which are not produced locally.

5.3.2 Direct public funding

Another form of intervention available to the Government in order to enable network rollout in rural areas is to **directly** support mobile operators to extend coverage, with public funds allocated on the basis of a **public tender**. One way of doing this is by, for example, using a "Dutch auction". In this auction type the price is automatically lowered over time until someone is willing to bid (or the reserve price is met). In the case of public funding, this would mean that the amount of subsidy received is increased over time until an operator is willing to bid and commit to roll out a network in an underserved area. We illustrate how this public funding might allow rollout in unprofitable areas in **Figure 22** below.

74 http://www.mia.org.my/new/downloads/circularsandresources/budget/2014/B18.pdf

Figure 22. Direct public funding to finance rollout in uneconomic areas

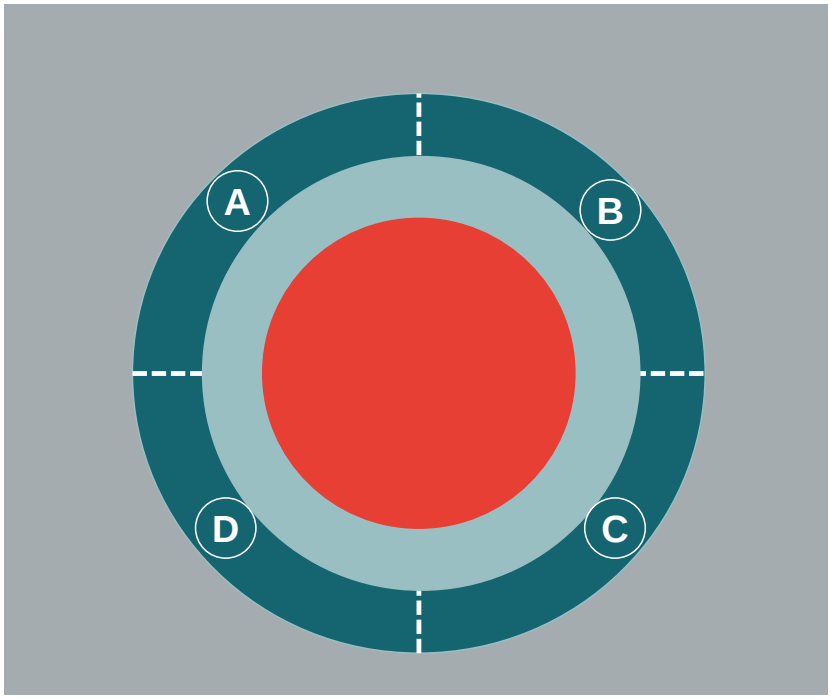


Source: Frontier Economics

In low demand areas, an operator may estimate that the expected rollout costs exceed the expected margin that it would generate from potential subscribers in the area. As a result, it would be loss-making to roll out, and so the area will remain uncovered (Area 3).

There are different ways in which Governments can and have run such public tenders geographically: one option is to structure these tenders such that a single entity/operator rolls out in all uneconomic areas (and potentially provides wholesale access to other operators). Another option implies running several tenders to allocate funds for providing coverage in different predefined geographic areas. In this case, the Government could request that a **national roaming** offer is developed under which existing retail mobile operators can have access to these networks in uneconomic areas under a common, national contract. This means that operators would not have to negotiate with all the different operators of these wholesale networks, thereby facilitating the provision of retail services in uneconomic areas. We illustrate this graphically in **Figure 23**.

Figure 23. Using public funds to facilitate rollout of several wholesale networks in uneconomic areas



Source: Frontier Economics

Examples of direct funding

The Government could provide funding to bridge the gap between costs and margins so that with such funding the area becomes viable to cover. Programmes similar to this have already been implemented in different European countries, such as France, the UK and Ireland. The experience from these countries provides us with some key elements to be considered.

- **France** - in 2003, the French Government established a system of collaborative funding to improve mobile coverage in rural areas. 3,000 not-spots (areas that did not have 2G coverage from any one mobile network) were identified and a consultation process took place to help local communities to identify and nominate themselves for inclusion in the scheme.

The three MNOs jointly contributed around 75% of the total cost, with the balance being provided by central and local public funds.[75]

- **UK** - In 2013, the UK Government introduced the Broadband Delivery UK ("BDUK") scheme. Although this programme refers more generally to the broadband sector, the conditions operators have to satisfy in order to obtain the aid can also be adopted in the case of mobile networks. According to the BDUK scheme, each body which intends to rely on public intervention to deliver its broadband project has to follow three steps:
  - identify the geographic areas where public intervention is needed;
  - motivate why intervention is needed; and
  - run a public consultation.

