Assessing the case for Single Wholesale Networks in mobile communications

A REPORT PREPARED FOR THE GSMA

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Executive Summary

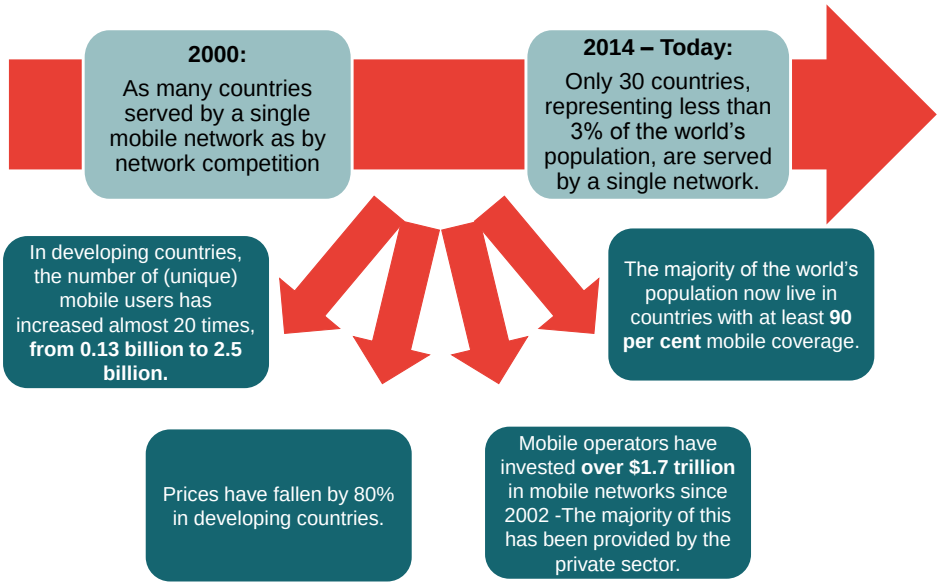
Policymakers in a number of countries are proposing to establish a single wholesale network (SWN) instead of relying upon competing mobile networks to deliver 4G mobile broadband services in their country.

These proposals often appear to be motivated by concerns that existing models of network competition have failed to deliver sufficient network coverage, particularly in rural areas. They may also arise from concerns about a lack of competition in the retail market or a wish for Government to take a direct ownership interest in the telecommunications industry.

The GSMA commissioned Frontier Economics to critically assess the economic case for SWNs in mobile communications, looking at the cost and benefits of SWNs compared with the prevailing network competition model and examining how well are SWNs suited to meet Government's socio-economic objectives. Our main findings are summarised in this report.

Our understanding is that no SWN has yet been implemented in mobile and the current proposals vary in detail. We do know, however, that SWNs would represent a radical departure from the competing networks approach which has been favoured by policymakers around the world for the past 30 years. We also know that the available evidence indicates that this approach has been successful, resulting in over 2.5 billion mobile users in developing countries, over $1.7 trillion of private investment since 2002, and providing mobile 3G broadband coverage to over half of the world's population, see **Figure 1** below.

Figure 1. Benefits of network competition



Source: Frontier Economics

This report considers how SWNs might be expected to perform in practice and whether they would meet the goals that policymakers are seeking to achieve. It also considers whether there might be other, more effective, ways to achieve the same goals.

It is important to note that this report considers the arguments in general terms, and without detailed references to the circumstances of a specific country or market. We think our recommendations have widespread applicability for policymakers around the world, but we accept that they may need to be adapted to the specific circumstances of individual countries.[1]

Achieving coverage and other objectives in mobile markets

Coverage objectives

We have found no reason in principle or theory why network competition should result in less coverage than might be achieved by an SWN. There are several important points to note:

- Coverage by both network competition and SWNs could be extended to uneconomic areas with the assistance of public subsidies. It is important,

[1] Recognising this, we have also developed two country specific case studies (Mexico and South Africa), which supplement the results presented in this report and are available on request.

therefore, to compare network competition and SWNs under the same conditions and not to compare a subsidised SWN with unsubsidised network competition.

- Network competition can avoid duplication of costs through network sharing arrangements, or by one operator moving first to cover the territory. This is why the costs of rural networks under SWN and under network competition can be expected to be broadly comparable.

- Network competition tends to drive cost reductions which allows for greater coverage to be achieved economically. This is because competition between firms provides them with a strong incentive to be more efficient in using existing technologies, and also to be innovative and to adopt rapidly new technologies. In a fast moving, technology driven industry like mobile communications, this has a significant impact on performance.

The empirical evidence from more than 200 countries over a 15 year period shows that network competition has driven mobile network coverage for 1, 2 and 3G networks further and faster than has been achieved by single networks. We would expect this to apply to 4G coverage too. After taking into account other factors such as differences in GDP/capita, we find that **3G population coverage is 36% higher** in countries with network competition compared to countries served by a single network. Overall coverage also increased **three times faster**.[2]

While we recognise the limits of our empirical analysis, in the absence of real world examples of SWNs in mobile, analysing the performance of countries with a single mobile network provides a useful indication of how the SWN is likely to perform in practice. It also illustrates challenges that any SWN is likely to encounter in trying to over-perform outcomes of competitive markets in delivering coverage outcomes.

Innovation and new services

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.

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2 Given the limited number of countries with a single mobile network today, our analysis compares the performance of single network countries and multiple network countries in 2001 (and 2005), to ensure a sufficient variation in our data set. In particular, we have identified countries that had below 50% 2G coverage in 2001 and calculated by how much 2G coverage had increased by 2005.

Competitive markets are generally better at promoting innovation than monopolies. We recognise that SWNs will still allow competition in the retail market. But innovation in mobile services invariably requires co-ordination between both the retail and the network activities of an operator. New data services require new handsets and new networks to be introduced at the same time and to work together. We would expect vertically integrated operators to be more efficient at co-ordinating these activities than an SWN, where the network is a separate entity. This is another reason why new services are likely to be introduced more quickly by integrated operators who compete with each other.

Again, the empirical evidence supports our view. Using the same data set as before, we find that having network competition increased **3G take-up by 17 percentage points** compared to having a single network.

Spectrum efficiency

Some supporters of SWNs argue that network competition fragments radio spectrum and causes it to be used inefficiently. This prevents the competing networks from maximising the potential of new technologies because each has insufficient spectrum to do so.

We think these concerns are overstated. Today's radio technologies have been designed to work within the spectrum allocations we find in competitive markets, since these represent the overwhelming majority of mobile markets in the world. Increasing spectrum aggregation beyond such levels should therefore be expected to provide an individual country with little benefit in terms of spectral efficiency.

In addition, the main efficiency gains arise from the adoption of new technologies, rather than the aggregation of spectrum using existing technologies. We have already seen that competitive markets tend to adopt new technologies more rapidly, which more than compensates for any potential loss from spectrum fragmentation.

Other considerations

The empirical evidence reveals that network competition has outperformed single networks across many markets for many years. But we also recognise that competition can be imperfect and markets can fail, whilst regulation can be used to improve the performance of single networks and mimic some of the results we might otherwise associate with network competition.

We recognise, for example, that SWNs may avoid some of the duplication of costs that may be associated with competing networks. Network sharing arrangements may also take some time to conclude and roll out may sometimes be delayed.

Policymakers need to balance these considerations against the other challenges of SWNs, particularly the challenges involved in establishing and then regulating the

SWN, but also the risks that it might fail. On balance, we consider that these challenges will make SWNs an unattractive option in the overwhelming majority of cases, even when network competition is not thought to be meeting Government policy objectives. In these cases, we think other interventions can be made to improve the performance of network competition and which will produce better results than any SWN.

Challenges of SWNs

The creation of SWNs can also be expected to pose a number of implementation challenges, including:

- Establishing SWNs will involve a number of stakeholders likely leading to time consuming and complex negotiations.
- Building SWNs will typically involve major investments over a period of years, with returns further away in the future. Providing the appropriate structure and returns to attract the required funding in SWNs will also likely raise complexities.
- The SWN is also likely to require government support which could lead to potential distortions of competition during a period of co-existence of the SWN with existing network operators.
- The SWN will finally require regulation to protect consumers from high prices – this will need to balance, amongst other, the objective of encouraging the use of the SWN and providing a return to investors in the SWN that reflect appropriately the associated risks.

We provide a summary of the challenges faced in implementing a SWN below.

Challenges of SWNs: establishing the network

SWNs for the provision of mobile broadband services are unproven. There are no working models available anywhere in the world. Even the countries that implemented an SWN to deliver fixed broadband services (e.g. Australia, New Zealand and Singapore) are relying on network competition to deploy next generation mobile networks. Nevertheless, the experience from the fixed segment suggests that the design, financing and implementation of any SWN are likely to be very challenging. The Australian Government required at least 5 years to partially implement a fixed network SWN. A mobile SWN will be even more complex because technology changes more frequently and typically there are likely to be more existing operators to negotiate with.

Establishing an SWN is therefore likely to involve long and difficult negotiations amongst a wide range of parties. It is important to remember that whilst this happens, no network is being built and investors in the existing operators may

stop further investments until the outcome is clear. In contrast, network competition normally involves the issuance of spectrum licences without any lengthy commercial negotiations between the parties. Once issued, the operators have a strong incentive to move as quickly as possible to build the networks and exploit the spectrum.

SWNs that do not enjoy the support of the existing mobile operators are potentially facing an additional risk of failure. Without such support, the SWN will risk duplicating existing networks, having higher costs, and finding itself potentially unable to generate sufficient demand for its services.

Any private investor in the SWN will want to understand how the SWN is to be regulated in advance, since this will determine the costs incurred by the SWN (to meet coverage and other targets) and the revenues the SWN can expect to earn (from wholesale access charges which are likely to be set or influenced by Government). It is, however, very difficult for policy makers to guarantee returns for a network that has yet to be built, and is even more challenging when forecasting costs many years ahead in the face of highly uncertain demand.

Both the regulator and the SWN will find it challenging to negotiate the commitments which the other side requires. For example, whilst the regulator could set a coverage target for the SWN, it is not clear what it could do if the SWN failed to meet it due to a shortfall in demand. There is nobody else to turn to instead. Private investors will be reluctant to invest in loss making areas and may prefer to exit altogether. These risks are likely to mean the SWN faces a relatively high cost of capital.

Challenges of SWNs: funding the network

SWNs can, in theory, be either privately or publically financed (or a combination of the two). Some proposals also foresee some private investment without the involvement of existing network operators. Different approaches have been suggested by different advocates of SWNs and a wide variety of ownership models are conceivable.

Private investors for an unproven project such as an SWN may be difficult to attract and manage without significant returns to reflect the risks they take. Partial public ownership may mitigate some of the risks by aligning the Government's interests with those of other investors, but could equally increase the risks if the Government exerts greater political control over the SWN as a result. A public-private ownership which involves the existing network operators appears the best approach.

Challenges of SWNs: co-existence between competing networks and SWN

In order to achieve the objectives of its proponents, the SWN will typically need to be a regulated monopoly over which 4G mobile services are then provided. However, some SWN proposals suggest that the SWN could co-exist with existing networks in the market, potentially for a long period of time. This means that, in the short term, the SWN might 'compete' with existing networks, whilst in the long term, it is expected to replace them, in part or completely.

In the short term, the SWN will represent an additional network in the market and this will increase, rather than reduce, the overall network costs in the country. The new SWN network will need to attract traffic to its network in order to achieve scale and reduce costs, but existing operators may be cautious about transferring traffic if the cost of maintaining traffic on their own networks is lower than the wholesale price offered by an SWN, or if they are uncertain how the SWN will perform. New MVNOs will also take time to build scale. So it is not clear that the SWN will be able to generate sufficient demand for its services to reach efficient scale quickly or at all.

Governments and regulators are likely to try to ensure that the SWN will succeed in attracting traffic to its network. This 'assistance' could take several forms, including

- assigning all the available LTE spectrum to the SWN so as to force the existing operators to use the SWN to meet LTE demand;
- subsidising the wholesale prices which the SWN charges its users, so as to make them sufficiently attractive; or
- restricting what the existing operators can do with their existing networks.

All of these measures would distort how competition works and so would involve costs for consumers.

Equally important, the future of the SWN during any period of co-existence will be uncertain. Existing operators may be reluctant to direct traffic to the SWN if they cannot be confident it will succeed. But they may equally be reluctant to invest in their own networks if there is the possibility that they will have to switch to the SWN later.

Challenges of SWN: regulating the SWN

Many of the issues identified in connection with SWNs arise from the fact that it is a monopoly. There is widespread evidence that monopolies have weak incentives to invest, to seek to expand output, to reduce costs or to improve the quality of the services they provide.

Those who support SWNs therefore recognise that extensive regulation will be required in an attempt to address these issues. Regulators can, for example, set wholesale 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), or to encourage retailers to expand their output (e.g. through 'two part' charges). They can also set coverage targets for the SWN in an attempt to accelerate or extend roll out, or require the SWN to upgrade its network at specified dates (e.g. by benchmarking against other countries). They can also define the speeds of the services, or other aspects of the quality of the services to be provided. 'Regulation' in this context could take the form of clear rules or targets included in the licence granted to the SWN or in subsequent directions from the regulator, or it could involve the Government influencing the conduct of the SWN through its ownership position.

Such measures could, if implemented well, go some way towards reducing the concerns of a SWN operating as a monopoly. However, the key question policymakers must consider is whether we could reasonably expect the SWN to be regulated effectively and, even if we could, whether it would outperform network competition.

As with any monopoly regulatory regime regulators will have limited information on which to set targets for the SWN, and the SWN itself may have little incentive to co-operate. Often, the 'right' regulatory answer will be unclear. For example, a regulator may find that trying to set wholesale access prices too low will threaten the capacity of the SWN to attract investors, whilst setting them too high may mean that the SWN is unable to attract traffic to the network. Enforcement may also be difficult, since the Government may have no alternative to the SWN in meeting its objectives and the investors in the SWN will realise this. To the extent that the Government has a significant influence in the ownership of the SWN, regulation of the SWN may also raise conflicting objectives: for example, the interests of the Government as owner of the SWN may be to opt for relatively higher wholesale prices to try and maximise the chances of the SWN's commercial success, which may differ from its interests as regulator, to primarily protect consumers from too high prices.

We therefore find that the performance of the SWN will be decisively affected by how well it is regulated, and that there are good reasons to believe that effective regulation will face a number of challenges. The performance of network competition is not determined by regulation to anything like the same extent, which implies that there is a materially lower risk of regulatory failure leading to undesirable consumer outcomes under network competition.

Challenges of SWNs: risk of failure

If a mobile competitor fails, then consumers are temporarily inconvenienced until they switch to a rival network. The costs of failure are much greater with an

SWN. As discussed above, the risk of failure of a SWN is expected to be higher. If the SWN succeeds in becoming the only mobile network in the market, there will however be no alternative if it fails. In such circumstances, it is likely that Government would need to take the SWN into full public ownership to avoid a catastrophic disruption of the mobile communications of the country.

Alternative ways to achieve the objectives of SWN proponents

As noted earlier, network competition may not always achieve the outcomes which policymakers are seeking. In these circumstances, and in light of the assessment of the risks for consumers associated with SWNs, the desirable first response should be to consider regulatory interventions which can preserve the benefits of network competition whilst achieving the other goals which are not being met. We consider the case of coverage in our report, although we recognise that for some other concerns, such as a lack of competition on the retail market, other forms of intervention may be required which are not considered here.

We show that additional coverage can be achieved, relying upon competing networks, in a variety of ways. Network sharing or 'first mover' coverage by a single operator are examples. In addition, Governments or regulators can intervene to impose coverage obligations at the time of licence award for new coverage spectrum, particularly in low frequency 700 MHz and 800 MHz bands, to ensure faster roll out and greater coverage. These can be applied to some operators, or to all. Alternatively, public subsidies of some form can be offered to operators who volunteer, normally through some form of competitive bidding process, to cover areas of the country which might otherwise be uneconomic.

1 Introduction

Policymakers in a number of countries (Mexico, Rwanda, Kenya, Russia and South Africa) have proposed or are proposing to establish single wholesale networks (SWN) to deliver mobile broadband services instead of relying upon the model of competing mobile networks which has been used throughout the world for the past 30 years.

Those who support SWNs argue that they can solve problems which arise when applying the traditional model of network competition to some markets. These concerns generally include:

- **Inadequate or slow coverage in rural areas** – that competing operators will not deliver enough or fast enough network coverage, particularly in rural areas;
- **Inefficient use of radio spectrum** – that dividing spectrum amongst competing operators leads to it being used inefficiently and that better results can be obtained if it is combined in the single network;
- **Concerns around private ownership** – that the private sector may lack incentives to maximise coverage or investment in the country in question.

In this report we assess each of these claims. We use economic principles and real world evidence to do so.

The report is structured as follows:

- Section 2 outlines the key concerns that SWN is supposed to address and presents the framework for our analysis.
- Section 3 explores the impact of mobile network competition on coverage.
- Section 4 discusses the importance of network competition in relation to innovation in mobile markets.
- Section 5 looks at the merits of network competition and SWNs in terms of spectrum efficiency and cost savings.
- Section 6 discusses the impact of the SWN under a co-existence scenario.
- Section 7 analyses the cost and risks of implementing SWNs.
- Section 8 considers the issues of SWN ownership.

- Section 9 presents alternative measures to promote rural coverage in mobile markets.

Introduction

2 Network competition and SWNs

In this section we first explain what we mean by 'network competition' between mobile operators and consider its performance in general terms. We then define SWNs and refer to those countries in which specific SWN proposals have already been made. We recognise that the current SWN proposals vary across countries and we describe these briefly. We show how our definition of the SWN can be used to evaluate the prospects for SWNs in general and in individual country case studies.

2.1 What is network competition?

We can define network competition as a situation in which two or more vertically integrated mobile operators compete for retail customers while relying on more than one network infrastructure to provide their services. Network competition can therefore be distinguished by the **presence of multiple mobile networks in some or all areas.**

Network competition arises in two ways. Either it involves the licensing from the outset of more than one mobile network operator to construct and operate a mobile network in a specific geographic area or it involves 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 must involve some degree of competing networks, but this does not mean that there would be multiple networks in all areas:

- In many markets, operators are required to share towers and masts in order to reduce the environmental impact of network rollout. The operators will build competing 'active' networks, but may share other 'passive' elements of the network. As well as minimising the environmental impact of towers and masts, this sharing of passive network elements allows a society to reduce the costs of duplication and use resources more efficiently.

- In some cases and in some areas, sharing can extend beyond 'passive' networks and will involve 'active' sharing (normally between two operators) of equipment. This type of sharing is generally confined to rural areas which neither operator could otherwise hope to cover as well, or at all, on their own.

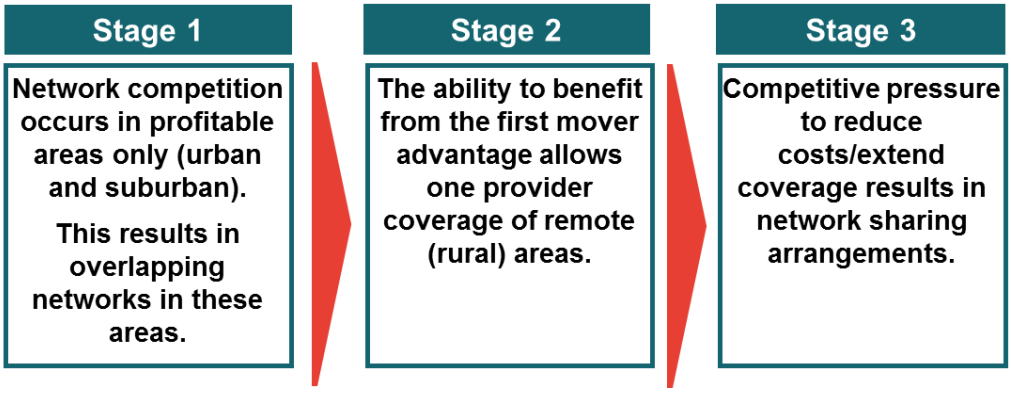
- In some cases, the rural areas will be covered by one network operator only. Having done so, it will be uneconomic for any other operator to follow as long as there is insufficient demand for services to support multiple

networks.[3] Although there may be some rural areas that are served by a single network operator, network operators will typically face network competition in most other served areas of the country. As mobile network operators tend to set national prices, these prices will reflect competition on a national basis. This model is therefore also consistent with our definition of network competition.