  The public funds are awarded according to who makes the most economically advantageous offer. All local bodies are required to include a claw back provision in the contracts with suppliers to deliver local broadband projects. This ensures that the successful supplier does not receive excess funding in the target areas.[76]

- **Ireland -** in 2008, Hutchison Whampoa ("Three") won a competitive tendering process to implement and operate the National Broadband Scheme (NBS). The objective of the NBS was to deliver basic, affordable broadband to certain target areas in Ireland in which broadband services were insufficient.

  According to the NBS contract, Three was required to provide services to all premises in the NBS coverage area who sought a service. In order to facilitate competition in the area, Three also had to provide wholesale access to any other authorised operator who wished to serve premises in the area covered by the NBS.

  The rollout of the provision of NBS services advanced incrementally over a 22 month period and was completed in October 2010. In line with the NBS contract, broadband services were made available to all premises within each of the 1,028 designated NBS Electoral Divisions across 25 counties.

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75 PA Consulting Group (2010): "Not-spots research Impacts, causes and potential solutions for areas of poor coverage, not-spots". Available at:

http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/notspots/PA_Consulting_main_report.pdf

76 European Commission (2012), "State aid SA.33671 (2012/N) – United Kingdom National Broadband scheme for the UK - Broadband Delivery UK". Available at: http://ec.europa.eu/competition/state_aid/cases/243212/243212_1387832_172_1.pdf

Direct funding as a form of intervention has also been adopted outside Europe. Examples of non-European countries where Governments have provided operators with subsidies awarded through a competitive tendering process are Chile and India.

- **Chile -** to increase access to public telephones in rural and low-income urban areas, the Chilean government set up Fondo de Desarrollo de Telecomunicaciones (FDT) in 1994. The fund is financed by the national budget and administered by the regulatory authority, SUBTEL.

  The regulator decides on the annual programme of projects eligible for subsidy and awards these through competitive bidding, each project being awarded to the bidder asking for the lowest subsidy. These projects covered almost 1,300 localities throughout the country. The localities typically have fewer than 1,000 inhabitants and are located within roughly 50 kilometres of existing telecommunications facilities.

  The original goal for the Fund was to provide a public telephone service to about 6,000 unserved localities – a target that was met over the 5 year period between 1995 and 1999.

  After having achieved Chile's social telephony objectives, the Fund was redefined to support tele-centre projects. The Fund aimed to launch a national tele-centres programme in 2002. An initial target was to set up tele-centres in about 90 municipal headquarter towns with over 8,000 rural inhabitants. By 2006, there were tele-centres in all 341 municipalities. The Fund still exists and receives an annual budget to carry out projects aiming at increasing coverage in uneconomic areas.[77]

- **India -** A number of initiatives have been undertaken by the Government to improve the telecom penetration in rural India. The Government's Bharat Nirman programme was aimed at intensifying rural infrastructure development. The subsidy support for mobile towers in rural areas through the USF is another example of the Indian Government's initiatives to promote rural telecommunications. Under the Bharat Nirman programme, 61,186 out of the remaining 62,302 villages have been covered as of December 31, 2009.[78]

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77 The World Bank Group (1997), "Extending Telecommunications Service to Rural Areas—The Chilean Experience". Available at:

http://siteresources.worldbank.org/EXTFINANCIALSECTOR/Resources/282884-1303327122200/105welle.pdf

78 RAD (2010), "Rural India holds the key to push the country's broadband base". Available at: http://www.rad.com/12/broadband-in-rural-India/22081/

Issues in relation to direct public funding

Although this option is attractive in principle, we show below some practical implications that make it more of a risk:

- ensuring **competitiveness** of the auction; and
- ensuring **transparency** in the way funds are managed.

First, any tendering process needs to **safeguard competition**. If not properly designed, there might be limited room for multiple operators to compete. If the number of operators participating in the tender is limited, this could negatively affect the competitiveness and the bidding behaviour of the operators.[79] This can be a way for the winning bidder to extract more money from the Government than what would be necessary to roll out efficiently in uneconomic areas.

One of the reasons why in mature economies there might be an absence of bidders other than the fixed incumbent is that, in general, fixed incumbents provide (near) universal coverage. This means they can be at an advantage compared to other operators in relation to such tenders.

In developing/emerging economies where fixed incumbents typically provide much less than universal coverage, they should necessarily be considered to have an advantage in relation to rural coverage as a result of the coverage of their fixed networks. They may, however, still enjoy some advantages as a result of being the legacy fixed telecommunications providers.

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79 In an extreme case, there is only one bidder who will win the auction at any price/ the reserve value.

Text box 5. The UK experience from public tendering of public funds

UK example of allocating public funds

During the 2010-15 spending review period, a total of £530 million has been allocated to broadband delivery in the UK. Each local authority has been given funding to help provide 90% of homes and businesses with access to super-fast broadband and everyone with access to at least 2Mbps.