Network competition can also change over time. In early phases, network competition generally involves the construction of competing, separate networks in urban and suburban areas. One operator may also become the first to cover remote rural areas. In later stages, operators may then enter into voluntary sharing arrangements to rationalise costs and/or further extend coverage in some areas. The important point at this stage is that these changes in the industry structure happen in response to competitive and market forces over time, rather than as a result of Government intervention.

This is illustrated in **Figure 2** below.

Figure 2. Network competition can result in changes in industry structure of time



Source: Frontier Economics

Although not central to our definition, we think network competition will also be typically characterised by the following factors:

- Competing mobile networks will be mostly privately owned and independently operated. Sometimes, the original monopolist will be publically owned, but subsequent entrants into the market will generally be privately financed.

3 With increasing demand for mobile services and decreasing cost roll-out over time, it is possible that an area becomes economically viable for more than one network.

- Spectrum holdings will vary between operators but none of the operators would typically hold all of the spectrum in a given frequency band.

- Mobile operators will themselves determine the extent of network coverage and speed of rollout, including the speed at which they upgrade the network, subject to specific coverage and speed of roll out obligations that may be attached to operators' licences.

- Competing mobile operators will be active in both retail and wholesale markets (although they may also provide wholesale access to their network to MVNOs or other resellers).

2.2 The performance of the mobile sector under network competition

The vast majority of countries around the world have adopted models of network competition in their mobile markets[4]. This reflects the fact that policymakers have actively tried to promote network competition over the past 15 years.

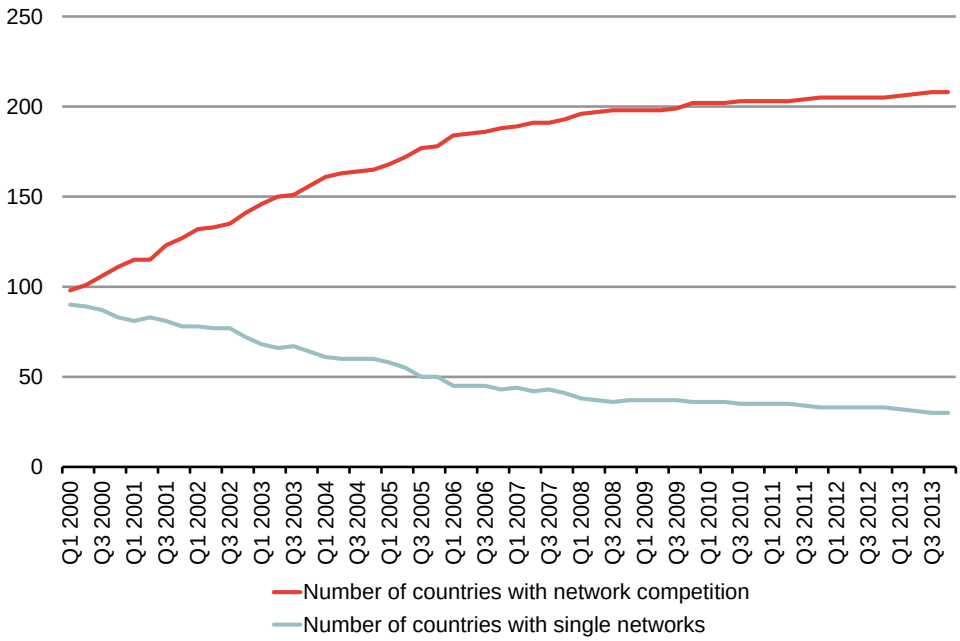
In 2000, there were an almost equal number of countries with network competition and single networks (see **Figure 3**)[5]. However, since then, there has been a significant move towards network competition. There are now only 30 countries with single networks representing less than 3% of the world's population[6].

4 Annex 1 provides more information on the evolution of mobile markets – note there is overlap with the data/analysis presented in the main body of the report.

5 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 millennia.

6 Andorra, Bahamas, Cocos (Keeling) Islands, Comoros, Cook Islands, Cuba, Diego Garcia, Djibouti, Eritrea, Ethiopia, Falkland Islands, Greenland, Kiribati, North Korea, Marshall Islands, Micronesia, Monaco, Montserrat, Myanmar, Nauru, New Caledonia, Niue, Norfolk Island, Saint Pierre and Miquelon, San Marino, Sao Tomé and Principe, Svalbard and Jan Mayen, Swaziland, Tuvalu and Åland Islands.

Figure 3. Number of countries with network competition and single networks



Source: GSMA intelligence database

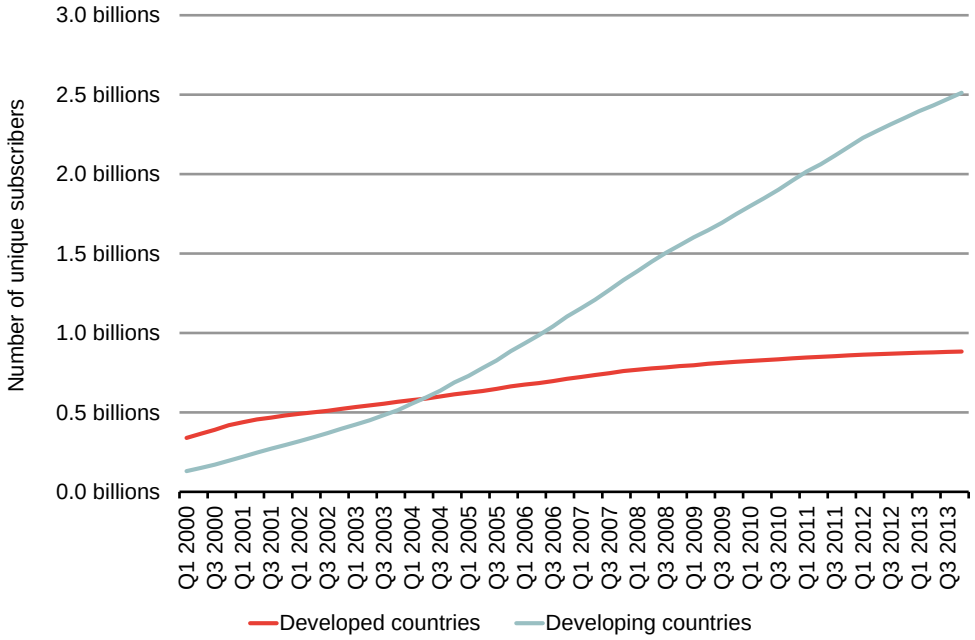
During the period in which countries have adopted network competition, mobile markets across the world have delivered significant benefits to consumers and the wider economy, particularly in developing countries[7]. We summarise this in the following section.

7 We have defined developing countries in the same way as the GSMA does in its intelligence database.

Network competition and SWNs

Since 2000, the number of unique mobile subscribers[8] has almost tripled in developed countries from 339 million to 884 million. In developing countries, the number of subscribers has increased from 131 million to more than 2.5 billion. There are 7 billion SIMs issued globally today.

Figure 4. Take-up over time

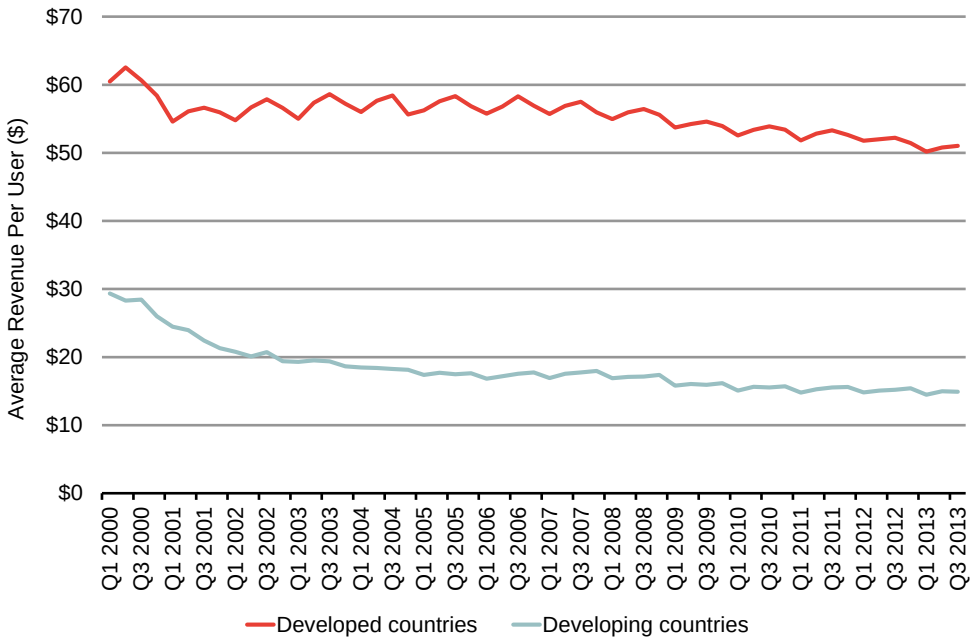


Source: GSMA intelligence database

8 Focussing on the number of unique subscribers avoids double counting subscribers who have multiple SIM cards, which is common in many countries.

Since 2000, Average Revenues per User - a measure of how much people pay for their mobile services - have fallen across the world. The fall is particularly stark in developing countries, where ARPUs[9] have fallen by around 50% (see **Figure 5**).

Figure 5. ARPUs over time



Source: GSMA intelligence database

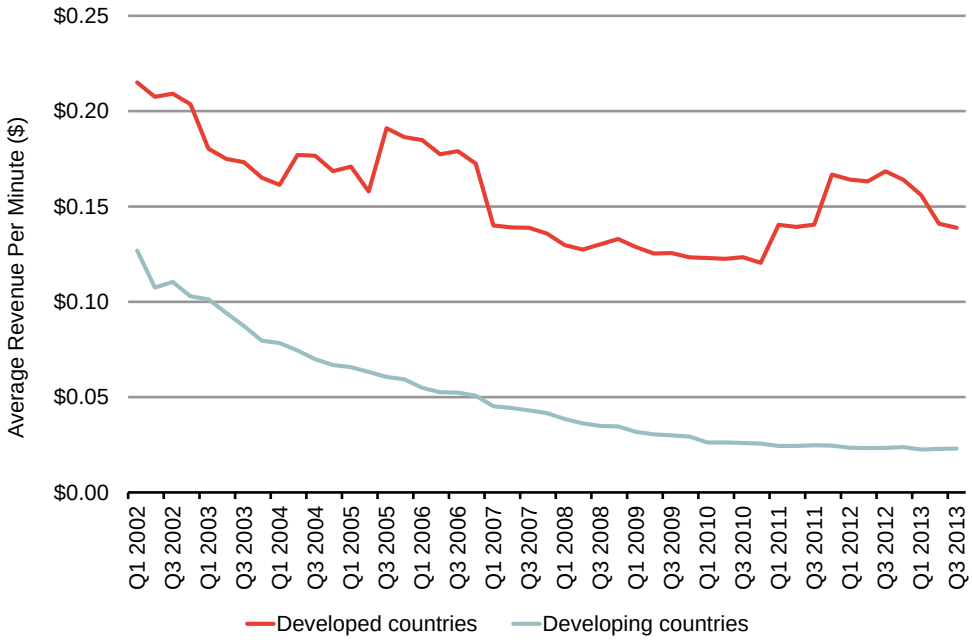
The fall in ARPUs occurs even though usage has also increased significantly since 2000. This means that mobile users overall are paying less and consuming a great deal more. Data usage, in particular, has increased exponentially. Voice usage has also increased, with the average number of minutes per connection in developing countries increasing from 137 to 299 (a 118% increase) since the early 2000s[10].

The Average Revenue per Minute (ARPM) – an approximate measure of prices paid for call services - has fallen in both developed and developing countries. The fall in developing countries is particularly large, where the ARPM has fallen from 13 cents per minute to 2 cents per minute, see **Figure 6**.

9 This shows the fall in ARPUs in nominal terms. The fall in real terms would be even larger.

10 GSMA intelligence database

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



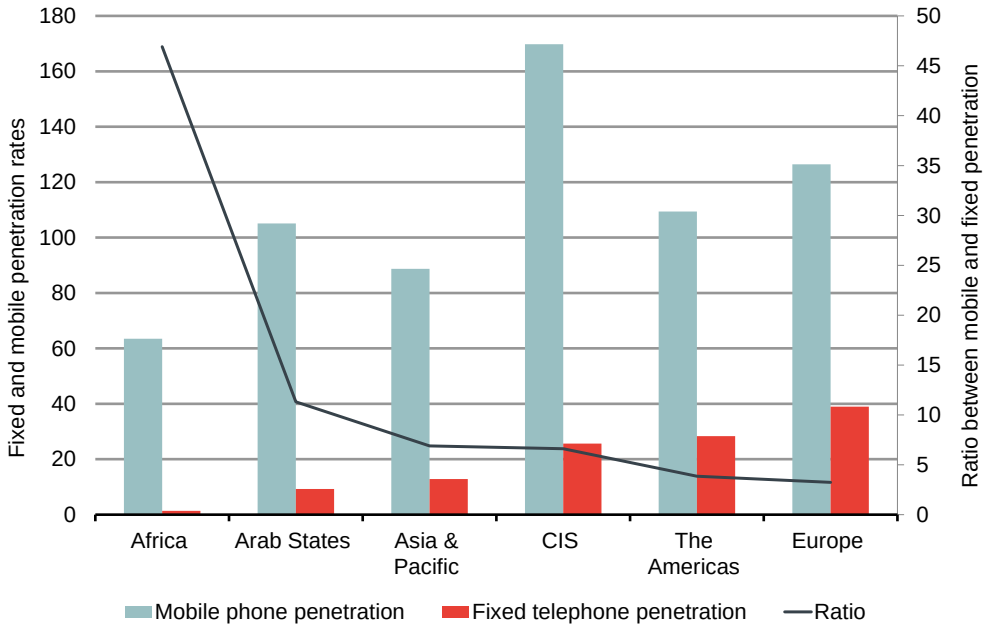
Source: GSMA intelligence database

The majority of the world's population live in countries with at least 90 per cent mobile coverage, as of 2012[11]. Many of these countries are estimated to have 100 per cent population coverage.

The mobile sector has played a particularly important role in many developing countries, where the fixed-line infrastructure is often underdeveloped. The wide availability of mobile services has allowed these countries to achieve communication penetration that is comparable to those in developed countries, without having to make significant investment to upgrade their fixed infrastructure, see **Figure 7**.

11 GSMA data

Figure 7. Take-up of mobile and fixed services



Source: ITU

Capital investment by mobile operators has amounted to an estimated $1.7 trillion since 2002. Most of this was undertaken by privately-owned mobile operators.

The overall performance of the mobile sector on a global basis since 2000 has been impressive on any measure. Much of this has been achieved by privately owned network operators competing with each other, since this has become the dominant model under which the industry is organised. We recognise that performance has differed between markets, and that aggregate results may disguise concerns about performance in particular markets. In addition, models which have delivered strong results in the past may also be inappropriate to the challenges of the future. But this should not detract from the widespread evidence over many years which shows that network competition can deliver very significant consumer benefits under a wide range of conditions.

2.3 What is an SWN?

2.3.1 Current SWN proposals

It is useful to start our discussion of SWN by referring to real world examples of SWN proposals. These include those in Mexico, Rwanda, Kenya, Russia and South Africa.[12]

The Government in **Mexico** intends to build a public wholesale network for broadband and mobile telecommunication services, with a plan to start building the network in 2014 so that it would be operational by 2018. The SWN will rely on 90 MHz of 700 MHz band, with the possibility of using other spectrum bands, for example the 2.5 GHz band, in the future. The regulatory reform bill states that it will consider both private and public investment. In either case, existing operators will not be involved in the operation of the network[13]. The SWN will have access to the infrastructure of other Government-owned utilities and we also understand that the SWN will have access to any mobile assets/infrastructure that is required for the purpose of installing the SWN. The SWN will only provide wholesale services. If an existing operator were to buy wholesale services from the SWN, that operator will only be allowed to resell these services to third parties under the same conditions it enjoyed from the SWN.

In **Rwanda**, the Government, in a joint venture with South Korean operator KT, is planning to build a wholesale LTE network which will be allocated 800 and 1800 MHz spectrum and will then offer access to retail providers of LTE based services. KT will control the management of the firm with an exclusive licence for 25 years and the Rwandan Government is set to provide financial and administrative support.

Other SWN proposals include **Kenya, Russia** and **South Africa**. Kenya's national broadband policy includes a proposal for a Government led wholesale open access wireless broadband network via a PPP approach and it is suggested that this would use 700 and 800 MHz spectrum bands. In Russia, the Government has decided to withdraw 800 MHz spectrum previously allocated to mobile operators and transfer it a new stated-owned national LTE network, which will operate in the 700 and 800 MHz bands. In South Africa, the Government is considering building a fixed and wireless wholesale open access network to address the issue of broadband availability in the country. In 2011, the communications regulator ICASA proposed to create a new wholesale-only mobile entity that would operate in 800 MHz and 2.6GHz bands, with a mandate

12 Annex 2 provides more detail of the proposals.

13 We note that transitory article 16.IV of the constitutional reform leaves some room for interpretation.

to roll out to underserved areas. ICASA has since withdrawn these plans and we understand that Government is now re-considering its options for potential intervention in the mobile market in South Africa.

While there are differences between existing SWN proposals, the above examples suggest that SWNs may have the following features:

- They tend to be Government initiated networks, providing wholesale services only.

- Although SWNs can be privately owned, they are much more likely to involve a degree of Government ownership (in whole or in part) than competing networks. The nature of the SWN ownership is important in determining how it might perform, and we consider this further in Section 8 below.

- SWNs will often be allocated the entire spectrum in a particular frequency – for example 700 MHz or 800 MHz for 4G services – rather than sharing it with other networks. This is for two reasons: Governments may believe that aggregating all spectrum in a single network allows it to be used more efficiently than dividing it amongst competing networks (we consider this claim in Section 5.2) and/or they may believe that it is necessary to give the SWN exclusive rights to certain spectrum in order to force or encourage existing competing operators to use the SWN for their own retail activities.

2.3.2 Defining SWN to compare with alternative model of network competition

Whilst there is no commonly accepted definition of an SWN, it is necessary to develop such a definition for the purposes of evaluating the merits of an SWN model relative to the network competition model. We broadly define an SWN as a Government initiated network monopoly, with mobile operators and others competing for the retail customers by relying on wholesale services provided by the SWN.

Under our definition, SWNs are distinguished by the following characteristics:

- **Government initiated network monopoly**: the SWN will be a Government initiated single national network from the outset, with no prospect of entry by another network or overbuild at a later date, either as a result of legal restrictions on competition or other reasons (such as the reservation of all the available spectrum to the SWN). We consider below the main 'alternative' to this definition, which would involve the co-existence of an SWN with competing mobile networks and explain why such a model would likely be expected to result in a network monopoly SWN or in the failure of the SWN and a return to competing mobile networks.

Network competition and SWNs

- **Active only in wholesale markets:** The SWN is not involved in retail activities directly. Instead, the SWN wholesales access to third parties, which are likely to include the existing operators and may include others, under regulated conditions. The SWN is expected to meet all of the retail demand for the services it offers, although retail demand for other services may still be met by other networks if they remain separate.

- **Performance targets set by the Government:** The SWN is a monopoly and it is therefore not possible to rely on competition to provide the appropriate incentives for cost reductions, coverage increases, etc. Network coverage and other targets are likely to be set by the Government and monitored/enforced through regulation.

Table 1 below summarises key differences between network competition and the SWN.

Table 1. Differences between network competition and SWNs

	Network competition	SWNs
Number of networks	> 1	1
Infrastructure overlap	Yes	No
Ownership & management	Typically privately owned and managed by mobile operators	Typically not owned or managed by mobile operators
Spectrum holdings	Fragmented	Concentrated
Network coverage targets	Commercial drivers and spectrum license conditions	Set by the Government
Activities	Retail and wholesale	Wholesale only

Source: Frontier Economics

The plans for the SWN that we have reviewed do not anticipate that the existing network competitors will be forced to contribute their existing networks to the SWN, close them or otherwise exit the market or transfer their traffic onto the SWN from the outset. We have identified three potential scenarios for the evolution of these 'hybrid' scenarios:

- **The SWN dominates:** We think that one outcome of the 'hybrid' market is that it will become an SWN market, even if competing networks remain today. In this scenario, the SWN will have all the attractive 4G spectrum and the existing networks will have none. Although the existing operators may be able to use their existing 3G networks to compete with the SWN for some time, in the long term, the advantages of the SWN network will be sufficient to force the existing operators to co-operate rather than compete with it. To the extent that the existing operators continue to build new networks or to enhance their existing networks after the SWN has been established, these are likely to complement rather than substitute for the services offered by the SWN itself. In the long run, therefore, it is likely that the existing operators will decommission their own networks and migrate their remaining traffic to the SWN, or simply contribute their existing networks to the SWN in some way. Whatever the exact scenario, the 'hybrid' situation of today will evolve over time into a full SWN, with no network competition.

- **The SWN as another network competitor:** An alternative scenario would arise if existing competing networks and the SWN continue to co-exist far into the future. As already noted, this would require existing operators to have access to appropriate spectrum or other assets, to be able to compete with the services offered by the SWN. If this was possible (and it is not clear that it would be), the result of the SWN would be to add an additional network competitor into the market assuming it would be able to retail its services through MVNOs or others. We would therefore consider this outcome as simply another form of 'network competition', albeit one in which the competitive process would likely be distorted at the expense of consumers, as explained in Section 6 below.

- **The SWN fails:** If the existing network operators are able to meet their future retail demand using their existing networks and without relying upon the SWN, the SWN will find that its network is empty if it cannot find others to retail its services. Alternatively, the regulator may set access prices at a level which allow the existing network operators to use the SWN to support their traffic in 'uneconomic' areas but to retain profitable traffic on their own networks. In this case, the SWN will either be unsustainable or the regulator will have to increase access prices, at which point the traffic would migrate back to the existing networks again. Whatever the scenario, in the long run, the SWN as a national network would be likely to fail. The spectrum and other assets will then need to be reallocated, and the market would eventually revert back to network competition amongst the existing operators.

In short, only if the SWN comes to dominate the market are we likely to move away from the 'network competition' model we have defined above. Under other scenarios, the SWN either becomes an additional entrant in an already competitive market or the SWN fails altogether. Either way, network competition is maintained, but distorted by the SWN presence. This is summarised in **Table 2** below.

Table 2. Potential long-term outcomes of the SWN

Scenario	Description	Likely long-term outcome on competition
SWN dominates	The existing operators will gradually decommission their own networks and migrate their remaining traffic to the SWN	No network competition
SWN co-exists	The existing operators will be able to compete with the SWN, which becomes another network competitor	Network competition remains, but distorted
SWN fails	The existing operators will be able to drive the SWN out of the market.	Network competition remains, but distorted

Source: Frontier Economics

In the next sections, we assess the merits of an SWN relative to network competition.

We start by looking at the effects of the SWN under the scenario in which the SWN dominates and effectively replaces network competition in the long-run.

In Sections 3 and 4, we show that the introduction of an SWN will have fewer incentives to increase coverage or innovate, and this is consistent with the empirical evidence showing that network competition has achieved greater and speedier coverage.

In Section 5, we show that the claimed SWN benefits in terms of significantly lower network costs are unlikely to materialise.

In Section 6, we discuss the likely effects of the SWN under a co-existence scenario in which the SWN competes with existing mobile networks. We show that co-existence between an SWN and existing mobile networks is likely to distort competition and lead to worse outcomes for consumers.

Section 7 examines challenges which are unique to an SWN, namely, that of setting up the SWN, regulating it and the costs that would occur if the SWN fails.

In Section 8, we discuss the additional challenges of the SWN related to the type of ownership.

Finally, in Section 9, we present alternative and more efficient measures to promote rural coverage under network competition model.

3 Achieving coverage objectives

An important claim for SWN advocates is that it will deliver faster and more extensive coverage, particularly in rural areas, as compared to network competition. In this section, we consider this further.

We find that there is no reason in theory to expect an SWN to produce significant coverage improvements compared to effective network competition. An SWN is a monopolist (at the network level) which will tend to have incentives to restrict output and maintain higher prices than competing networks. Regulation of the SWN may go some way towards countering this tendency, but we would expect the results to be inferior to those delivered by network competition.

The empirical evidence supports our view. It shows that mobile coverage, both in population and area terms, is significantly higher in countries with network competition, compared to those with monopoly or single mobile networks.

Our statistical analysis (econometric results) shows that, compared to network competition:

- Having a single network **reduced total population coverage by 12 percentage points** and reduced area coverage by 15 percentage points.
- Having a single network **reduced 3G population coverage by 36 percentage points** and reduced 3G area coverage by 20 percentage points.

Finally, coverage in countries with network competition **increased three times faster than in single network countries.**

3.1 Incentives on firms to expand coverage

Network operators can generally be expected to compete to provide faster or more extensive coverage. This means they have strong incentives to cover an area where it is profitable to do so. However, advocates of SWNs argue that coverage would be higher under an SWN scenario than under network competition because the expected costs of coverage would be lower.

We consider the evidence that SWNs can obtain lower network costs in Section 5. Our results show that any static benefits from avoiding fixed cost duplication which the SWN achieves are likely to be exceeded by the dynamic efficiency losses that SWNs may incur compared to network competition. Overall, the analysis suggests that unit costs of coverage for SWNs will tend to be *higher* and not lower than network competition.

Even if this were not the case, it does not mean that an SWN would provide coverage where network competition would not. This is because an area that can

profitably be covered by an SWN is also likely to be viable for one of the competing networks, either as a result of one operator obtaining a 'first mover advantage' and/or as a result of network sharing agreements:

- **'First mover' advantage:** when it is not profitable for multiple operators to roll out in a particular area, it may nonetheless be possible for one network to gain a 'first mover' advantage and capture the entire retail demand in the area. Once they have done so, they can be confident that it would be unprofitable for any other operator to follow, at least in the short-term. This is consistent with the evidence from countries with network competition, where there is often a significant coverage gap between the first and second largest operator (indicating that there is a first mover advantage and some areas are only covered by one network)[14], but this gap can decrease over time as more areas become economically viable for multiple mobile networks.

- **Network sharing agreements:** a first mover may be unsure whether rolling out a network in a particular area will be profitable. If there is subsequent rollout by a rival operator, it may turn out to be unprofitable for both. This can be avoided if the operators instead engage in a network sharing agreement, see Section 9.1 for more details. Regulators will generally support such arrangements, recognising that they allow operators to extend coverage beyond that which may be possible with duplicate infrastructure. [15]

Thus, even if an SWN could deliver some cost efficiencies over network competition in the short-term, there is little reason to believe that SWNs will result in more coverage than network competition on a like for like basis. 'First mover' coverage or network sharing arrangements between competing networks operators should capture the same cost efficiencies and so deliver similar levels of coverage as the SWN.

At the same time, an SWN is likely to result in lower coverage in the long-run. This is because network coverage is largely driven by the cost of rollout. As explained below, by foregoing benefits of network completion, the SWN as a

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14 For example, in Brazil, Vivo's 3G population coverage was more than 10 percentage points above its rivals in 2012Q4 (Vivo – 86%, Oi – 73%, TIM – 72%, Claro – 70%). In Rwanda, MTN's 3G population coverage is significantly ahead of its rivals. In 2014Q1, MTN's 3G population coverage was 71% compared to 47% for Tigo and 12% for Airtel. In 2013Q4, the market leader in Morocco, Maroc Telecom had a significantly higher 3G population coverage than Meditel (73% compared to 52%). Source: GSMA intelligence database.

15 For instance in Bangladesh, operators are obliged to share their passive infrastructure while being able to commercially negotiate the price of infrastructure access. In India, the telecoms regulator TRAI is encouraging the sharing of mobile infrastructure to promote rural coverage, which led to a creation of Indus Tower, a joint venture between three mobile operators and the largest owner of mobile towers in the world. Another example is Malaysia, which has been at the forefront of network sharing in South-East Asia.

regulated monopoly would not be able to achieve the same level of cost efficiency. This would lead to lower coverage compared to network competition.

Of course, if the SWN is not required to make a profit or is otherwise subsidised by the Government to extend coverage beyond the point where it is profitable to do so, then the SWN may be able to provide coverage where privately owned operators cannot. But this is not an argument in favour of SWNs over network competition, but an argument that public subsidy can extend coverage into areas where it would not otherwise be profitable to do so. As we explain in Section 9, there are other mechanisms which would also allow public subsidy to co-exist with network competition, and there is therefore no necessary relationship between public subsidy and SWNs.

3.2 Empirical evidence on coverage performance

All of the countries considering an SWN have overall population coverage that is above 90 per cent[16]. In this section, we have compared coverage[17] in countries with single networks with countries with network competition (whilst recognising, as noted earlier, that the SWN cannot be directly equated with vertically integrated network monopoly[18]). We have based our main analysis on data from 2001[19], as there were considerably more countries with single networks at that date than we see today (see **Figure 3**). This also provides us with more variation in the coverage estimates, since many countries have almost 100 per cent coverage in 2014. Over half of the single network operators in 2001 were either wholly or partially owned by the Government. Therefore, our analysis provides a good insight into the potential impact of state ownership. The following figure shows how the single network countries were distributed across regions in 2001.

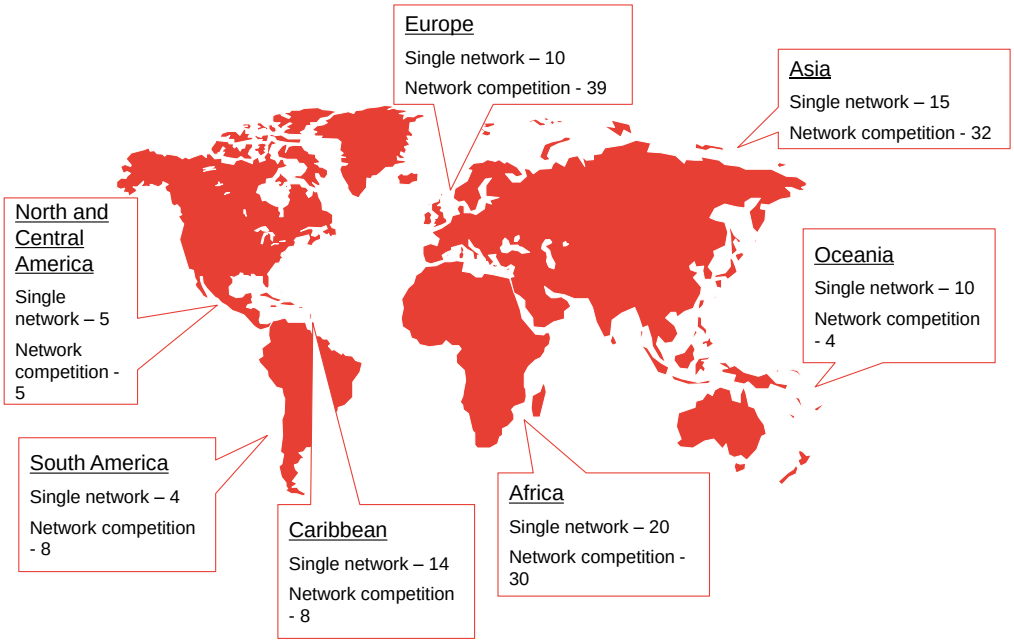
16 GSMA data.

17 The coverage estimates come from the GSMA.

18 There have been several countries that have relied on only one vertically-integrated mobile operator, either Government owned (and thus likely to take into account the interest of consumers/voters more than a profit maximising privately owned monopoly) or often subject to some form of price regulation to prevent excessive pricing. Therefore, comparing the outcomes under network competition relative to single network can be used as a 'second-best' approximation to assess the expected long-term effects of moving away from network competition to an SWN model.

19 The data quality gets considerably worse if going back before 2001, which is why we have chosen 2001. As a sensitivity check, we have repeated our analysis for a later period 2005, as shown in Annex 4.

Figure 8. Number of single network countries in each region

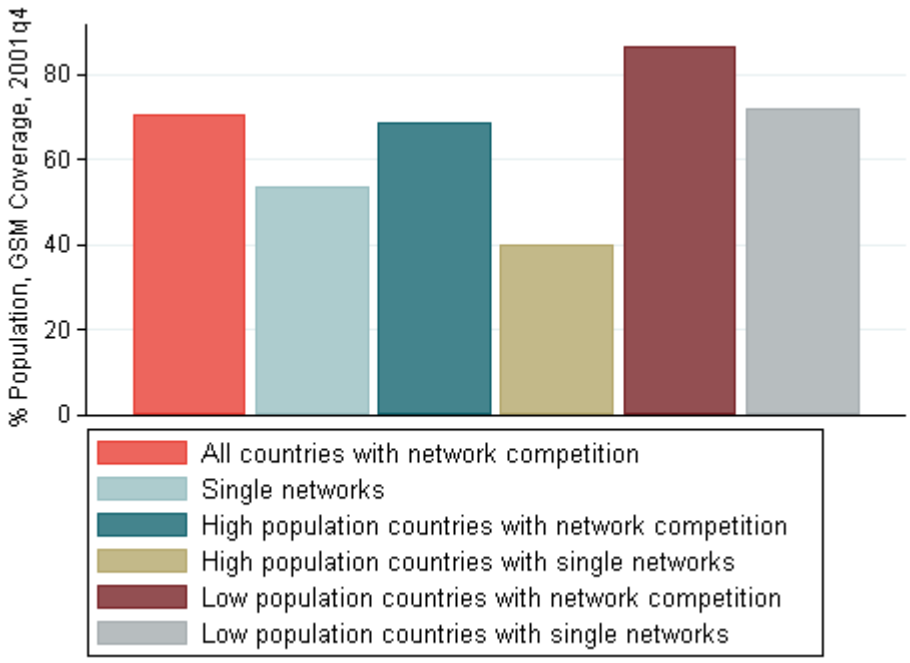


Source: GSMA intelligence database

Figure 9 shows that overall population coverage was considerably higher in countries with network competition (70.4% compared to 53.4% when including all countries regardless of their size)[20]. As a sensitivity check, we have repeated our analysis by splitting our sample into different groups. First, we split countries into two groups based on their population size. We then split countries into two groups based on their GDP per capita. When performing these sensitivity checks, we arrive at the same conclusion: population coverage is higher in countries with network competition than those without.

20 This difference is statistically significant with a p-value of 0.0029.

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

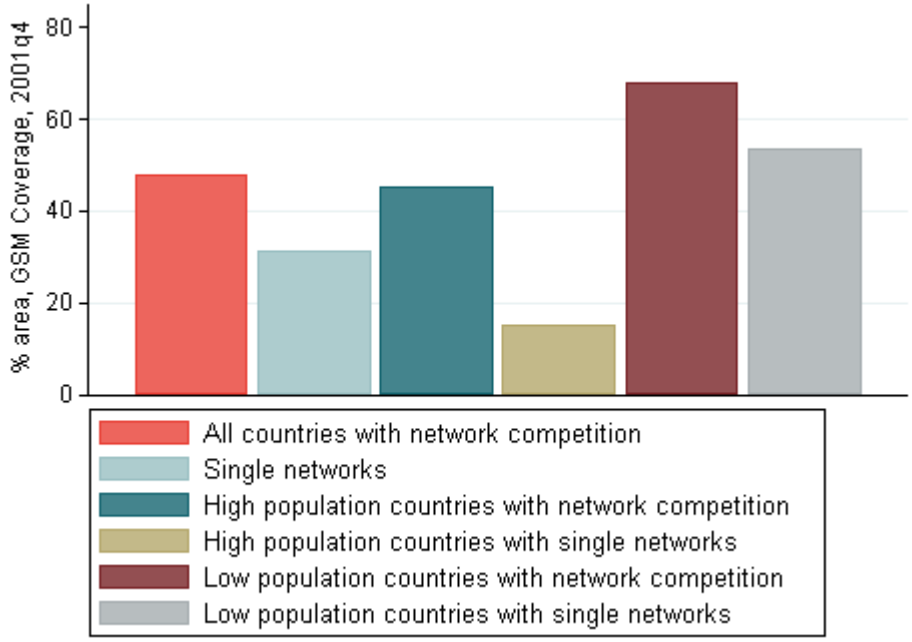


Source: Frontier analysis based on GSMA data

We have carried out the same analysis for coverage by area (see **Figure 10**). Again we find that **coverage is much higher in countries with network competition (47.9% compared to 31.4% when including all countries regardless of their size**).[21] We arrive at the same conclusion when splitting our sample into countries with a population above and below one million.

[21] The difference for all countries is statistically significant with a p-value of 0.0229.

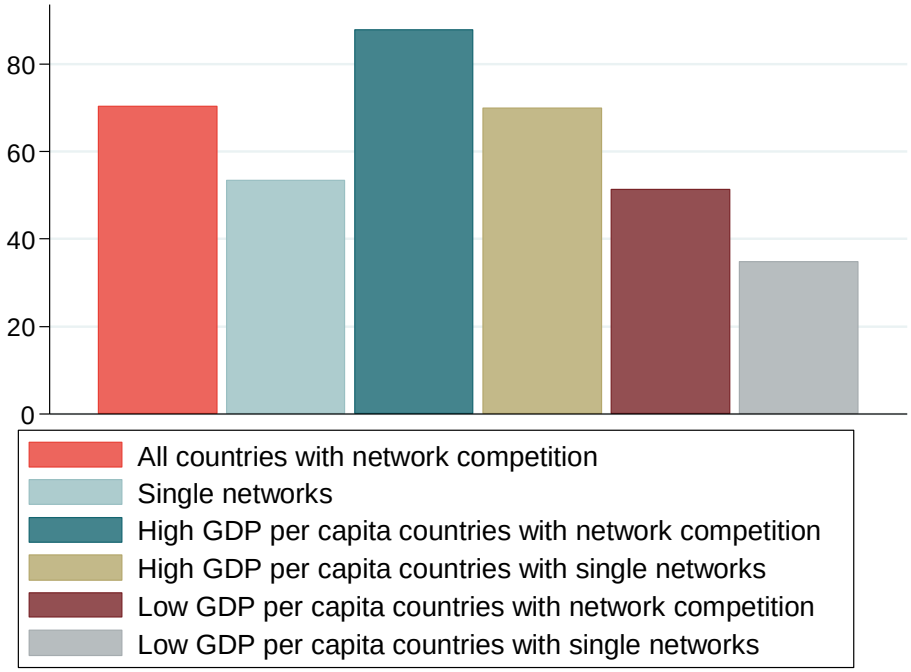
Figure 10. Total area coverage in countries with single networks and network competition (population split)



Source: Frontier analysis based on GSMA data

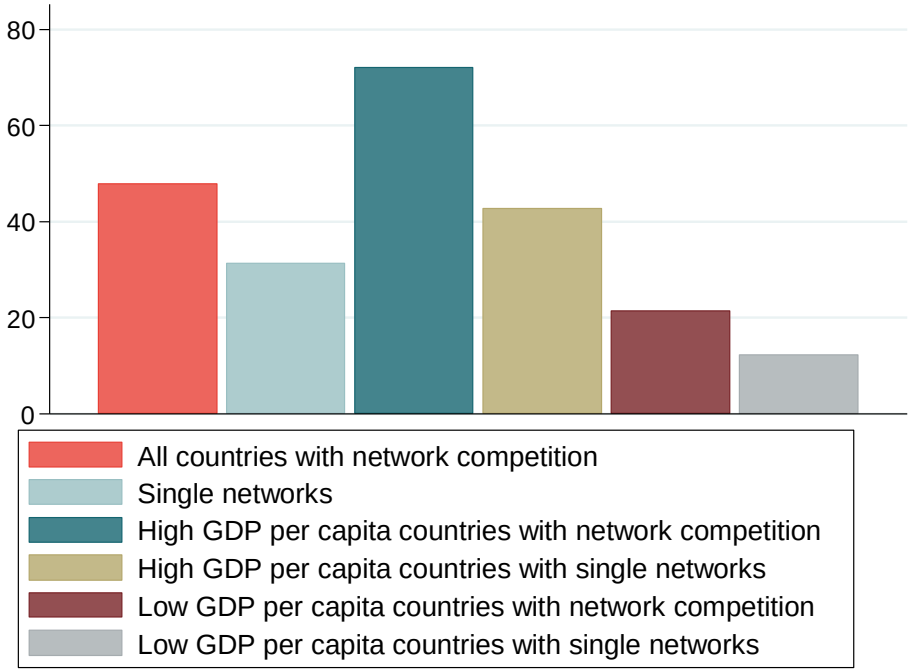
As a further sensitivity test, we have also considered how coverage varies between countries with network competition and single networks when splitting the sample based on GDP per capita. Consistent with our other results, **Figure 11** and **Figure 12** show that coverage is higher in countries with network competition in both low and high income countries.