Broadband Delivery UK (BDUK) has the role to manage the Government's broadband funding. BDUK's **framework contract** has been introduced to help local authorities with the procurement process and to speed up the realisation of the rural broadband plan. Initially nine suppliers passed the selection process to be included in the framework agreement but seven were subsequently deterred by the cost of delivering broadband to uneconomic areas.

As BT and Fujitsu were the only two bidders left from the original list, this implied that in theory, there could be a risk of limited competition in these tender proceedings. In fact, as of April 2013, the media reported that BT was the only company to have been awarded delivery contracts. Fujitsu withdrew from the BDUK process, leaving BT as the only participant in the framework agreement.[80]

Second, directly awarding funds to operators is a similar but less **transparent** option than licensing low frequency spectrum in combination with coverage obligations.[81] The lack of transparency can be an issue for this or other kinds of funds. For example, a recent GSMA study[82] provides evidence for a range of issues in relation to Universal Service Funds ("USFs") in African countries. Among the most prominent is the lack of transparency and poor administration which often leads to inactive or ineffective funds.

Providing public funding indirectly through a single spectrum licence award auction with coverage obligations could be, where feasible, a more efficient option to allocate public funds.

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80 Baker, Hirst and White (2014) "Broadband – Update 2014", House of Commons Library. Available at: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.parliament.uk%2Fbriefing-papers%2FSN06643.pdf&ei=vJUhVI7gHJC07QalnIDQAw&usg=AFQjCNFerrUCh5z-EbGbB970pNt977Qnew&sig2=DKkSeihfepY4OXI7oh9hwQ&cad=rja

81 We showed in **Section 5.1** the benefits of awarding coverage obligations and licences in the same auction.

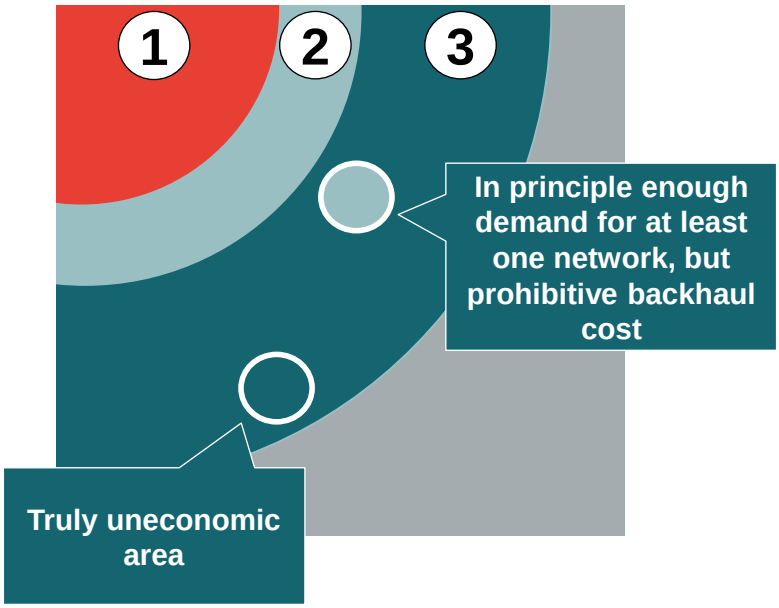
82 http://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/Sub-Saharan_Africa_USF-Full_Report-English.pdf

5.3.3 (Co-)financing backhaul links

The third option to use public finances to enable coverage of uneconomic areas is the **(co-)financing of the backhaul links**. The backhaul is defined as the portion of the telecoms network that connects the tower/BTS to the core/backbone network. It is also used to refer to any portion of the network that connects into the centre of the network.

In some local areas, there may be sufficient demand to support operators rolling out an access network. However, the difficulty may lie in providing backhaul connectivity from this access network to the core network in a cost-effective way. In remote areas, a lack of backhaul connectivity may therefore result in operators deciding not to roll out in areas that would otherwise be commercially viable.

Figure 24. Identifying regions where backhaul cost prohibits rollout



Source: Frontier Economics

The Government could decrease the cost of rollout in remote areas by supporting the extension of backhaul links to bring broadband connectivity closer to rural consumers. This could come in the form of either public funding (either paid to existing operators or used to finance a Government-led rollout) which provides fibre backhaul on an open access basis and on affordable terms, or through promoting backhaul network sharing. This would make it more cost effective for mobile operators to roll out their wireless access networks.