Figure 11. Total population coverage in countries with single networks and network competition (GDP per capita split)



Source: Frontier analysis based on GSMA data

Figure 12. Total area coverage in countries with single networks and network competition (GDP per capita split)

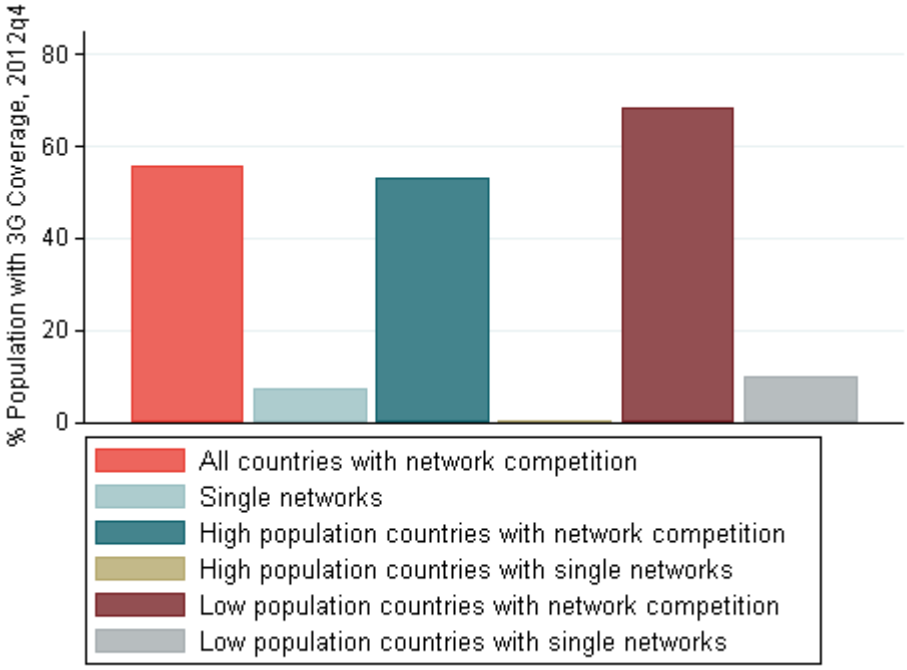


Source: Frontier analysis based on GSMA data

The benefit of network competition is even more obvious when analysing 3G coverage in 2012 (see **Figure 13**). Countries with network competition have made considerable progress with rolling out 3G networks. In contrast, countries with single networks have very little 3G coverage. We have only included countries where 3G is available, so the low coverage in single network countries cannot be explained by 3G not having been launched in these countries yet.

Achieving coverage objectives

Figure 13. 3G coverage in countries with single networks and network competition[22] (population split)



Source: Frontier analysis based on GSMA data

To test whether our results for coverage are robust, we have performed a statistical analysis using econometric techniques. This allows us to control for differences between countries with network competition and single networks, which are unrelated to the number of network players. We have considered GDP per capita, population density, population size and time since 2G was introduced as our explanatory variables.[23] Further sensitivity analysis is presented in Annex 4[24].

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22 The sample size is quite small for single network countries, as many single network countries are yet to introduce 3G. This is why we have not shown a graph with a split of countries based on GDP per capita for 3G coverage.

23 We have estimated the regression results using Ordinary Least Squares (OLS) with robust standard errors. The GDP per capita, population and time since 2G was introduced data comes from the GSMA. The population density data comes from the United Nations. The impact of single networks is picked up by a dummy variable.

24 In particular, we have considered the impact of a) including a measure of political risk, b) including urbanisation, c) excluding time since 2G launch and d) using a different time period. We did not include political risk in our main specification, despite being significant, because there will always be a degree of subjectivity in deciding how to construct an appropriate measure of political risk.

The table below shows that single networks have lower population and area coverage once these other factors have been controlled for. In particular, the results show that having a single network **reduced total population coverage by 12 percentage points** and **reduced area coverage by 15 percentage points**.

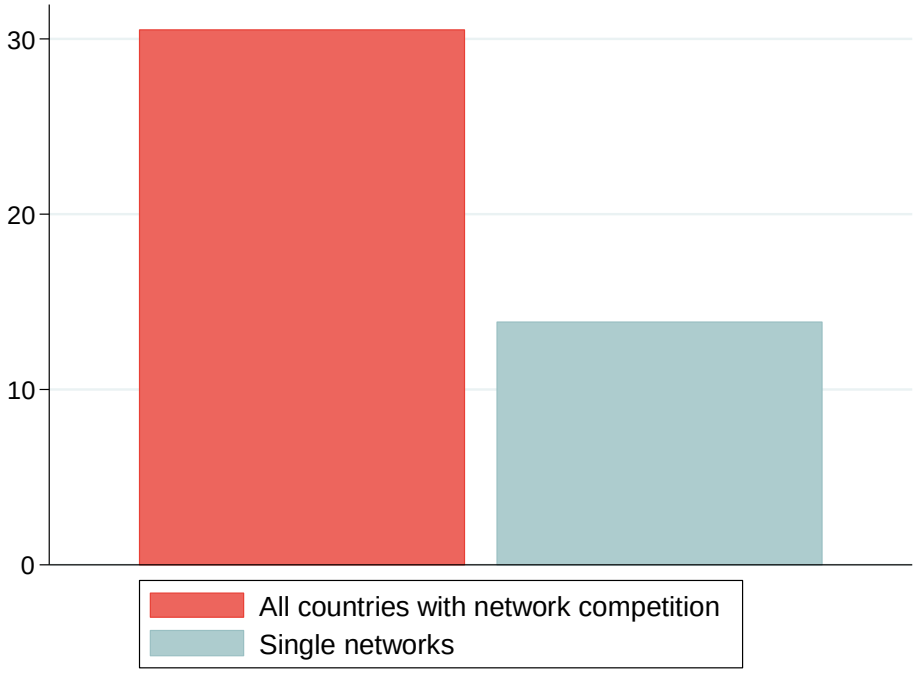
We have also found that single networks have a negative impact on 3G coverage. The results suggest that having a single network **reduced 3G population coverage by 36 percentage points and reduced 3G area coverage by 20 percentage points**. These results are particularly relevant, given the claim that SWNs will be better able to meet demand for data services than competing networks. These econometric results help confirm the results shown in **Figure 9**, **Figure 10** and **Figure 13**.

	Overall population coverage	Overall area coverage	3G population coverage	3G area coverage
Single network	-12.20**	-14.55***	-36.09***	-19.86***
GDP per capita	0.000812***	0.00109***	0.00102***	0.000930***
Population size	-3.00e-08*	-4.17e-08***	-1.35e-08	-1.89e08
Population density	-0.00105	0.000194	0.00499*	0.00949**
Time Since 2G was launched	1.574***	1.636***		
Constant	29.97***	3.445	32.66***	15.79***
Observations	137	136	121	124
R-squared	0.521	0.471	0.395	0.427

As well as comparing coverage across countries in 2001, we have analysed the *speed* at which coverage has increased over time. To do this, we have identified countries that had below 50% coverage in 2001 and calculated by how much coverage had increased by 2005. As shown in **Figure 14**, population coverage increased at a faster rate in those countries with network competition. The difference is statistically significant and shows that coverage in countries with network competition **increased three times more quickly than countries without**.[25]

25 The difference on the whole sample is statistically significant with a p-value of 0.0942.

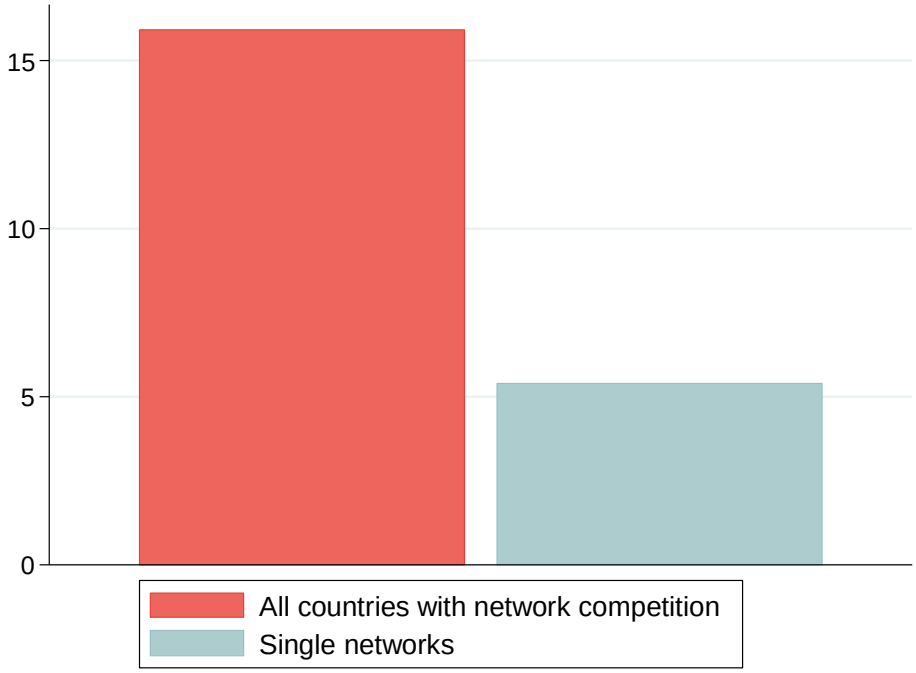
Figure 14. Rate of increase in population coverage over time



Source: Frontier analysis based on GSMA data

We have repeated the above analysis for area coverage (**Figure 15**), and find that there is once again a large difference between countries with single networks and countries with network competition.

Figure 15. Rate of increase in area coverage over time



Source: Frontier analysis based on GSMA data

3.3 Conclusion

We can find no reason to expect an SWN to produce significant coverage improvements compared to network competition. The empirical evidence we have carried out confirms this, showing that network competition outperforms single networks in terms of both the extent of coverage and the speed of rollout.

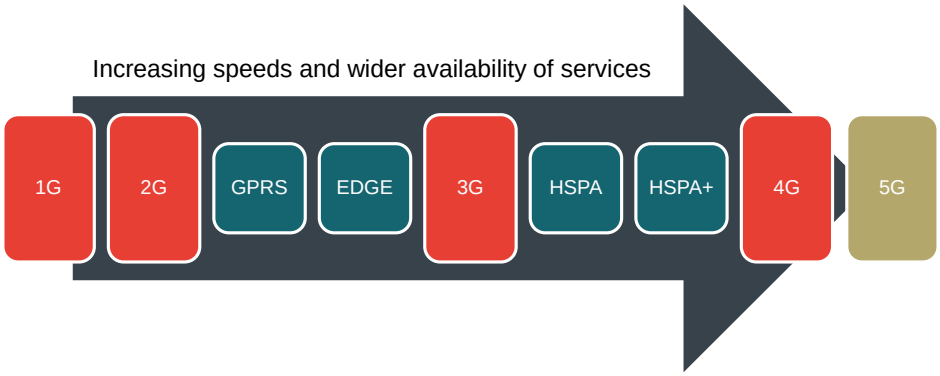
4 Achieving innovation objectives

Advocates of SWNs do not often consider innovation, which refers to the introduction of new services for consumers and the introduction of new ways to deliver existing services more efficiently. However, in this section we explain that it is a central feature of the mobile industry. Innovation determines the speed of adoption of new technologies and technology upgrades in mobile networks. This in turn has a major effect on the unit costs of services for consumers and for the ability of operators to extend network coverage.

If mobile technologies were stable then innovation would be less important. In network industries with low levels of innovation (such as the water industry), additional networks may bring limited benefits and some costs. However, in industries where innovation plays a central role, competition can drive discovery and disruption in a way that is very difficult for regulated monopolies to replicate. If that monopoly is publically owned, it may be even more difficult. We show that mobile communications is an industry where the greatest achievements have been made as a result of such innovation.

The services now offered by the mobile sector on a global basis are unrecognisable to those of 30 years ago. The industry started off providing 1G services, which offered low quality voice services with poor security. During the early 1990s, 2G services were launched, which offered improved voice services alongside messaging capabilities. GPRS and EDGE represented upgrades to 2G services, which allowed low speed data usage. At the start of the new century, operators launched 3G services, which provided improved data speeds allowing a much wider range of services to be offered over mobile networks. HSDPA and HSPA+ were two upgrades to 3G that improved data speeds. The improved data speeds facilitated the exponential growth of applications that could be used on mobile phones. In the past few years, operators have been rolling out 4G services, which have again improved data speeds and increased the range of applications that can be offered.

Figure 16. Innovations in the mobile sector



Source: GSMA intelligence database

The use of mobile services is not restricted to mobile phones. Tablets and dongles are rapidly growing, increasing the need to boost network capacity. There are more innovations to come. Countries are still in the process of fully rolling-out 4G and there are also upgrades to 4G, such as LTE-Advanced, on the horizon. This is needed as data usage is forecast to grow rapidly. For example, Cisco has predicted that data usage will grow by 61% per year (CAGR) between 2013 and 2018.[26] Further down the line, operators will look to launch 5G services. In short, dynamic efficiencies will continue to be vital for the mobile industry over the coming decades.

In the rest of this section, we first explain why an SWN is likely to support less innovation than network competition. We consider two types of innovation which are not easily replicated by an SWN: those innovations arising because network operators compete with each other and those innovations that arise because the network and retail operations are vertically integrated under network competition but separated under an SWN.

We support our views with empirical evidence showing that network competition has driven innovation in mobile markets.

26 Cisco (see http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html)

We show that:

- Countries with network competition were much faster in introducing new technologies than countries with single networks, **with major network upgrades coming 1 to 2 years later in single network countries.**[27]
- We also find that **take up of mobile services, including 3G, was considerably lower in countries with single networks.**

Our econometric analysis shows that these results hold even when we control for country specific factors, such as income level and size of the country.

It is important to note that the costs of lower innovation rates can be very significant. This is because dynamic efficiency is particularly important in markets like mobile telephony, which have a strong focus on technological improvements and where customers are demanding that improved services are delivered rapidly. When the introduction of new products and services is delayed, consumer benefits (surpluses) associated with the sale of those goods are lost. These losses can be expected to be larger than those associated with 'static' inefficiencies, such as those considered in **Section 5**. For example, one study found that the cost related to delays in the introduction of new telecoms services, such as voice messaging in the USA in the period from the 1970s to 1990s, were close to $100 billion.[28]

4.1 Impact of network competition and vertical integration on innovation

We consider that a mobile market with network competition is more likely to introduce new technologies quickly for two reasons:

- competition encourages operators to bring new technologies to market as soon as possible; and
- vertically integrated operators can ensure that both network and mobile terminal upgrades are co-ordinated to ensure efficient usage.

We discuss these two points in more detail below.

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27 As explained below, because mobile operators are frequently upgrading their networks, single network countries end up being consistently behind, so it's a persistent problem that lasts for more than 1 to 2 years. The delay in introducing mobile technologies results in lower speeds achievable on mobile data networks and this subsequently can have a significant negative impact on productivity and economic growth: GSMA estimates that doubling of mobile data speeds increased economic growth by 0.5 percentage points on average.

28 Hausman (1997), "Valuing the Effect of Regulation on New Services in Telecommunications", Brookings Papers on Economic Activity: Microeconomics, 1-38.

Competition between networks and innovation

It is widely recognised by economists and policymakers that a monopoly has weaker incentives to innovate and that it is not feasible for regulation to alter this. The reason is that monopolies will not generally benefit from introducing and developing innovative improvements to their products, as the new innovation will displace the old one and the monopoly will retain the same level of monopoly profits as before. This so-called "replacement effect" reduces the incentives of a monopolist to innovate.[29]

In competitive markets, the incentive to innovate is much stronger as there is a chance to steal competitors' customers and hence earn higher profits than before (or risk losing profits to a competitor who innovates before oneself)[30]. In competitive markets, there will also be more firms who are searching for innovations and this increases the probability of an innovation being discovered[31].

One of the key differentiators that mobile operators can use under conditions of network competition is the introduction of new technologies in advance of their rivals. This encourages all operators to introduce technologies as soon as possible. Under an SWN, investment in new technologies may be delayed until there is clear demand for the technologies, the cost of operating existing technologies has been fully amortized or the Government otherwise directs the SWN to introduce a new technology.

Vertical integration and innovation

We also consider that the vertical separation between networks and retailing under the SWN model might lead to reduced investment and innovation.

Vertical integration favours the coordination between investment and production decisions of a firm. This reduces the risk of opportunistic behaviour by the service providers once the investment is undertaken (the "hold up" problem)[32].

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29 Sastry (2005), "Market Structure and Incentives for Innovation" INTERTIC Policy Papers (found at: http://www.intertic.org/Policy%20Papers/Sastry.pdf)

30 Theoretical and empirical work indicates that there is an "inverted U relationship" between competition and innovation. At low levels of competition (i.e. monopoly) incentives to innovate are low and will increase as competition increases, however at a certain point the Schumpeterian effect kicks in (i.e. too much competition reduce investment incentives because the profit margins are too low to fund the costs of innovation). (See Aghion et al (2002), "Competition and Innovation: An Inverted U Relationship" NBER Working Paper No. 9269.)

31 Geroski, (1990), "Innovation, technological opportunity and market structure", Oxford Economic Papers, 42, 586 – 602

32 For instance, investment horizons of network operations are likely to be long while retailers have a short term focus. This creates issues with contract design and lead to risks of investment hold-up as retailers have little incentive to enter into long term contracts, and this leads to delays in investment due to uncertainty. Renegotiation risks also reduce incentives to invest. (See Howell, Meade,

This risk occurs because the mobile network can only be used for the provision of mobile services. This is particularly relevant in dynamic sectors, such as mobile telecommunications, where demand is constantly evolving and where investment cycles (e.g. 3G to 4G) tend to be reasonably long. A vertically integrated network operator will make better investment decisions than a network operator which provides wholesale services to independent resellers because it will have more and better information about the retail market and the needs of its own business. This is why firms tend to vertically integrate, particularly in complex, high technology markets. Apple is a classic example of this theory in action.[33]

Under an SWN, consumers will need to rely on MVNOs and other retailers' ability to come up with attractive and innovative retail offerings. But these will largely depend on MVNOs' ability to access the SWN's network services in a way that allows creating highly differentiated retail packages. Subsequently, this will depend on the structure of the SWN's wholesale prices and the specifics of potential 'non-discrimination' obligations imposed on the SWN, as explained in more detail in Section 7.2 below.

It is not clear that under an SWN, MVNOs will be able to replicate the wide range of retail products available under the network competition model and meet demand of specific groups of retail customers. Under an SWN, it is more likely that MVNOs will build their business models and retail offerings around the wholesale products offered by the SWN, rather than actively meeting the preference of individual customer groups by creating tailored retail products. Moreover, under an SWN there will only be a limited scope for MVNOs to take advantage of excess capacity in the network to come up with aggressive retail offerings, which is something that one would typically observe under network competition. For example, some operators have started offering 'all-you-can-eat' tariffs. It is not clear that such innovative tariffs would have been launched if there had been vertical separation between the network and retail levels.

Furthermore, in mobile markets, many new technologies require upgrades to both networks (e.g. base stations) and handsets. Vertically integrated network operators with control of both the network and handset distribution can better co-ordinate to ensure that customers upgrade handsets to allow new network technology to be fully utilised or that the network is adapted to better meet the needs of new devices or new services. Under an SWN, where the network and

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O'Connor (2010), "Structural separation versus vertical integration: Lessons for telecommunications from electricity reforms". Telecommunications Policy Volume 34, Issue 7, Pages 392–403)

33 We recognise that vertical integration does not automatically imply consumer benefits and that there are conditions under which vertical integration can have negative effects; in particular if vertical integration allows a dominant operator to leverage its market power from up-stream into downstream market. Nevertheless, the available evidence from competitive mobile markets suggests that vertical integration between retail and network business seem to be a preferred modus operandi for wireless networks providers.

retailing operations are separated and operate on an 'arm's length' commercial basis, there may be a 'chicken and egg' situation in which new technologies are delayed with the SWN not rolling out new technology because there are no customers with handsets that can use the technology and retail service providers not providing such handsets because the network has not yet deployed the technology.

Operators have highlighted several innovations that would not be possible with vertical separation, such as:

- **Hand-over between mobile and fixed networks**. Going forward, mobile operators will continue to face rapidly increasing data usage. To help cope with this, operators intend to rely more on off-loading traffic to fixed networks using Wi-Fi. However, managing the hand-off between mobile and fixed networks would not currently be possible without vertical integration.

- **Location information**. Telefónica offers a service that allows its customers to locate other customers without using GPS. This would not be possible for MVNOs to do, as they do not have access to the necessary information from base stations.

The economic literature indicates that vertical separation has a negative effect on investment at the industry level. This is further exacerbated by evidence of negative effects on R&D[34]. Rapid technological development in the industry also leads to high levels of complexity and uncertainty, whilst network design is critically related to the service provided.[35]

4.2 Empirical evidence on innovation

As we have seen, over the past few decades, the mobile industry has moved from 1G to 2G to 3G to 4G. In between these generations of technologies, many mobile network operators have upgraded their networks with technologies that fit in between the different generations. For example, many MNOs upgraded to GPRS and then to EDGE to help bridge the gap between 2G and 3G. And then MNOs made use of HSDPA and HSPA+ in between 3G and 4G.

The time at which 2G, 3G and 4G were launched will depend on when regulators and Governments released the required spectrum. Operators will generally not have had that much influence over when the different generations

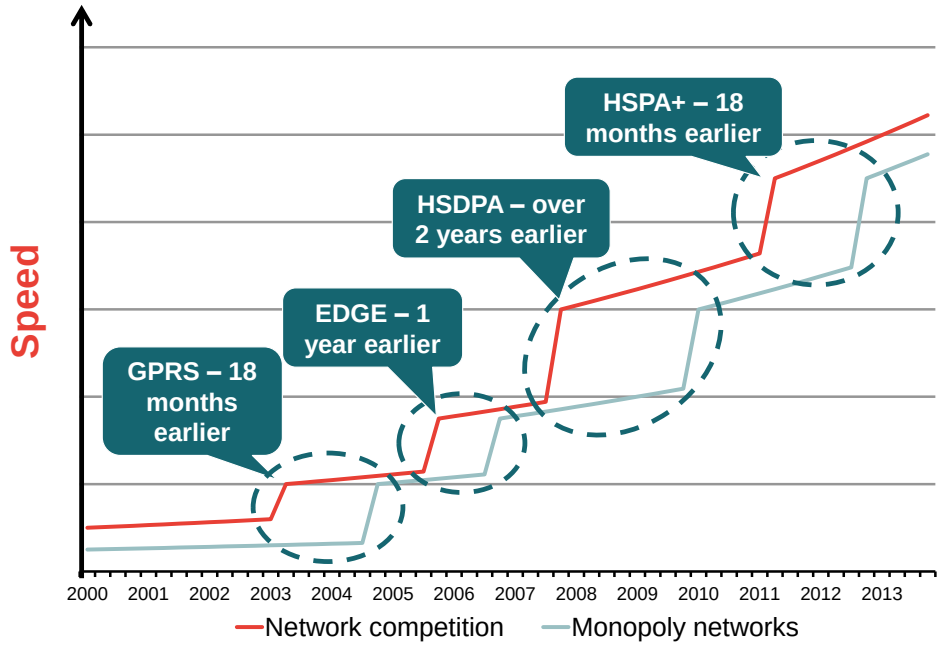
34 Salanave (2007), "The real impact of structural separation" COMMUNICATIONS & STRATEGIES, no. 65, 1st quarter 2007, p. 185.

35 Lafontaine & Margaret Slade (2007), "Vertical Integration and Firm Boundaries: The Evidence", 45 J. ECON. LIT. 629, 653.

were first introduced. However, operators will have had more influence on when they upgraded to GRPS, EDGE, HSDPA and HSPA+, if at all.

We have analysed how quickly operators in countries with single networks and countries with network competition launched these services. The following figure (**Figure 17**) shows the median year in which each of these technologies were first launched. This shows that single networks tended to be much slower to introduce new technologies. For example, GPRS and EDGE were both launched at least one year later in single network countries on average. **HSDPA was typically launched over two years later in single network countries**. These results are likely to understate the difference between countries with single networks and network competition, as we have not accounted for the fact that some countries will not have introduced these technology upgrades at all.

Figure 17. Diagram showing timing of technology upgrades



Source: Frontier analysis based on TeleGeography data

Out of the first 25 countries to launch GPRS, only one country (Albania) had a single network. Similarly, of the first 25 countries to launch EDGE, only two (Barbados and Cambodia) had a single network.

Because mobile operators are frequently upgrading their networks, single network countries end up being consistently behind. This means it is a persistent problem that lasts for more than 1 to 2 years. The above analysis understates the drawbacks of single networks, as many single network countries never introduced

technology upgrades in the first place, so these countries would have been excluded from the analysis.

The timing at which countries introduce technology upgrades is important because there are significant differences in speeds across technologies. For example, EDGE is more than three times quicker than GPRS. A previous GSMA study showed that mobile data speeds can have a significant impact on economic growth by helping to boost productivity throughout the economy.[36]

Network upgrades also lead to considerable improvements in spectral efficiency. This means that the small static gains from aggregating spectrum are likely to be outweighed by the dynamic spectral efficiency gains from using superior technologies (see **Section 5** for a more detailed discussion).

As well as the time at which technologies were introduced, the speed of roll-out will also impact consumer outcomes. We do not have data on the speed of roll-out, but we have analysed overall take-up and 3G take-up to help further assess the impact of network competition. Take-up will be a reflection of how well the mobile market is working and will be influenced by network quality, coverage and prices.

We find that overall take-up[37] (**Figure 18**) was considerably higher in countries with network competition in 2001. This difference is statistically significant[38]. We arrive at the same conclusion when repeating our analysis for countries with a population above and below one million.

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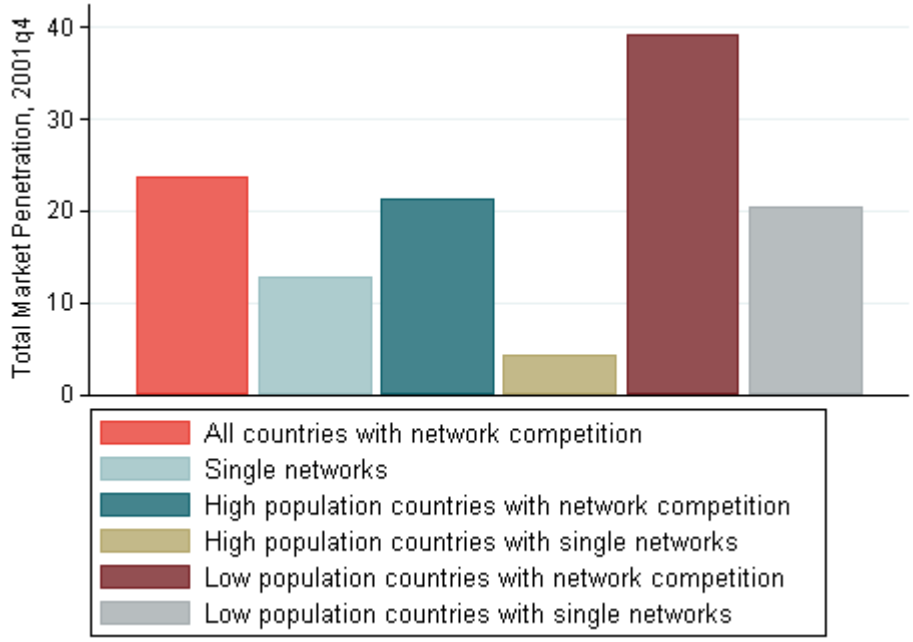
36 Deloitte paper (See http://www.deloitte.com/assets/Dcom-UnitedKingdom/Local%20Assets/Documents/Industries/TMT/uk-tmt-GSMA-report-112012.pdf)

37 Take-up is measured based on the number of unique subscribers.

38 The difference is statistically significant with a p-value of 0.0001.

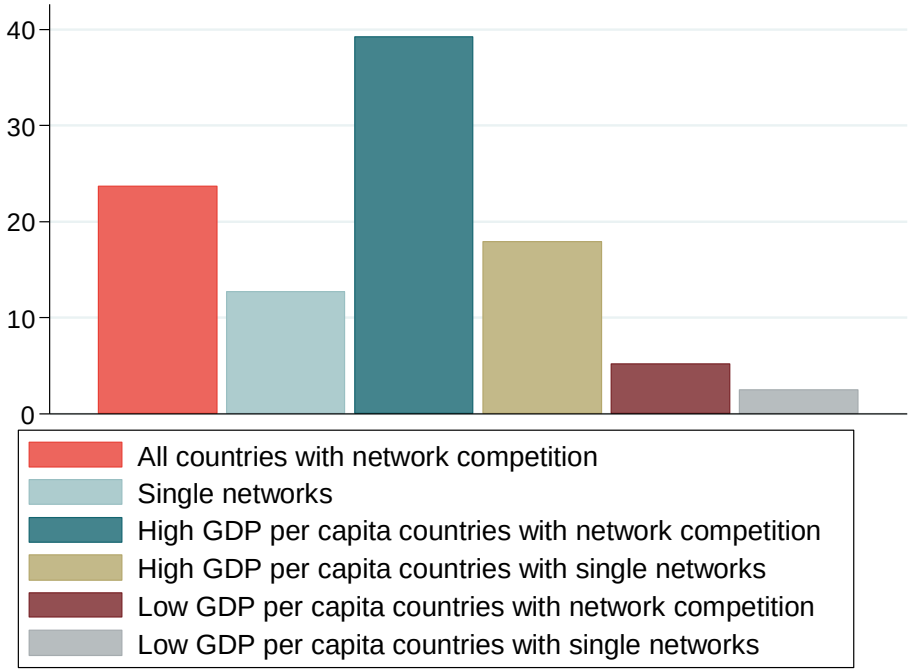
Figure 18. Overall take-up in countries with single networks and network competition



Source: Frontier analysis based on GSMA data

As a further sensitivity check, we have also considered how market penetration varies across countries with network competition and single networks when splitting the sample based on GDP per capita (**Figure 19**). These results show that network competition resulted in higher take-up regardless of whether we look at high GDP per capita or low GDP per capita countries.

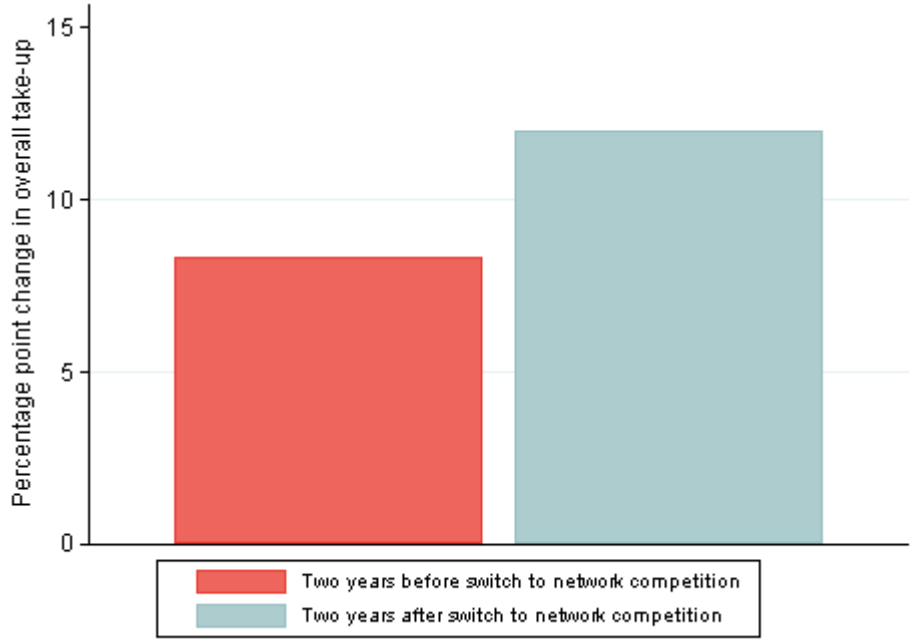
Figure 19. Overall take-up in countries with single network and network competition (GDP per capita split)



Source: Frontier analysis based on GSMA data

As well as the above cross-country comparison, we have analysed the outcomes in countries that have moved from single networks to network competition. **We find 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).** See **Figure 20.**

Figure 20. Change in take-up in the two years after the move to network competition compared to the two years before

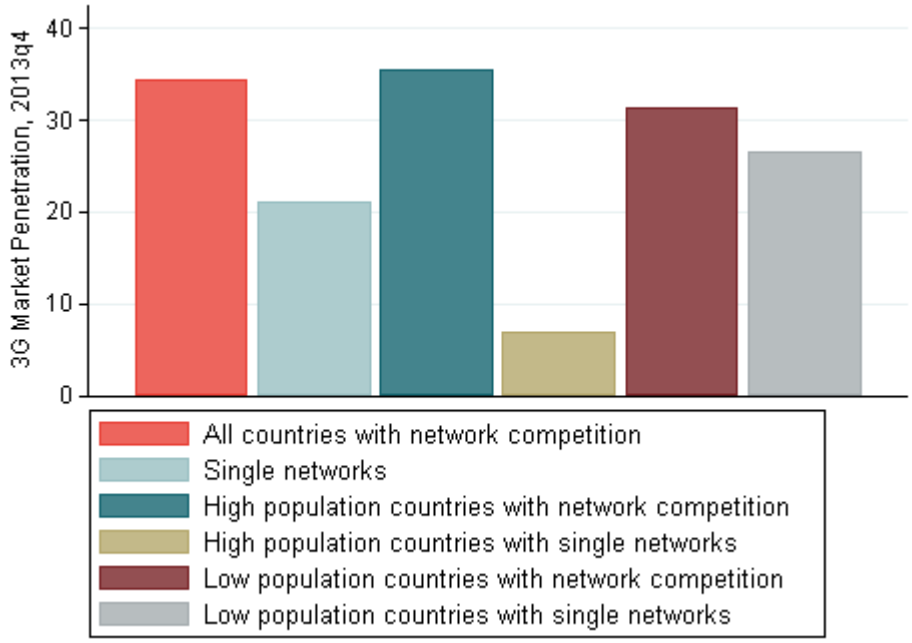


Source: Frontier analysis based on GSMA data

We have also considered how the take-up of 3G[39] compares across countries. (**Figure 21**). We have used data from 2013, given that 3G is still a relatively new technology in some countries. The results show that 3G take-up is much higher in countries with network competition. This holds true regardless of whether we are looking at all countries or just those countries with a population greater than or below one million.

39 3G take-up is measured based on the number of SIM cards. Although this will overstate the number of unique subscribers, we have no reason to believe that this will affect the relativity between take-up in countries with single networks and network competition.

Figure 21. Take-up of 3G in countries with single networks and network competition[40]



Source: Frontier analysis based on GSMA data

We have also performed an econometric analysis to test the impact that having a single network has on take-up. We have controlled for different demographic variables, including GDP per capita, population density, population size and time since 2G was introduced. The results suggest that **having network competition increased overall take-up by 7 percentage points**.[41] These results suggest that the negative impact from single networks cannot be fully explained by countries with single networks having been slower to launch a 2G network.[42]

40 We have not shown a graph with the countries split by GDP per capita due to a lack of data availability.

41 We have estimated the regression model using OLS.

42 We have modelled the impact of entry on take-up (and coverage). In other markets, there have been academic papers that have considered whether the impact could run in the opposite direction, meaning that favourable market outcomes, such as high take-up, may encourage entry. If this were the case, then this could affect the interpretation of the econometric results. However, we do not consider that this is a concern in this particular case. This is because the decision to move from single networks to network competition is likely to be driven by the regulator's decision to liberalise the market, which is outside of the control of potential new entrants. It is not clear that regulators would use the level of take-up (or coverage) as a key determinant of when to liberalise markets. Even if they did take into account take-up (or coverage) in its decision making, it's not clear whether liberalisation would be more likely with high or low take-up (or coverage). There may in fact be more pressure on regulators to liberalise the market if take-up (or coverage) is low, which would

We also performed an econometric analysis to assess the impact of single networks on 3G take-up. Again, we have found that single networks have a detrimental impact. The results suggest that **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 4.

	Overall take-up	3G take-up
Single network	-6.928***	-16.91***
GDP per capita	0.00104***	0.00109***
Population size	-1.63e-08***	-2.13e-09
Population density	-0.000991	0.00730***
Time since 2G was launched	0.515***	
Constant	4.014**	11.99***
Observations	175	157
R-squared	0.683	0.716

4.3 Conclusion

Innovation in the mobile industry has largely driven the extraordinary growth of the mobile sector for the past 30 years. We would expect network competition to be more effective at driving innovation, and the adoption of new technologies, than SWNs. This is for two reasons. First, monopolies have very weak incentives to innovate at all. Regulation can try to encourage monopolists to innovate, but often performs poorly at doing so. Second, vertical separation of network and 'retail' activities under the SWN would lead to less innovation, since most innovation in mobile telecoms requires close co-ordination between the network and retail operations (which is easier to achieve in a single entity).

The empirical evidence confirms that countries with network competition introduced major network upgrades 1-2 years earlier than countries served by single networks and that adoption of new mobile services, including 3G, is much faster in countries with network competition.

mean that our econometric results would understate the positive impact that network competition has on take-up (or coverage).

5 Achieving reductions in network costs

An important criticism of network competition by some SWN advocates is that economic resources are being used inefficiently because there is network duplication, even where network competition provides adequate coverage (e.g. in urban areas). In Kenya, for example, the arguments for the SWN proposal suggest that this would avoid duplication of infrastructure and efficient use of spectrum.[43]

It is clear that some degree of duplication is a feature of almost any competition in any market. Governments generally do not worry about this because they believe that the dynamic benefits of competition – more innovation, greater efficiency – will far outweigh any 'static' costs of duplication. This can be seen from the empirical evidence from mobile markets which shows large reductions in end user prices at the time of entry, despite the need for some duplication of assets. We therefore need to balance the static costs of duplication against the dynamic advantages of competition to determine whether, overall, the case made by SWN advocates is compelling[44].

Duplication would be inefficient if it resulted in lower returns for investors (if higher costs are absorbed by operators), or if higher costs are passed on to consumers. In the former case, provided the private sector is prepared to fund network competition – which it has been for 30 years across a wide range of geographies – then it is not clear why Governments should be concerned about the potential impact of cost duplication. The latter case – duplication leading to higher prices for consumers - could be of potential concern to Governments. Underlying this are two key assumptions:

- that the duplication of assets under network competition (combined with a fragmented use of spectrum) leads to a significant increase in overall network costs; and
- that this increase in costs leads to higher unit costs (and higher end user prices).