Examples of (co-)financed backhaul links

- **Hungary** – based on the 5 year Digital Renewal Action Plan (2010-2014), the Hungarian Ministry of National Development published a draft call for projects to finance broadband backhaul network developments. This project will help increase the usage of ICT skills in those areas where demand is not that high and make broadband Point of Presence available for those areas where optical connection is present.[83]

- **New Zealand** – New Zealand is another country implementing a series of major telecommunications policy initiatives, aimed at accelerating the deployment of ultra-fast broadband to its citizens and social services institutions. These initiatives include the Rural Broadband Initiative (RBI), a NZD 300-million government funding programme aiming at improving the availability of fibre backhaul links in less-urbanised parts of New Zealand, and providing the country's schools with reliable, ultra-fast connectivity. The current objective is to bring broadband of least 5 Mbps to 86% of rural customers by 2016.[84]

5.3.4 Public provision of network infrastructure in uneconomic areas only

Another possible way for the Government to subsidise rollout in uneconomic areas consists of directly providing public network infrastructure in underserved areas.

As set out in **Section 4** of this report, there will be some truly uneconomic areas of the country, typically remote rural areas where commercial operators are unable to roll out in the short- to medium-term, even taking into account potential cost savings associated with network-sharing. In these areas, it may be possible for the Government to justify an intervention in the form of publically funding network infrastructure. The key purpose of any network intervention will be to extend coverage to these uneconomic areas, while minimising market distortions and the public funding required to co-finance the network rollout and operation. We discuss in turn the two dimensions along which network intervention can be defined – **geographic footprint** and **scope of the intervention**.

- **Geographic footprint of intervention –** as explained above, we believe that any intervention should only be considered in areas which are truly under-served (Area 3 in **Figure 15**). Intervention should not occur in any areas that are already covered (or will be covered in the short- to medium-run) either

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83 https://ec.europa.eu/digital-agenda/en/best-practice-%E2%80%93-broadband-backhaul-network-development-hungary.

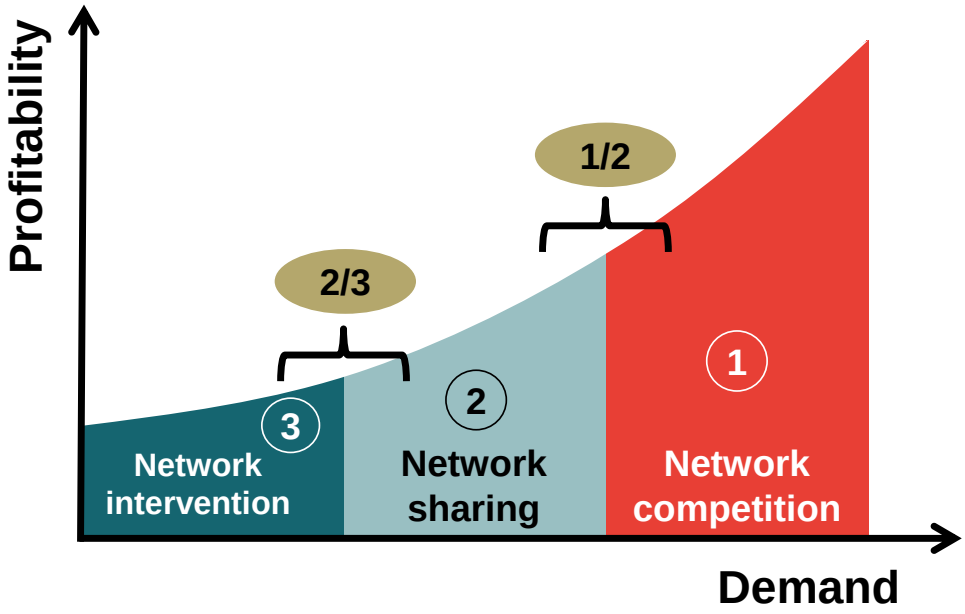
84 The Broadband Commission for Digital Development (2011), "Broadband: A platform for progress".

through the model of network competition (Area 1), or through some form of network-sharing agreement (Area 2).

The main reason for this is that the Government should seek to minimise the public funding necessary to achieve its aims and to maximise the use of private capital invested by the existing operators. Public intervention in areas where some form of network competition is viable would likely distort market structure at the expense of end users. Therefore, the boundaries of intervention should be clearly defined to minimise the extent of such a distortion, which further amplifies the importance of the accurate mapping exercise / gap analysis described in **Section 4** above.

However, we recognise that the boundaries between these different models or 'areas' (i.e. between (i) network competition and network-sharing; and (ii) network-sharing and the public intervention) are likely to be fluid and subject to change over time. This is illustrated in **Figure 25** below.

Figure 25. 'Boundaries' between different approaches should be flexible



Source: Frontier Economics

For example, as equipment becomes cheaper over time and income-levels (and therefore demand) increase over time, areas that were once only profitable to cover using some form of network-sharing agreement may become sufficiently profitable for operators to roll out competing networks. This represents a move from 2 → 1.