In the rest of this section we examine the assumptions.

43 See Annexe 2 for more details on Kenya's SWN proposal.

44 There are some industries where the costs of duplication are prohibitively high: these are generally referred to as 'natural monopolies'. In this case, the costs of duplication are so high that any entry would be clearly inefficient and would likely lead to.

5.1 Impact of duplication on overall network costs

5.1.1 Mobile network cost structures

The costs of mobile operators can be broadly divided into network costs and retail costs. Network costs are the cost of connecting to subscribers and conveying traffic to and from these subscribers. Retail costs include the ancillary cost associated with serving subscribers such as customer acquisition, customer care and billing. Since the SWN is expected to operate with competing retail operators downstream, retail costs should remain broadly similar to markets with network competition.

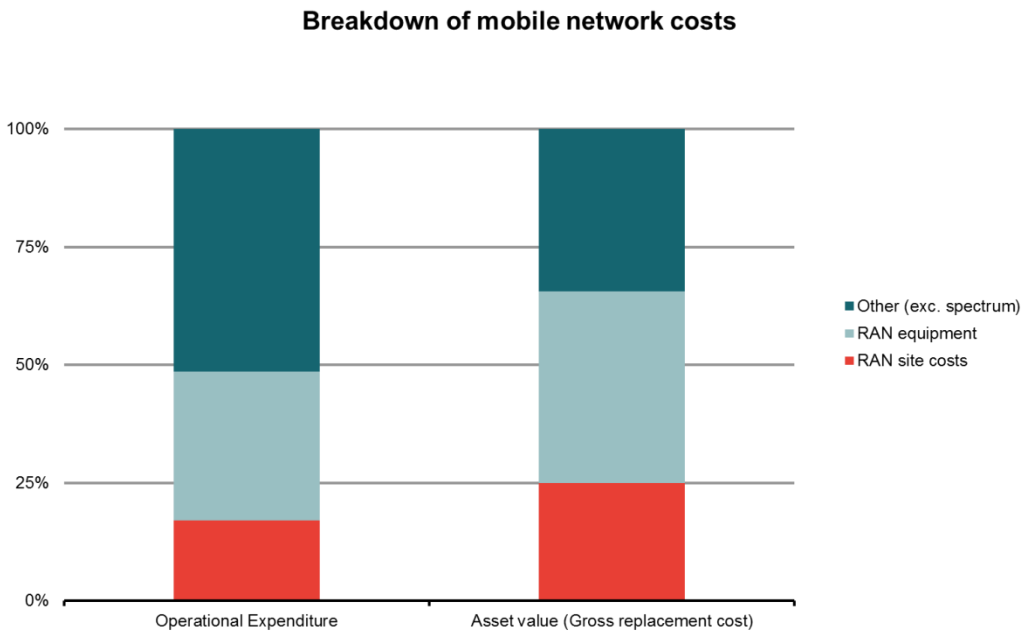
Mobile network costs can then be grouped into four categories:

- The radio access network (RAN) consisting of the base stations used to provide connections and deliver traffic to end users;
- The core network which provides network intelligence and routes traffic between subscribers and to other networks, including the Internet;
- The backhaul network which connects base stations to the core network, including traffic aggregation; and
- Central network management and control functions.

The most significant element of the network, in terms of both the number of components and the overall cost, is the RAN and associated backhaul.

The figure below indicates the relative magnitude of these costs in the mobile network as a whole.

Figure 22. Magnitude of RAN costs in the mobile network

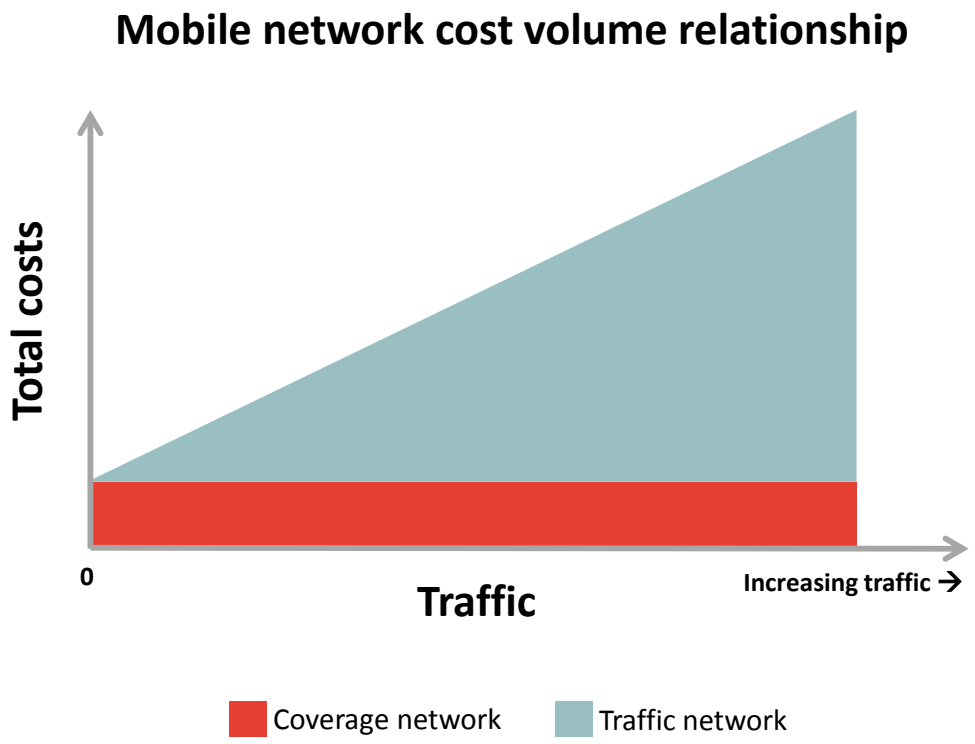


Source: Frontier analysis of Ofcom MTR model (Nov 2011)

In principle, costs in a mobile network can be broadly divided into costs which can be considered as fixed with respect to the level of demand (customers and traffic) and costs which vary with the level of demand (principally traffic[45]). In mobile networks, individual base stations will provide both coverage and capacity, making it impossible to directly assign individual assets into "fixed" and "traffic sensitive" components. However, the division between fixed and coverage costs can be estimated for a hypothetical network through network modelling with the fixed costs being those costs that remain as traffic is reduced towards zero while keeping coverage fixed.

45 There are some costs associated with the number of customers, such as the cost of location registers, which increase as the number of customers increase, but these costs are immaterial.

Figure 23. Mobile cost structure



Note: Diagram not to scale

Source: Frontier Economics

A large proportion of costs in mobile access networks are fixed with respect to the level of traffic, but variable with respect to the area covered. For example, Ofcom in the UK have estimated that less than half of the total costs of a national mobile network are incremental with respect to traffic.[46] Increasing coverage requires additional base stations to be deployed, as the area covered by each base station is largely fixed by the propagation characteristics of the spectrum and the technical requirements of the technology used. In marginal areas with relatively low population density, the minimum base station configuration required to provide services will be sufficient to serve all traffic

46 Estimated incremental costs of call termination of 0.69 pence per minute compared to a cost of 1.61 pence per minute including a mark-up for fixed cost. Wholesale mobile voice call termination statement, 15 March 2011, Table 9.1.

generated within the associated coverage area[47]. In these areas, costs will be invariant for small increases in traffic from current levels.

The exact proportion of costs which is coverage driven will vary between counties depending on the distribution of population, with countries with a low population density likely to have more areas where costs would be largely coverage driven, and the degree to which rural areas are covered. Whilst in developed economies mobile networks generally cover a the vast majority of the national territory of a country, in developing markets coverage is may be limited to those areas with high population density, reflecting the higher level of traffic needed to justify the cost of additional base stations.

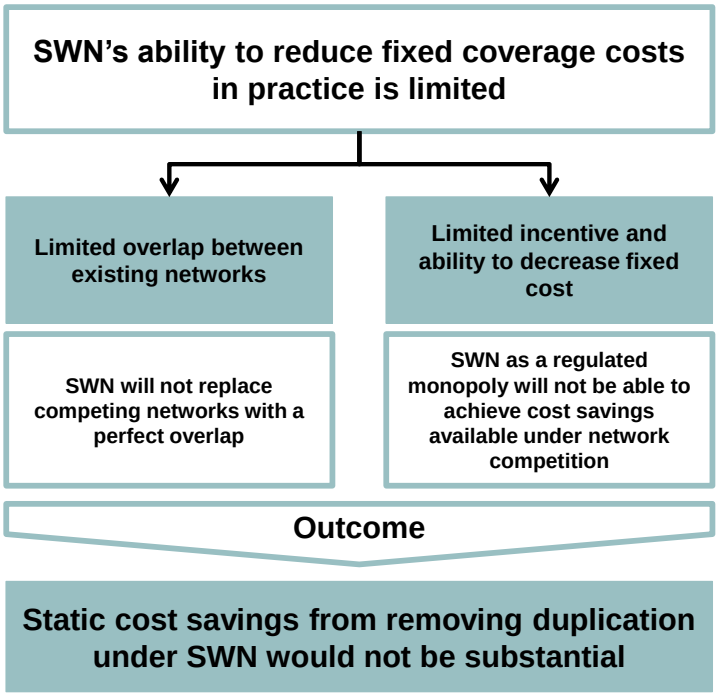
5.1.2 Impact of SWN on fixed network costs

If multiple networks are built, each network will incur coverage related costs and then each network will incur the traffic related costs associated with their own subscribers. In contrast, if an SWN is built, only one set of fixed "coverage" costs will need to be incurred and the resulting total costs of the network should be lower (assuming that the SWN is a monopoly network).

This argument assumes that the fixed costs of each competing network will be broadly equal to the fixed costs of an SWN. In practice, this is likely to significantly overestimate the actual cost savings achievable under an SWN for two reasons, see **Figure 24** below.

47 As mobile pricing is by its nature independent of location, end user pricing will be set such that demand in areas of high traffic density matches available capacity in those areas. As a result, traffic in relatively low density areas will be significantly below available capacity.

Figure 24. SWN will not result in significant reductions in fixed coverage costs



Source: Frontier Economics

First, even where there are multiple mobile networks operating within the country, the overlap of these networks will not be 100%. Not all costs are duplicated. This implies that the extent of cost savings that can be achieved from removing duplication is more limited than might first be supposed.

Second, where there are competing networks, the operators of these networks are likely to have both:

- stronger incentives to minimise fixed costs than an SWN; and
- opportunity to reduce fixed costs through network sharing.

The incentives of competitive networks to reduce costs, including fixed costs, are widely recognised and understood. Monopoly networks will generally lack such incentives, although we recognise that regulation (for example, through the use of RPI-X price caps to set efficiency targets) can seek to mimic the incentives to reduce costs which we find in competitive markets. We discuss the challenges of regulation in Section 7 but think it is reasonable to expect that the SWN is unlikely to be able to match the results of competitive networks in terms of cost efficiency.

Competing network operators also have an obvious means to reduce duplications through various levels of network sharing. Evidence suggests that such sharing can effectively halve the coverage cost borne by each of the networks, i.e. there is

no duplication of equipment or costs. Based on publicly available information, a voluntary network sharing joint venture led to CAPEX savings up to 46% and OPEX savings up to 29% (see text box below). Similarly, an estimate by Vodafone shows that network sharing between two operators can achieve significant cost savings, up to 30% of costs, while still preserving full control over their logical networks. [48]

Net4Mobility estimated cost savings

The joint venture Net4Mobility ("N4M") in Sweden was established in 2008 between Telenor and Tele2 who both hold equal shares in the company. The objective of the operators is to share their 2G and 4G networks and spectrum pools[49].

In a publicly available presentation[50], Telenor report the following cost savings resulting from the N4M joint venture[51]:

- accumulated CAPEX savings of SEK 1.2bn[52]
- annual OPEX savings of SEK 135m[53]

In order to turn these numbers into percentage cost savings, we have calculated total accumulated CAPEX (SEK 2.6bn) and annual OPEX (SEK 459m) of the joint venture.[54] We then use these figures to estimate that CAPEX savings from network sharing are up to 46% and OPEX savings are up to 29%.

As a result, the benefits of SWNs in terms of non-duplication of network fixed costs are likely to be much smaller than what is supposed, under the assumptions that competing mobile networks operate fully overlapping networks, they cover most of the national territory of a country, and engage in no network sharing.

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

49 3G network sharing is covered by other existing agreements in Sweden.

50 Telenor (see Slide 10: http://www.telenor.com/wp-content/uploads/2013/09/03_CMD_2013_Telenor_Europe_FINAL.pdf)

51 We assume that these are the cost savings for N4M as a whole, rather than just Telenor's share of it (50%).

52 It is not clear up to which date Capex savings are accumulated. We assume that they are accumulated until the end of 2013.

53 In the presentation it reads "cost savings". We assume this refers to 2013 Opex savings.

54 We found this information in the annual reports of N4M which we downloaded from the website of the Swedish Companies Registration Office. (See http://www.bolagsverket.se).

5.1.3 Impact of SWN on spectral efficiency

Proponents of SWN argue that another potential benefit of a single wholesale network is the ability to deploy the available spectrum in a given band in one block rather than dividing it among a number of competing operators. Such aggregation can bring two potential benefits:

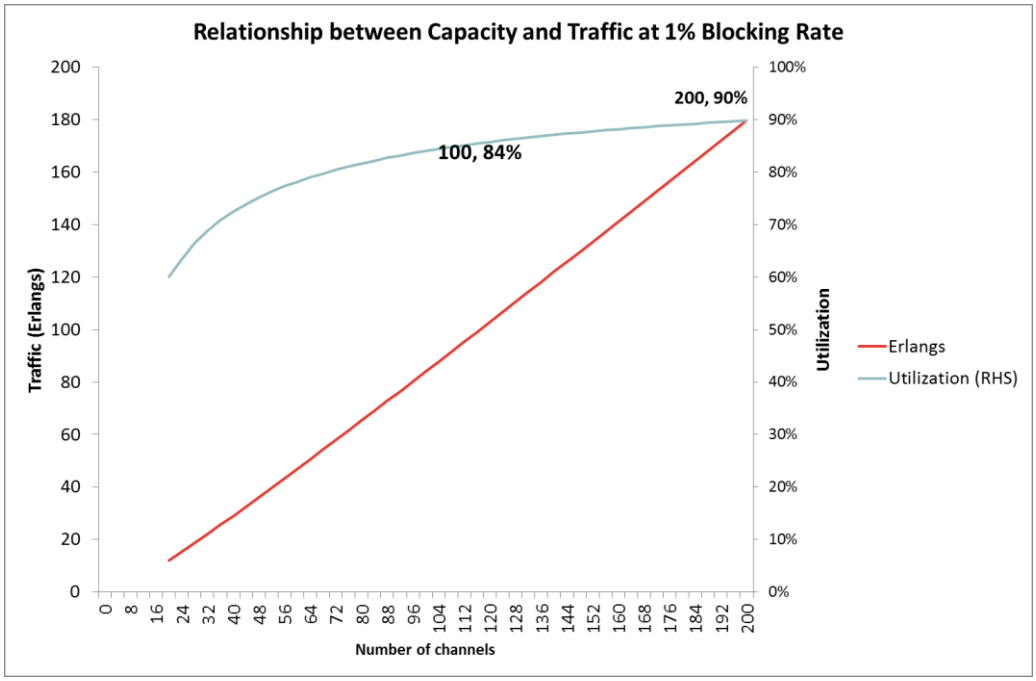
- with current LTE technology, larger carriers are marginally more spectrally efficient (i.e. 2 x 20 MHz carriers have more than twice the capacity of two 2 x 10 MHz carriers); and
- pooling of capacity allows for a higher utilization of the available capacity.

Annex 3 shows that the static impact of increased spectral efficiency is less than 10% currently, which is small compared with the dynamic efficiencies due to technological developments over time. Below we also consider the impact of capacity pooling.

Capacity pooling effects

The relationship between traffic at a given quality of service and capacity is non-linear. This means that, at low volumes, a proportionately smaller level of traffic can be carried per channel at a given level of blocking, i.e. the level of utilization of the available capacity is relatively low. At higher volumes, a greater volume of capacity per channel can be carried, i.e. the utilization can be greater. In other words, doubling capacity more than doubles the level of traffic that can be served at a given level of quality of service. This means that, in theory, an SWN which carries all the traffic of the entire market can use spectrum (and other network resources) more efficiently than competing operators who serve only their portion of the traffic.

Figure 25. Relationship between capacity and traffic at constant quality of service



Source: Frontier Economics

Having accepted this, we consider that in modern mobile networks the potential gains from pooling spectrum in an SWN are likely to be relatively small for a variety of reasons:

- These 'pooling' benefits only arise when the network is being fully utilised, which is rarely the case in most networks today.
- The benefits in terms of quality and user experience will only be apparent with real time, delay intolerant services such as voice services. The impact of pooling on 'best efforts' data traffic, which is driving demand for additional capacity in most markets today, is likely to be much less significant. Even in the case where all traffic is delay intolerant (e.g. based on real time voice services), the increase in utilisation moving from 100 channels to 200 channels (i.e. from 84% to 90%) is around 7% only.

Thus, whilst there are some theoretical benefits to large contiguous allocations of spectrum, in practice, in modern mobile networks, the magnitude of these benefits is relatively small – a potential of the order of 10% additional capacity in traffic constrained parts of the network through a combination of spectral efficiency and capacity pooling. As traffic constrained parts of the network are

likely to be a relatively small proportion of the overall network, the impact on overall costs will be less than this.

5.2 Impact on unit costs

From a cost efficiency perspective, the key issue is the impact on *unit* costs. Unit costs will be a function of both the overall costs of the network and also level of demand on the network.

Even if one scenario results in relatively lower overall network costs, this will not directly translate into a difference in unit costs, unless the level of demand is identical in both cases. However, it is very unlikely that the level of demand would be the same under an SWN scenario versus a scenario of competing networks for two reasons:

- the technical capacity of networks is constantly increasing, allowing more traffic to be delivered at a lower unit cost; and
- competing integrated operators are likely to have a stronger incentive to maximise demand in order to reduce their unit costs compared to an SWN.

We address each of these points in turn.

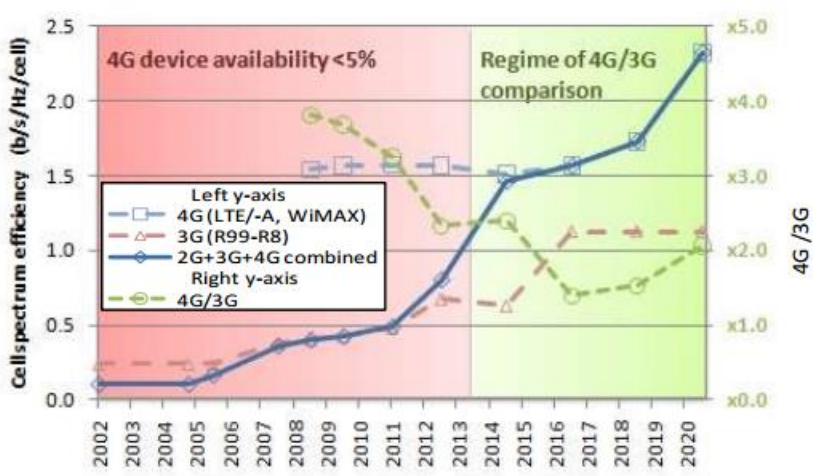
5.2.1 Capacity increases

The benefits outlined above associated with spectrum aggregation and capacity pooling are static productive efficiency benefits which would provide a like for like cost advantage for SWN compared to competing networks, all else being equal.

However, these relatively small static benefits related to productive efficiency need to be balanced against dynamic benefits due to technological developments.

In particular, in the past the dynamic benefits of upgrading networks more quickly to new technologies which deliver far greater spectral efficiency (without aggregation) have been very large. Spectral efficiency has increased by broadly tenfold over a decade due to technological developments as can be seen from the figure below.

Figure 26. Spectral efficiency over time



Source: Ofcom

Looking forward, the potential for increasing spectral efficiency with new technologies is likely to be smaller than in the past[55]. However, data demand is likely to continue increasing rapidly with additional capacity being provided through a range of changes in networks[56] including:

- some increases in spectral efficiency due to the introduction of new technologies such as LTE-Advanced;
- improvements in spectral efficiency through the migration of customers (and their equipment) to more efficient technologies and the subsequent re-farming of spectrum;
- use of an increasing range of frequency, in particular high frequency networks; and
- heterogeneous networks ('HetNets') using an increased number of smaller cells in urban areas to offer greater capacity.

This combination of factors will likely allow increasing demand to be met by networks for the next decade, but will require continued investment in networks

55 The Shannon-Hartley theorem shows there is an upper bound on the rate at which information is transmitted over a given bandwidth.

56 See for example: Clarke, Richard (2013), "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy*. Available at http://www.sciencedirect.com/science/article/pii/S0308596113001900.

Achieving reductions in network costs

and subscriber equipment. Assuming that total capacity will continue to increase over time at a rate of a broadly tenfold increase each decade, this is equivalent to an average increase of 25% per year. Translated into average unit costs, this equates to significant reductions in unit costs year on year, even with the additional costs required to implement technological developments. In competitive markets these unit cost reducitons are passed through to end users.

As noted above, competing network operators have stronger incentives to lower costs and as such will tend to quickly introduce technology which increases spectral efficiency, hence capacity per base station and lower traffic related costs. This is supported by the empirical evidence which shows that in markets with a single network, technology tends to be introduced significantly later than in markets with competing networks, see Section 4.

This dynamic effect can easily overwhelm any static effects related to spectrum aggregation. For example, if an SWN has a static capacity advantage of approximately 10% compared to competing networks, this translates into less than 6 months' increase in capacity due to dynamic effects. In other words, if competing operators' incentives to innovate lead them to bring forward investments leading to additional capacity by even six months or more, then this will negate the small theoretical benefit due to spectrum aggregation and capacity pooling. As shown in Section 4.2 above, in countries with network competition, new mobile technologies tend to be introduced 12 to 24 months earlier than in countries with single mobile networks.

In particular, to the extent that capacity requirements are contingent on evolution in technology, vertically integrated network operators are better able to co-ordinate the update of the network and handsets, for example by targeting high usage subscribers with subsidies to migrate to new technology handsets. This will tend to further enhance the incentives of competing networks to roll out newer technologies compared to a SWN.

5.2.2 Demand stimulation

Investing in increased capacity can potentially reduce unit costs only by increasing demand. Competing vertically integrated network operators have levers that they can use to stimulate demand that are not open to a single wholesale network for example:

- promotional pricing to increase demand when capacity utilisation is low;
- handset subsidies, for example migrating users to smart phones to increase data usage; and
- price differentiation to match prices more closely to an individual customer's willingness to pay, thereby stimulating penetration and traffic.

Because single wholesale networks will not have control of the customer relationship, they will not be as effective at stimulating demand[57], and in the case where they are monopoly providers, will not have the same incentive to stimulate demand as this could lead to increased investment requirements. MVNOs and other retailers operating on an SWN will not generally have the same incentive as network operators to stimulate demand as wholesale prices will typically be based on average network costs while network operators can price down to marginal network costs. Regulators may attempt to construct wholesale access pricing arrangements which attempt to mimic some of these incentives (again, see Section 7 for a general discussion of the challenges of regulating SWNs) but this will add complexity and risk to the regulatory regime.

5.3 Conclusion

Even if SWNs could reduce the duplication of fixed network costs (albeit to a lesser extent than some SWN advocates may suppose), we consider it unlikely that the resulting unit costs will be lower. This is because competing network operators have stronger incentives than an SWN to invest to increase capacity and have more levers to stimulate demand to make full use of this capacity.

The evidence suggests that the effects of this dynamic efficiency, which could lead to approximately a 20% reduction in unit costs each year, are likely to outweigh any potential static efficiencies resulting from spectrum aggregation with the combined effects of capacity pooling and spectral efficiency being less than 10% of costs.

57 See section on Access pricing in Chapter 7.2.

6 Co-existence between an SWN and existing mobile networks

To achieve what appear to be the stated objectives of its proponents, the SWN will effectively need to evolve into a regulated monopoly over which 4G (or other services) will be provided. At the same time, current proposals suggest that the SWN could co-exist with the existing networks, potentially for a prolonged period of time. In this section, we consider how co-existence might work in practice and the main risks related to achieving the objectives of SWN advocates.

We find that:

- The SWN under the co-existence scenario will increase rather than reduce network duplication, since it is yet another network in the market. As a result, the SWN will add to the overall cost stack of the mobile sector, but without a clear ability to generate sufficient retail demand to cover these additional costs, as discussed below.

- Assigning large amounts of valuable low frequency spectrum to a new (empty) network would likely lead to inefficient allocation of scarce resources, at least in the short term. Even if the SWN is able to generate sufficient retail demand, it is not obvious that the existing operators would not be able to use the additional spectrum more efficiently to meet increasing demand of their own customers.

- The SWN will operate as a wholesale network provider, with no retail function. It is reasonable to expect that existing operators may have less of an incentive to transfer traffic to the SWN as long as the incremental cost of maintaining traffic on their own networks is lower than the long run average cost offered by an SWN. And any new MVNOs will take time to build up scale. Therefore, it is not clear that the SWN will be able to attract sufficient demand for its services to reach an efficient scale. This would lead to inefficiently high average costs for the SWN, which in turn may result in high wholesale access prices, making the SWN even less attractive..

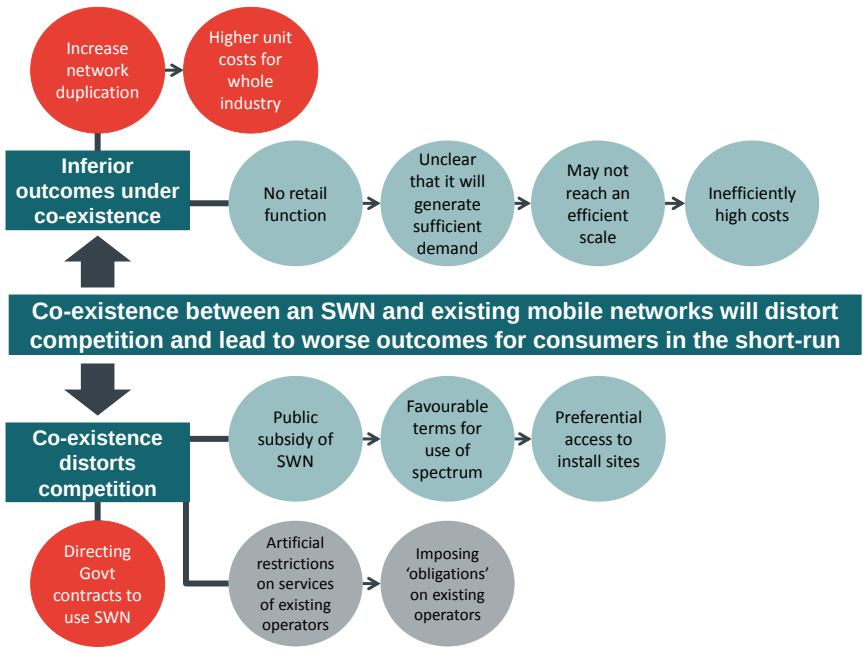
- Some form of public intervention is therefore likely to be required to artificially 'favour' the SWN and ensures that it captures traffic. This could take several forms, all of which are likely to distort competition in the market, to the detriment of consumers.

- In addition, the future of the SWN during the period of co-existence will be uncertain. Existing operators may be reluctant to direct traffic to the SWN if they cannot be confident that it will prosper, but may equally be reluctant to invest in their own networks if there is the possibility that they will migrate

to the SWN later. In the long run, the SWN will either succeed in capturing sufficient traffic to be sustainable, or it will fail. But in the meantime, the uncertainty created by the SWN is likely to reduce investments in all networks in the country.

A high level summary of our finding is illustrated in **Figure 27**. We discuss these points in more detail below.

Figure 27. Co-existence leads to worse outcomes for consumers



Source: Frontier Economics

6.1 Impact of co-existence on market performance

Below, we discuss why co-existence between the SWN and existing operators is unlikely to achieve at least some of the stated objectives of SWN proponents. In particular, we show that the SWN under the co-existence scenario increases network duplication, and could lead to inefficient use of spectrum and negatively impact investment in the mobile sector.

6.1.1 Impact of co-existence on network costs

The SWN under the co-existence scenario implies that a new mobile network will be built to compete with the existing networks. Even if we assume the SWN would not be a Greenfield investment, and it could partly rely on reusing the existing mobile infrastructure, the SWN can be expected to increase, not reduce, the level of network duplication in the country.

Co-existence between an SWN and existing mobile networks

As a result, the SWN will likely lead to higher unit costs for the whole industry in a static sense, as long as the SWN enters the market as another network competitor with its own network infrastructure. While the SWN will add to the cost stack of the mobile sector, it is less clear the SWN will be able to attract sufficient demand to cover these additional costs, at least in the short run.

This is because the SWN will operate as a wholesale network provider, with no retail function. Therefore, in order to obtain retail traffic, the SWN would likely need to rely on:

- existing operators migrating their traffic to the SWN (if they choose to 'cooperate' with the SWN – which is not guaranteed); and/or
- new MVNOs using the SWN to compete with existing operators.

As MVNOs will typically need time to build up scale and it is unclear what share of the retail market they will be able to serve, the SWN will largely depend on the co-operation of the existing operators and their willingness to migrate their traffic to the SWN. Therefore, the position of the existing operators will be critical to the prospects for the SWN under the co-existence scenario.

The key challenge for the SWN is likely to be incentivising existing operators to migrate traffic from their own networks (where costs have been sunk) to the SWN. Assuming that the SWN would not price its wholesale products below costs, existing operators could have weak incentives to transfer traffic to SWNs as the incremental cost of maintaining traffic on their own network will likely be lower than the long run average cost offered by an SWN.

This is particularly the case if operators have the ability to, at least partly; replicate the next generation services offered by the SWN, for instance, through re-farming their existing spectrum for LTE or by extending the life of 3G via various network enhancements. Some form of Government intervention will probably be required to make the SWN more attractive for the existing operators. As explained below, such an intervention comes with a significant risk of distorting market competition at the expense of consumers.

6.1.2 Impact of co-existence on efficient use of spectrum

According to the current proposals, an SWN will typically have access to a large amount of valuable low frequency spectrum; see **Figure 28** below. In Mexico, the SWN will have access to at least 90 MHz of 700 MHz spectrum and the proposals in Rwanda, Kenya and Russia indicate that the proposed SWNs should be allocated a significant proportion, if not all, of 800 MHz spectrum.

Figure 28. Spectrum assigned to the SWN under current proposals

COUNTRY	SPECTRUM	OWNERSHIP	Timing/details
MEXICO	700MHz spectrum	Existing operators may have a share in the network but will not influence the operation	Construction aimed to begin in 2014 and end in 2018
SOUTH AFRICA	Potentially spectrum in 800 MHz and 2.6 GHz bands	Public Private Partnership	Exact proposal still being developed
RWANDA	800 and 1800MHz spectrum	Joint venture with South Korean operator KT	Construction to begin 2014 with targeted access of 95% of the population by 2017
KENYA	700 and 800MHz spectrum	Public Private Partnership	Held up by difficulties in negotiations with private suppliers
RUSSIA	700 and 800MHz spectrum	State ownership	Withdrawal of spectrum allocated to current operators for SWN

Source: Frontier Economics

Our understanding is that this spectrum is likely to be assigned to the SWN on favourable terms (i.e. either 'for free' or at only a fraction of the market value) and often in the absence of any allocative market mechanism, such as spectrum auctions. This has two key implications:

First, without an auction mechanism, it is possible that the low frequency spectrum will not be allocated to the operator(s) that can put it into the best use, which includes putting it to immediate use rather than incurring delays whilst the SWN is established. This implies an inefficient use of scarce resources, to the cost of society. This is particularly relevant since low frequency spectrum is suitable for extending mobile coverage in rural areas.

Also, under co-existence, the existing operators will still need to serve their 'legacy' customer base of 2G and 3G users. This could potentially lead to an inefficient use of spectrum, as operators would need to run their 'legacy' networks in order to serve an ever decreasing customer base. In the absence of the SWN, this inefficiency can be partly overcome by operators voluntary re-farming their spectrum and using it to meet the demand of 'next generation' users. Under co-existence, this is likely to be challenging, given that operators will be disadvantaged in providing next generation services and may face uncertainty about the future of the SWN (discussed below). Therefore, their ability and incentives to re-farm legacy spectrum and put it to more efficient use are likely to be limited.

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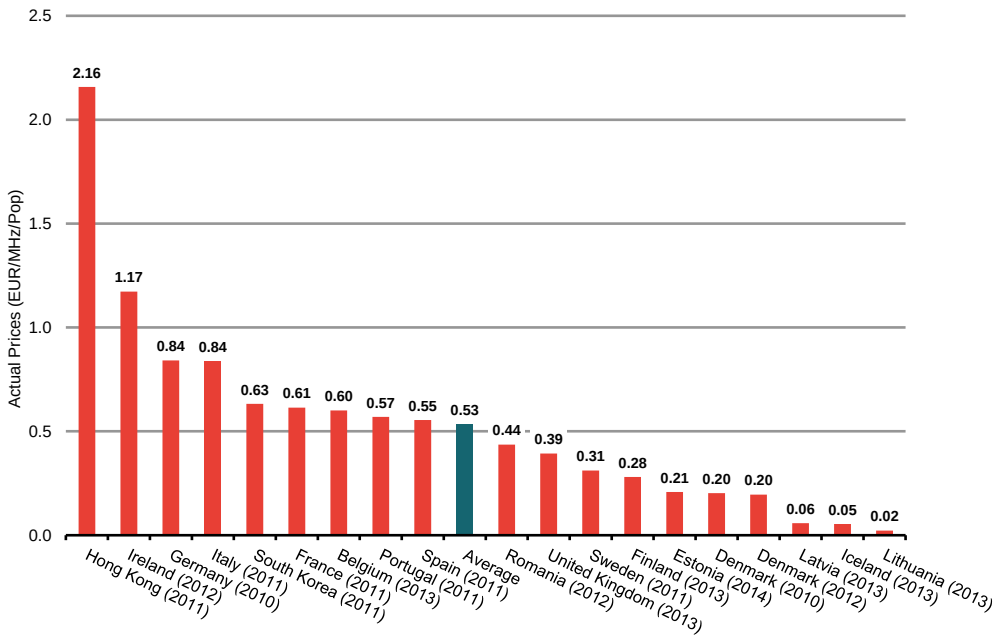
Second, by assigning the spectrum to the SWN on favourable terms, the Government is foregoing potentially significant revenues, which could otherwise be raised through a spectrum auction. The experience from recent 4G auctions in Europe and elsewhere suggests that mobile operators value spectrum suitable for delivering LTE services, in particular, low frequency sub-1GHz spectrum.

Figure 29 below shows that the average prices paid for 800 MHz spectrum in spectrum auctions over the period May 2010 to January 2014 range between EUR 0.02 and EUR 2.16 per MHz/population, with an average of around EUR 0.5 per MHz/population. For illustration, this implies that a country with 50 million inhabitants that allocates 60 MHz of 800 MHz spectrum to the SWN would be expected to forego average auction revenues of around EUR 1.6 billion.

Figure 29. Prices paid for 800 MHz spectrum in recent auctions (EUR MHz/population)



Source: Frontier Economics

6.2 Impact of measures to promote the SWN

As explained above, under the co-existence scenario, the level of network duplication will inevitably increase, as the number of competing mobile networks will increase. This does not imply, however, that end users will necessarily benefit from increased network competition in the long-run.

First, the SWN as a wholesale network will rely on service-based competition, rather than network based competition. The potential benefits of an additional competitor in the market are therefore likely to be more limited than they would be in the case of an end-to-end entry of a new mobile operator. In practice, this will largely depend on the actual setup of an SWN and the ability of service-based providers to compete with existing operators, e.g. by having access to a superior network or technology not available to existing operators.

Nevertheless, as explained in Section 4, SWN-based retail competitors are likely to be less able to match the innovation capabilities of the existing, vertically integrated operators. This is primarily because the SWN will not be able to coordinate its network investment decisions with its retail activities in a way that vertically integrated operators are able to. This could put the SWN at a significant disadvantage compared with the existing mobile operators during the interim period of co-existence.

In addition, the MVNOs operating over the SWN would likely focus on price competition, as their ability to differentiate their retail offerings would be limited by the availability (and pricing) of suitable wholesale products. This could impede the ability of MVNOs to compete with existing operators at the retail level, and may therefore reduce demand for access to the SWN.

Therefore, it is not obvious that an increase in retail competition delivered by an SWN will automatically lead to significant consumer benefits, as this will largely depend on SWN's ability to impose a competitive constraint on the existing network operators.

Second, as indicated above, the SWN is a Government initiated project and is likely to receive preferential treatment. In particular, some form of public intervention is likely to be required to artificially 'favour' the SWN and allow it to attract the necessary traffic to make the network investment viable. This could take several forms, including:

- assigning all LTE spectrum to the SWN, thereby inhibiting the ability of existing operators to serve LTE demand other than through the SWN;
- direct public subsidy of the SWN, allowing setting wholesale access prices at or below incremental cost and making the SWN artificially attractive for existing operators to migrate their traffic;
- indirect public subsidy of the SWN, through subsidised provision or more favourable terms for the use of spectrum, or preferential access to Government property to install sites etc;
- directing all Government contracts to use the SWN; and
- artificially restricting the services existing operators can offer using their existing networks/spectrum compared to the SWN, or imposing

Co-existence between an SWN and existing mobile networks

'obligations' on existing operators, all of which would be unnecessary under network competition.

While these measures are beneficial for the functioning of an SWN in the short-term, they would be expected to distort competition, and could potentially harm consumers in the longer-term, see text box below. In particular, if the SWN continues to co-exist with existing networks in the longer term, this might require continued interventions to keep the SWN viable. This would likely have a negative impact on consumers that will be reflected in higher prices and lower quality of mobile services, in line with what we typically observe in other markets where Government-subsidised entities require increasing funding to survive in competitive markets.[58]

58 An example of such continuous and inefficient Government intervention would be public subsidies for automotive industry in Australia (see http://www.abc.net.au/news/2014-01-31/productivity-commission-calls-for-an-car-industry-bail-outs/5231324)

Co-existence between an SWN and existing mobile networks

Maintaining competitive neutrality

Existing SWN proposals around the globe so far have been initiated by the states or Governments and envisage some degree of public participation in the ownership and operation of the network. While this could mean benefits for the SWN itself, there is a risk that this comes at the expense of a loss of competitive neutrality. Competitive neutrality might be at risk if the SWN receives a favourable treatment compared to other network operators which give it a competitive advantage that can't be replicated.

The OECD point out that competitive neutrality enhances economic efficiency and benefits 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*"[59].

In order to maintain a level playfield between the participation of the public sector in the economy and private undertakings the OECD make several recommendations including the following[60]:

- If the SWN receives compensation for a public service obligation (PSO), such as a coverage obligation, it will be necessary to identify the costs of the PSO in order to promote transparency and disclosure. This should ensure that the compensation covers only the true cost of the PSO.

- Procurement policies and procedures should be competitive, non-discriminatory and safeguarded by appropriate standards of transparency. Rather than in-kind payments, "*the most precise and transparent mode of compensation is direct payments provided from public sector budgets*"

- The Government participation should earn a rate of return like comparable businesses. Otherwise the costs of the SWN would be below the efficient cost of the provision of the service and private sector operators would be undercut.

- The Government businesses should operate to the largest extent feasible, in the same tax and regulatory environment as private enterprises. The OECD recommends that "*Differences in treatment between public and private businesses should be removed; where not possible, some jurisdictions confer tax or regulatory treatment equally among market participants*". If there are tax derogations, they "*should be made transparent and narrowly established*"

59 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

60 Idem

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- Debt neutrality must be tackled in order to achieve competitive neutrality. Government businesses, including the SWN, may benefit from special conditions in financial markets because of the Government backing.