Similarly, it may be the case that operators jointly build a single privately funded network, only to discover that it is economically unsustainable without some degree of public funding. Therefore, at a later date, this element of the network could potentially be transferred into the public network (representing a shift from 2 → 3). Or, on the other hand, public infrastructure might initially be rolled out in areas which were thought to require a degree of public funding, only for them to be transferred from public into private ownership by the operators at a later stage – representing a shift from 3 → 2. This would therefore reduce the cost to the Government.

By allowing operators to determine which model to adopt in a flexible way – provided that they meet the overall coverage targets – this means that the Government would not necessarily need to determine exactly where the boundary between these approaches lies. The broadband mapping exercise referred to earlier in **Section 4** will give the Government (and operators) a better understanding of where the boundaries may lie – but, again, the models should allow for a degree of flexibility.

- **Scope of intervention –** apart from the geographical footprint, the Government also has to decide upon the scope of any network intervention. It might not be desirable or even necessary to construct a full public network consisting of passive and active infrastructure and designated frequency bands. Governments have to consider that the more involved its intervention, the more costly and complex the project will become. We therefore suggest that public consultations with the commercial operators are held prior to any intervention to find out what the operator's appetite is in terms of its own engagement in any such intervention. It might, for example, be the case that all that is required is public provision of passive infrastructure and that operators are willing to provide active network elements themselves.

In what follows, we discuss some of the issues that are relevant to any Government contemplating the most radical option – implementing a Rural Wholesale Network (RWN)[85]. By this we mean a publicly financed network (either fully or partly owned by the Government) which provides non-discriminatory wholesale access to commercial operators in uneconomic areas (i.e. areas where no commercial operator provides coverage).

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[85] For brevity, we use the term RWN to refer to single wholesale network to roll out to only uneconomic areas, where such areas are defined on the basis of the market analysis described in **Section 4** of this report, rather than rural areas more widely.

RWN as a solution

Whilst we recognise that implementing the RWN in practice will be challenging, we believe that if designed properly, the RWN operating in uneconomic areas only would not face the significant challenges identified in relation to 'national' SWN solutions proposed in some countries (e.g. Mexico).[86]

It is reasonable to expect the RWN to operate as a single (regulated) wholesale network (i.e. minimising the duplication of assets), whilst allowing for competition at the retail level to drive down the unit costs and retail prices. The RWN would therefore act as a wholesale provider only (i.e. not be present in the retail market), providing access to the network in no (undue) discrimination terms to other mobile operators, allowing them to serve the rural population.

In the rest of this section we discuss the following issues:

- spectrum ownership and management;
- funding and ownership of the RWN; and
- regulating the RWN.

We discuss these points in turn below.

Spectrum ownership and management

The key input in establishing the RWN will be low frequency spectrum suitable for delivering mobile coverage in uneconomic rural areas (at the lowest cost possible). At the same time, one of the challenges in setting up the RWN is ensuring that spectrum is available to allow the RWN to operate in rural areas, whilst not depriving existing operators from using it in areas where network competition is commercially viable (e.g. urban and semi-urban areas).

One solution to this would be to grant the mobile operators use of spectrum nationwide but to allow (or require) them to assign spectrum to the RWN in uneconomic areas where they are not using the spectrum. A number of potential business models could be put in place to allow the RWN to operate using spectrum in uneconomic areas.

For instance, the RWN could operate a Multi-Operator Radio Access Network (MORAN) in uneconomic areas, where each MNO operates a virtual network on top of the RWN with their own spectrum, and this would allow seamless handover and for operators to maintain ownership of spectrum. Alternatively, the RWN could 'own' the spectrum frequencies and operate as a true single network in

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86 We discuss the main challenges of establishing and managing the national SWN in a separate report http://www.gsma.com/publicpolicy/wp-content/uploads/2014/09/Assessing_the_case_for_Single_Wholesale_Networks_in_mobile_communications.pdf

uneconomic rural areas, which would require some form of roaming agreement with existing operators to ensure seamless handover, etc.

Which of these options is preferable would depend on specific local circumstances, including potential legal and/or administrative constraints (e.g. the ability of operators to pool spectrum and assign it to a third party). There are likely to be further practical challenges in implementing these models. One challenge relates to radio frequency planning on the geographic boundaries between the RWN, and areas which are covered commercially. Also, technical arrangements will need to be made to allow users to roam seamlessly between these networks – e.g. moving from the RWN to an adjacent network.

However, the involvement of existing operators in the operation and management of the RWN should help with the addressing of such issues. For instance, co-ordination between the RWN and each individual operator to ensure seamless roaming is readily achievable and each party has an interest in ensuring it will work. Nonetheless, the technical arrangements for ensuring seamless handover will need to be agreed in advance.

Financing and ownership of the RWN

Another important issue will be in relation to the financing and ownership of the RWN. The RWN could be a complex and costly project, as it would effectively be a network operating in the least profitable areas of the country, where income levels are typically below the national average, and where rollout costs are likely to be higher than in more densely populated urban areas. The extent of the RWN cost will depend on the share of truly underserved areas in the country, which will likely drive both CAPEX and OPEX of establishing and maintaining the RWN.

There is a question as to what extent the Government will be willing, or able to, secure the necessary funds for financing the RWN and the costs it would incur in doing so. Whilst financing the RWN solely from public funds might be a feasible option for some Governments, there are significant risks related to these 'public ownership' solutions.[87]

In particular, there is a long-term funding risk as the RWN will have to compete for public funds alongside other Government priorities. This is particularly relevant since the RWN will not be a 'one-off' investment only and may require OPEX funding on an annual basis to keep it running. The RWN will be operating in uneconomic rural areas, where there is likely to be a lack of other infrastructure (e.g. energy, transport), which will have implications for the cost of maintaining the network. However, Government priorities may change, resulting in underinvestment in the RWN. In addition, public ownership could lead to the

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87 As described in more detail in Frontier Economics (2014): *Assessing the case for single wholesale networks in mobile communications*

complete exclusion of existing operators from participation in the RWN. This will make it significantly more difficult for the RWN to access the necessary information, data and skills to successfully operate the network.

There are two possible ways the Government could address these particular challenges:

- Firstly, the Government may consider additional complementary infrastructure based investment to decrease the cost of maintaining the RWN and increase the long term sustainability of the network. For instance, bringing electricity to more uneconomic areas will significantly decrease the cost of network rollout and maintenance of the RWN, with base stations that would otherwise rely on costly diesel fuel being powered up by cheaper electricity; and

- Secondly, the Government may also seek some form of private financing for the RWN. Also, the RWN is more likely to succeed from an operational and management perspective if the existing mobile operators are involved as (partial) owners of the network. This is particularly important if subsequently there will be transfers of assets into and out of the RWN as the boundaries between the models shift, as discussed above.

Therefore, a public-private ownership which includes the existing network operators is likely to be a preferable approach when establishing a RWN. Such a form of ownership is still likely to present challenges in terms of attracting investors, including the existing operators, to participate. This is particularly relevant given that the RWN will operate only in uneconomic areas, which are unattractive from the perspective of private investors.[88]

Furthermore, the Government could take additional measures to make the (co)investment into the RWN more attractive for private investors. For example, the Government could consider additional forms of underwriting the risk of investment in the RWN that will encourage participation of private investors, for instance through some form of an insurance product protecting private investors from making significant losses if the RWN is unable to generate sufficient returns, or if in the worst case scenario it goes bankrupt.[89]

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88 One option would be for the Government to (co)fund the RWN by financing all the CAPEX costs. The OPEX costs - for energy, network maintenance etc. - could then be passed onto the operators on a simple cost plus basis. The RWN would then breakeven in operating profits, but would not pay a dividend or make any further investments in passive infrastructure (if it did, the Government would subsidise these too).

89 This mechanism would be similar to export credit guarantee, protecting exporters from non-payment (default) of their foreign customers.

Regulating the RWN

Finally, the success of the RWN will largely depend on how efficiently it is regulated. As explained above, a well-designed RWN would operate only in areas that are not commercially viable for mobile operators. As such, it would be expected, absent some form of regulation, to have relatively weak incentives to invest, to seek to expand output, to reduce costs or to improve the quality of the services it provides. Therefore, some regulation will be required to address these issues.

Regulators will need to set wholesale access prices which are intended to encourage the monopolist to improve the efficiency of its operations (e.g. through RPI-X type wholesale price controls/caps), and to encourage retail operators relying on the RWN to expand their output (e.g. through 'two part' charges). They can also set coverage targets for the RWN to accelerate or extend rollout; and potentially require the RWN to upgrade its network at specified dates (e.g. by benchmarking against other countries). 'Regulation' in this context could take the form of clear and transparent rules or targets included in the licence granted to the RWN or in subsequent directions from the regulator.

Such measures could, if implemented well, go some way towards reducing the concerns of a RWN operating as a monopoly in the areas where it is present. The key question policymakers must consider is whether RWN could be regulated effectively and, if they could, whether a RWN policy option would outperform alternative, more 'market-based' options discussed in previous sections. For this reason, it seems sensible for the scope of the RWN to be restricted to those geographic areas which cannot be served sustainably by any other means. A geographically restricted RWN is likely to be much easier to regulate than a nationwide SWN.

- **Coverage targets:** these will be set based on a detailed mapping exercise to identify truly underserved areas. Therefore, setting the right coverage targets will be an essential input in establishing the RWN and will therefore not imply any additional regulatory costs.

- **Network quality and upgrade targets:** these can be linked to the network quality and upgrades in the areas of the country where there is network competition. For instance, a simple rule can be set that the RWN in a given area will be required to offer the same network quality as in the neighbouring 'competitive' area. Or alternatively, the quality targets can be linked to the latest technology available in the competitive urban areas, while offering the RWN opportunity to roll out with a 6-12 months' delay. In any case, this approach will not require any international benchmarking exercise, making it significantly easier for the regulator to manage the network quality of the RWN over time.

- **Wholesale access pricing:** assuming the RWN will cover a relatively small share of a country's population and mobile operators will continue to price their services on a national basis (i.e. no geographic price discrimination at the local level), the wholesale access prices could be set on the basis of some form of a retail-minus mechanism. This approach would leverage the information from competitive outcomes in areas where multiple networks are operating, without the need for the regulators to build complex cost-models to set cost-oriented wholesale access prices.[90]

In summary, while we recognise that regulating the RWN will need to address a number of issues, we believe that regulating a RWN that operates only in underserved areas will be significantly less complex and more likely to succeed than regulating a nationwide wholesale network. This will particularly be the case if the RWN is designed properly to limit the distortive competition effect, allowing the regulator to use market outcomes in competitive areas to efficiently regulate the RWN.

5.3.5 Summary of our findings

Indirect public funding by means of fiscal incentives could be used to support rollout in uneconomic areas. If these schemes are properly designed and targeted, they can be a powerful tool to achieve extended mobile broadband coverage.

Secondly, directly funding rollout in uneconomic areas through tenders to award the rights to existing operator(s) may also be justified. However, there could be more significant risks and challenges linked to this type of solution, as Governments would need to approach direct financing carefully in order to minimise the cost to the public purse, allocate the funds efficiently and minimise the risks of competitive distortions. Thirdly, it might be the case that while an area by itself might have enough demand to justify network rollout on commercial grounds, it is so remote that providing backhaul connectivity is the decisive factor for why rollout doesn't occur. In these cases, a way to provide coverage would be to use public funds to extend backhaul links to more remote areas and leave it to the private sector to roll out the local access network.

Lastly, the use of public finances to cover the cost of rollout in uneconomic areas could be undertaken through the establishment of an RWN infrastructure. Properly designed and regulated, this could offer an appropriate solution to improve coverage, but this is no easy task.

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90 Note that if the RWN is fully publicly funded than it effectively becomes a subsidy vehicle, and as such does not necessarily need to generate any revenues, the issue of wholesale access pricing becomes largely redundant.

5.4 Conclusion

Although network competition is usually recognized to perform better than other market structures in terms of ensuring extended coverage, further forms of public intervention might be required in some uneconomic areas in order to achieve the coverage targets defined by the Government. In **Section 4,** we discussed how to identify these areas. In this section, we illustrated three alternative tools that Governments might use: auctioning low frequency spectrum combined with **coverage obligations**, promoting **network sharing** or using some form of **public funding** to expand coverage in underserved areas**.**

While in principle, all of these can be designed to ensure that they are consistent with **competitive neutrality**, the available evidence suggests that coverage obligations attached to new (low frequency) spectrum, and voluntary network sharing could be expected to be more likely to be consistent with this objective.

Annex 1: Econometric results

In our main econometric model, we used an early time period (2001q1), as there were more single network countries at this point in time. As a sensitivity check, we have re-run the regressions for a different time period (2005q4). We have picked this time period because the coverage data is relatively comprehensive for 2005. Using a different time period does not change our main result, which is that network competition has a positive and significant impact on coverage or take-up (see **Table 3** and **Table 4**).

Table 3. Regression results for coverage[91], 2005q4

	Overall population coverage	Overall population coverage	Overall area coverage	Overall area coverage
Single network	**-13.88****	**-19.71*****	**-6.575**	**-13.28****
GDP per capita	0.000431***	0.000642***	0.000612***	0.000855***
Population size	-2.50e-08*	-1.48e-08	-4.43e-08***	-3.25e-08***
Population density	-0.000475	-0.000814	0.000524	0.000134
Time Since 2G was launched	0.754***		0.868***	
Constant	46.28***	69.13***	15.35**	41.64***
Observations	177	177	177	177
R-squared	0.315	0.234	0.273	0.214

Source: Frontier analysis using GSMA data

[91] *** p<0.01, ** p<0.05, * p<0.1

Table 4. Regression results for take-up, 2005q4

	Overall take-up	Overall take-up	3G take-up
Single network	**-12.16*** **	**-17.16*** **	**-1.988**
GDP per capita	0.000729***	0.000858***	7.70e-05**
Population size	-2.01e-08***	-1.34e-08**	1.57e-08
Population density	-0.000745	-0.000679	0.000602*
Time since 2G was launched	0.457***		
Constant	11.86***	25.38***	0.775
Observations	190	190	56
R-squared	0.541	0.496	0.112

Source: Frontier analysis using GSMA data

Including urbanisation and political risk

As a further sensitivity check, we have also assessed the impact of including urbanisation and political risk. Urbanisation could potentially impact coverage and take-up because it may influence the costs of rolling out a network. In general, the cost of network rollout per subscriber will be lower in countries with a high level of urbanisation. This is because fewer base stations are required per subscriber.

Political risk could be important as it may impact both operators incentive to invest (and therefore the number of players) and outcomes. We have derived a measure of political risk by taking an average of different indicators from the World Bank. These indicators related to accountability; political stability and lack of violence, effectiveness, quality of regulation, rule of law and control of corruption. As shown by the following tables (**Table 5**, **Table 6**, **Table 7**), when we include urbanisation and political risk, we still conclude that network competition has a positive impact on coverage and take-up.

Table 5. Regression results for overall coverage, 2001q4

	Overall population coverage	Overall population coverage	Overall population coverage	Overall population coverage	Overall area coverage	Overall area coverage	Overall area coverage	Overall area coverage
Single network	**-12.20****	**-20.79*****	**-10.57****	**-9.772****	**-14.55*****	**-23.58*****	**-13.76****	**-9.982***
GDP per capita	0.000812***	0.00117***	0.000509**	0.000226	0.00109***	0.00146***	0.000925***	0.000512**
Population size	-3.00e-08*	-1.83e-08	-2.14e-08	-1.64e-08	-4.17e-08***	-2.90e-08**	-3.67e-08***	-2.31e-08**
Population density	-0.00105	-0.00102	-0.00125*	0.000808	0.000194	0.000221	8.58e-05	0.00736
Time Since 2G was launched	1.574***		1.418***	1.126***	1.636***		1.546***	1.018***
Urbanisation			0.449***	0.347***			0.242*	0.116
Lack of political risk				13.71***				7.791**
Constant	29.97***	61.28***	9.642	22.77***	3.445	36.1***	-7.326	11.06
Observations	137	137	137	122	136	136	136	121
R-squared	0.521	0.324	0.601	0.622	0.471	0.335	0.485	0.544

Source: Frontier analysis using GSMA data

Table 6. Regression results for 3G coverage, 2012q4

	3G population coverage	3G population coverage	3G population coverage	3G area coverage	3G area coverage	3G area coverage
Single network	**-36.09*** **	**-31.92*** **	**-34.86*** **	**-19.86*** **	**-18.77*** **	**-20.24*** **
GDP per capita	0.00102***	0.000908***	0.000319*	0.000930***	0.000901***	0.000437**
Population size	-1.35e-08	-1.28e-08	-1.04e-08	-1.89e08	-1.87e-08***	-1.40e-08***
Population density	0.00499*	0.00422	0.00231	0.00949**	0.00929**	0.00734**
Urbanisation		0.226	-0.0407		0.0584	-0.161
Lack of political risk			23.58***		12.67	19.20***
Constant	32.66***	20.61*	46.66***	15.79***	12.67	33.07***
Observations	121	121	115	124	124	116
R-squared	0.395	0.403	0.502	0.427	0.428	0.517

Source: Frontier analysis using GSMA data

Table 7. Regression results for take-up, 2001q4 and 2012q4

	Overall take-up	Overall take-up	Overall take-up	Overall take-up	3G take-up	3G take-up	3G take-up
Single network	**-6.928*** **	**-12.34*** **	**-5.928*** **	**-4.751*** **	**-16.91*** **	**-15.26*** **	**-16.35*** **
GDP per capita	0.00104***	0.00118***	0.000864***	0.000499***	0.00109***	0.000871***	0.000634***
Population size	-1.63e-08***	-1.19e-08**	-1.17e-08**	-6.43e-09*	-2.13e-09	1.79e-10	1.66e-09
Population density	-0.000991	-0.000847	-0.00133	0.00286***	0.00730***	0.00687***	0.000442
Time since 2G was launched	0.515***		0.442***	0.316***			
Urbanisation			0.245***	0.154***		0.363***	0.265***
Lack of political risk				9.139***			9.668***
Constant	4.014**	13.49***	-7.359**	0.786	11.99***	-5.298*	5.233
Observations	175	175	175	148	157	157	141
R-squared	0.683	0.616	0.752	0.859	0.716	0.752	0.703

Source: Frontier analysis using GSMA data

FRONTIER ECONOMICS EUROPE
BRUSSELS | COLOGNE | LONDON | MADRID

Frontier Economics Ltd 71 High Holborn London WC1V 6DA
Tel. +44 (0)20 7031 7000 Fax. +44 (0)20 7031 7001 www.frontier-economics.com