In addition to the possible distortions to competition discussed above, the very existence and creation of an SWN could significantly increase uncertainty about the future, as the future evolution of the SWN will be unclear. Operators will likely face significant uncertainty in trying to assess whether or not to migrate traffic from their existing networks and rely instead on the untested SWN. They may also 'wait and see' whether other operators do first, since the success of the SWN is likely to depend not on the demand of any single existing operator, but on the collective demand of all of them.

During this period, there is a risk that existing operators put on hold investments in their own networks until the long term outlook becomes clearer.[61] This uncertainty may also have a negative effect on the overall investment climate in the country, which raises additional concerns about the implementation and financing of the SWN project in the first place.

In summary, we conclude that the SWN is not simply just another 'network competitor' which can be introduced into the market, but is a very particular type of competitor which is likely to create significant distortions in the market and could lead to worse outcomes for end users.

6.3 Conclusion

Based on the analysis above, we find that:

- The SWN under the co-existence scenario will increase rather than reduce the level of network duplication, which will likely lead to higher unit costs for the whole industry in a static sense. In addition, the SWN could lead to inefficient use of spectrum.

- The SWN will operate as a wholesale network provider with no retail function and some form of public intervention is likely to be required to artificially 'favour' the SWN and ensure that it captures traffic and reaches sufficient scale. This could take several forms, all of which are likely to distort competition in the market, to the detriment of consumers in the long-run.

61 The perceived risk of investors will likely be higher during this period of uncertainty, and increase the cost of financing for existing operators, which could further limit their ability to compete.

- The future of the SWN during the period of co-existence will be uncertain and this uncertainty could reduce investments in all networks in the country.

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7 Implementing and regulating SWNs

In previous sections, we have addressed claims that SWNs will deliver greater coverage, faster coverage or lower costs than network competition. We have also shown that innovation has a critical role in expanding the benefits of mobile communications, and that SWN are unlikely to have the same incentives to innovate and adopt new technologies as network competitors.

Advocates of SWNs may argue that some of these concerns can be overcome if the SWN is designed and regulated appropriately. This section therefore addresses those implementation issues and considers the challenges which Governments will face in first establishing an SWN and then regulating its conduct to realise the Government's objectives. We contrast this with network competition where, aside from allocating spectrum to the network operators (and potentially setting coverage conditions), the Government and regulators typically have a far more limited role.

The challenges we identify are divided into three categories:

- challenges associated with the initial establishment of the SWN;
- challenges associated with the ongoing operation and improvement of the SWN; and
- challenges associated with the risk of failure of the SWN.

SWNs are likely to be complex and expensive projects, which will require involvement of a range of stakeholders, with often opposing or diverging interests and incentives. Independent of whether the SWN is financed from private or public sources (or a combination of the two), establishing the SWN will be challenging. We show below that the involvement of the existing operators in both ownership and management of the SWN is likely to be essential for the potential success of any SWN project. Also, the SWN will inevitably lead to pressure on Government finances, and this pressure will be substantially higher, absent a meaningful involvement of the existing network operators.

We then discuss the challenges of ongoing operations of the SWN. We show that the SWN, as a monopolist, will have to be regulated; otherwise it will set inefficiently high prices, and will have fewer incentives to reduce costs or invest in innovation and new technologies. The regulator will therefore need to 'force' the SWN to try to 'emulate' a competitive market. The lack of competitive incentives on the network and the desire to see competition in the retail market means that SWNs will require complex regulatory arrangements. The areas where regulation will be necessary include coverage and performance targets and access pricing. We show that there are significant risks and difficulties related to setting, monitoring and enforcing these key parameters through the SWN regulation.

Finally, we briefly discuss the risks of the SWN being implemented and subsequently failing to deliver its objectives. As we saw in Section 2, there are a number of scenarios under which the SWN could indeed fail if it is unable to generate enough retail demand to support the network. We consider the significant negative impact this would have on the mobile sector and the wider economy.

7.1 Establishing the SWN

A mobile SWN is likely to represent a very substantial investment, which will need to be funded through public or private sources or a combination of the two. The majority of currently proposed SWN projects consider some form of private funding will be involved. Below, we discuss the key challenges and risks related to establishing the SWN, assuming the project will be at least partly funded by the private sector. The additional risks and challenges related to fully publicly funded SWNs are discussed in more detail in Section 8.

- **Meaningful involvement of existing operators in the SWN is likely to be important for the functioning of the SWN.** Without support from the existing operators, the SWN may find it very difficult to develop its business. The SWN will need to acquire or lease assets from the existing operators in order to limit the cost of inefficient network duplication. Furthermore, in many countries, there is a limited pool of resources with engineering and operational skills. Most of those who hold these skills are already employed by the operators.[62] The involvement of the existing operators would therefore be needed to decrease the perceived investment risk for other shareholders.

- **The number of owners and the nature of the owners will affect the complexity of establishment and implementation.** In simple terms, the more participants that need to be accommodated the greater the implementation challenges. But the incentives of the participants are equally important – Government and private shareholders may have different objectives for the SWN and different perceptions of risk and return. Even amongst private shareholders, key differences will arise between participants who are also retailing in the downstream market (and may therefore wish to earn profits there) and participants who seek only to realise returns from the SWN. Furthermore, amongst operators themselves, some may wish to expand the scope of the SWN to overcome disadvantages they believe they

62 The Government could seek to recruit new personnel from outside the country, or may seek to sub-contract the entire operation to a third party vendor or a foreign operator, but this will involve delay and risk.

face under existing network competition arrangements, which will in turn make it more complex to arrive at an agreement regarding the investment and shareholding of the different stakeholders.

- **Government involvement will affect the performance of the SWN.** The Government or regulator will have a central role in determining the cost and revenues of the SWN, by setting the targets for network investments to achieve coverage obligations as well as setting the wholesale prices that the SWN will be able to charge to recover these investments. Private investors will wish to fully understand these factors before they commit funds to the project. They will also seek safeguards which ensure that long term commitments are made about issues such as the objectives of the SWN, the governance arrangements, the prices it charges to its wholesale customers and the possibility of competition or other changes in the future environment, all of which will affect the likelihood of earning a return on the investment in the future. These may be required over a funding period of 15-20 years. These private investors will require reassurances that the current Government can make commitments on behalf of its successors, and that the regulator cannot and will not intervene at a later date to change the terms on which the original investments have been made. Without such assurances, private investors are likely to conclude that the regulatory and political risks associated with participation in an SWN are either unlikely to justify the investment, or require significantly higher and earlier returns than the Government would be prepared to agree to, to compensate for these risks.

- **The SWN could negatively affect performance of the private networks.** Unless the existing operators have a significant shareholding in the venture, a Government sponsored entity, even if partly privately financed, is likely to reduce the value of existing operators and raise fears that the Government will distort the market so as to ensure the success of the SWN to the detriment of other participants. This could have a chilling effect on investment, both private investment and FDI, to the extent that investors consider the SWN to be an unexpected 'change' in Government policy and during the period of the negotiations for its establishment, which are likely to be protracted.

Therefore, the challenges of establishing an SWN are likely to be significant. In practical terms, they are likely to require:

- identification of potential investors;
- agreement of strategic objectives and funding requirements (both equity and debt) over a 10+ year period;

- formulation of a regulatory regime and agreement of the terms on which an SWN may wholesale to customers;
- conclusion of a detailed shareholder agreement, including governance and the terms on which founding shareholders can exit and new shareholders can join;
- formulation of a detailed business plan;
- agreements with existing operators for the use or acquisition of towers and other assets;
- agreements with contractors (with appropriate financing arrangements); and
- recruitment of a board, senior management team and employees.

7.1.1 Challenges in setting up the SWN

Experience suggests these steps will take years rather than months to complete, and that it may not be possible to secure agreement at all if private investors are involved or if assets are to be acquired or leased from existing operators. If these negotiations are unsuccessful and the Government then reverts to a network competition model, the costs of delay could be very significant indeed For instance, the one year delay in allocating 800 MHz and 2.6 GHz spectrum to UK mobile operators was estimated to have cost British businesses more than £700 million.[63]

There are very few examples of SWNs which have actually been established but what evidence we have would tend to support the views outlined above. In Kenya, for example, the Government announced in November 2012, that it would begin deployment of a wireless 4G SWN, funded through a public-private partnership. This has yet to occur at the time of writing. In the Government's latest spectrum policy document, it summarises the challenges which it has faced as follows:

> *Efforts by government to encourage operators to roll out an open access network have not been successful. Between 2010 and 2013 the government, twice, unsuccessfully tried to deploy an open access network by adopting an Special Purpose Vehicle (SPV) model in which the government had encouraged existing operators to jointly invest in an open access network. In this model, the government was to be part of the consortium by providing the necessary frequency spectrum resources for free as its contribution while the private sector was to meet all other costs related to the deployment and operation of network. Later, the government also invited all licensed ICT operators, vendors and*

63 An estimate by Open Digital Policy Organisation (see http://www.ft.com/cms/s/0/b943abe2-f10a-11e0-b56f-00144feab49a.html#axzz2yOhLuGjC)

> *private equity investors to form an SPV to build operate and maintain a national open access mobile Broadband network. Those invited by the government were not able to agree on the best way forward and the effort collapsed.*[64]

We can also derive some lessons from experience in the establishment of fibre-based 'next generation' SWNs, although again it is notable that we are aware of only three examples of nationally based fixed SWNs in the world today. There is a crucial distinction between these fibre-based SWNs and wireless SWNs which we consider in this report, namely that economies of density are likely to be more significant in fixed networks than wireless networks.

Examples of fixed national SWNs occur in Singapore, New Zealand and Australia.[65] We note that none of these three countries has applied a similar model in the deployment of next generation mobile networks. We discuss these three examples of fixed SWNs in more detail below.

Singapore

Singapore's experience appears unlikely to yield many lessons for other markets or for wireless SWNs. Singapore has the world's third highest population density and one of the most digitally advanced economies in the world.

This means that the motivation for the SWN model was not an extension of rural network coverage, but a belief that:

- structural separation of different elements of the passive and active networks would promote greater innovation and competition; and
- the market would always be likely to support the rapid deployment of next generation infrastructure, whether by a vertically integrated operator or an SWN.

The Government sought applicants in late 2007 to build a national NGN network and awarded the contract to a four way joint venture, OpenNet, which is privately funded.[66] Construction of the network commenced in 2009 and now appears largely complete.

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64 Kenya Wireless Broadband Spectrum policy Guidelines (See http://www.information.go.ke/wp-content/uploads/2014/03/DraftSpectructionPolicy.pdf)

65 We are aware that there are many local and regional fixed fibre network initiatives, some of which involve wholesale only models. These can be found in Sweden and in the United States, for example. The record overall is mixed. An example is Utopia in Utah, United States, which has sought both Government and local authority funding (the latter in the form of security for long term bonds). The project has encountered numerous funding difficulties over the past decade and serves only 11,000 households today.

66 The 'active' network layer was developed by Nucleus Connect, a wholly owned subsidiary of Starhub, the owner of the existing cable TV network in Singapore.

The Government did not, however, adopt the same model for 4G wireless deployment, where network competition between the operators has ensured that Singapore is one of the fastest 4G adopters in the world. In the second quarter of 2014, Singapore's 4G penetration rate at 46% was third highest in the world, only after South Korea (70%) and Japan (47%).[67]

New Zealand

New Zealand has also adopted an SWN approach to the deployment of fibre-based next generation infrastructure. In this case, the Government awarded regional contracts to a number of providers in 2011, including the former Telecom New Zealand network operator, now renamed Chorus, and has committed $1.35 billion to the initiative via a holding company, Crown Fibre Holdings.

Rollout of the network has commenced, but has been affected by regulatory uncertainty about the impact of changes in the copper prices charged by Chorus to its ability to meet the SWN roll out targets contracted with the Government, see text box below. There is also an ongoing debate about whether one of the main existing operators, Vodafone, will retail services over its own recently acquired cable networks rather than use the SWN. It is too early to determine whether the SWN will succeed in New Zealand, and full deployment is not expected to be completed until 2019.

Again, however, it is also important to note that New Zealand has preferred to adopt a network competition model for 4G wireless deployment in a geographically challenging country, although it has also used public funds to support and extend the rural deployment of wireless broadband services in ways which are consistent with the network competition model (and which are discussed in Section 9).

Australia

Australia provides the best known and most ambitious example of fixed SWN deployment in a very large and challenging geography. Further details are provided in the textbox below.

Although it was established in 2008, NBNCo had passed fewer than 500,000 households by the time a new Government was elected in 2013 and the original plans abandoned. The Government is now undertaking a review to determine how to develop a more cost effective solution for Australia given the industry structure which they have inherited from their predecessor and the difficulties in 'unwinding' SWNs which are discussed further below.

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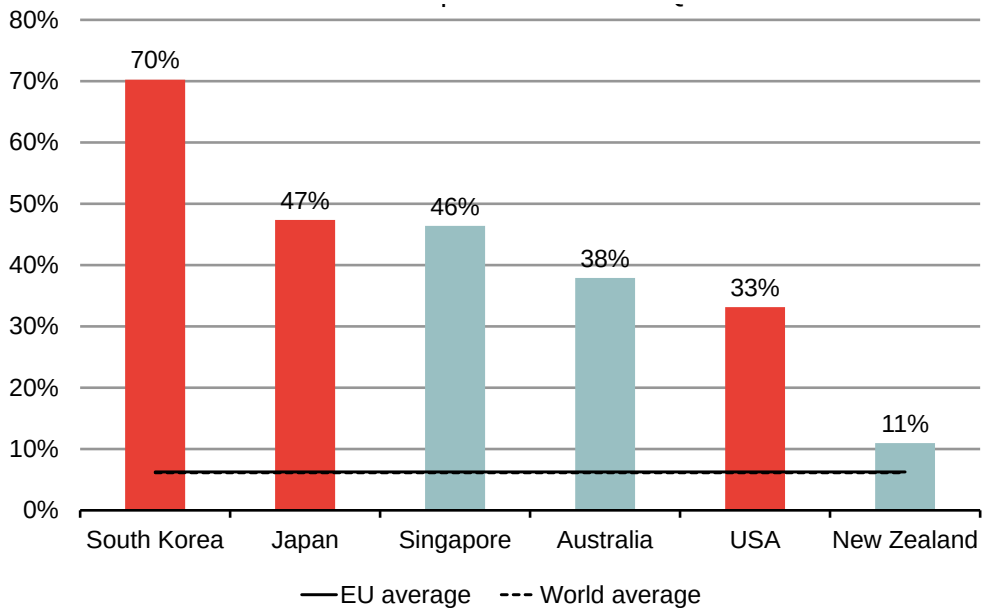
67 According to the GSMA intelligence database.

Implementing and regulating SWNs

It appears unlikely that NBNCo will be abandoned altogether and there is debate, for example, about the incorporation of existing cable TV networks into the NBN plans (the previous Government had assumed that existing cable infrastructure would be decommissioned once NBNCo had built in the relevant area). Again, it is worth noting that there have been no proposals to adopt the SWN model for 4G network rollout, where network competition (including a significant degree of network sharing) has again made Australia an early adopter of 4G technology, alongside South Korea, Japan and Singapore, see **Figure 31** below.

Figure 30. 4G market penetration in selected 'early adopter' countries (Q2 2014)



Source: Frontier Economics based on the GSMA data

Based on the above, we conclude that Rwanda provides the only example of a mobile SWN plan where commercial terms have actually been concluded with private investors - but it is too early to assess the potential success of that project. The failures in Kenya show the significant challenges that Governments face. In fixed networks, Singapore represents a successful SWN deployment, with the Government working very closely with the existing operators. However, the challenges of network deployment in Singapore are unlike anything faced by Governments contemplating mobile SWN projects in Mexico or South Africa. The failure in Australia shows that the challenges of implementing SWNs arise in fixed networks as well as mobile, whilst it is too early to tell whether the New Zealand fibre SWN project will fulfil its aims.

7.1.2 Challenges in financing the SWN

Financing of the SWN is also likely to present significant issues, especially for Governments that face budget constraints and therefore require significant private investment to build the SWN. Whether or not existing operators participate, investors in the SWN face significant risks which are likely to be reflected in the terms which private investors will require in order to participate and the cost of any debt which the SWN obtains. Significant sources of financing risk will include:

- demand uncertainty arising from (a) lack of evidence of demand for 4G services in the retail market itself (b) uncertainty about whether the SWN will be able to capture whatever wholesale demand does arise;
- risk arising from the SWN's inability to control its downstream retail operators and therefore affecting the rate at which its services are adopted or the terms on which they offered to users (a 'vertical disintegration' risk premium);
- uncertainty arising from the lack of existing SWN models in other markets against which investors can benchmark costs and the challenges of cost management in monopoly networks;
- execution risks arising from the risk of disagreements between shareholders with diverse interests, complex governance arrangements, a lack of liquidity in the stock, and the performance of a new, untested management team;
- regulatory and political risks arising from the close involvement of the Government, as shareholder or as regulator or both, and the fact that the SWN is established to pursue a variety of political as well as commercial objectives; and
- risks (for non-operator investors) arising from uncertainty about the intentions of the existing operators, particularly during a period of co-existence.

Any or all of these factors may require a significantly higher return on the capital to be invested, which in turn could increase the financing costs of the SWN compared to the alternative of existing operators developing competing networks. These higher costs will have to be recovered from the consumers of SWN based services or will ultimately be met by taxpayers if Governments have to offer private investors more preferential terms in a public-private partnership arrangement.

National Broadband Network in Australia

In 2007, a Labour Government was elected in Australia, with one of its election promises having been to improve broadband services in the nation. In 2008, it issued a request for proposals from private operators to improve broadband services and announced that Telstra, the leading Australian fixed operator, had been excluded from the contest.

At the end of 2009, the Government announced that it would instead fund a fibre to the home network using public funds, with private investors allowed to hold no more than 49% of the company. NBN Company was founded, with a target to serve 90% of households by 2021. The project would require $(AUS) 43 billion. The Government expected to exit 5 years after completion of the build. NBN Co hired its own employees and sought to develop a network using its own resources.

In 2010, NBN Company entered into an agreement to acquire the existing copper and other assets from Telstra for $(AUS) 11 billion and, in 2012, existing cable networks from Optus.

In 2013, the Labour Government was replaced by a Liberal Government. NBN Co had passed only 350,000 homes by the end of 2013, and was considerably behind target. It had over 2000 employees and the work to date is claimed to have cost twice as much as initially anticipated (over $(AUS) 7 billion). The new Government has stopped further significant construction by NBN Co and most commentators expect that it will now pass only 20% of households with fibre.

7.2 Regulating SWNs

As we have seen, the SWN, as a network monopolist, will have to be regulated; otherwise it will set high wholesale prices and have fewer incentives to reduce costs or invest in innovation and new technologies. The regulator will need to use regulation to ensure the SWN mimics the outcomes of a competitive market, to the extent that this is possible.

Economists and policymakers generally consider that regulation is an imperfect substitute for competition, even if regulators have adequate resources to apply it. The fundamental difference between a competitive market and a regulated one is that in a competitive market, rivals can be expected to have a strong incentive to discover information necessary for them to be able to compete effectively, and then use this information to try and compete.

If, for example, new technologies enable lower cost production, then competing operators have a strong incentive to both monitor the emergence of such technologies, and then to implement them as quickly as possible: a delay in either discovery or implementation would risk them losing revenues, customers and

market share to their rivals. In a regulated monopoly market, this process does not exist: the regulated company has more information than the regulator, and has every incentive to use this information to its advantage. This is why economists generally consider that a regulated market is likely to struggle to generate the same consumer outcomes as a competitive market.[68]

Regulators will typically not have all the relevant information to mimic competition, and this information deficit is worse in uncertain environments, such as the telecommunications sector, where there is rapid demand and technology change. This leads to what economists call "information asymmetry", in which the regulator is trying to set targets (for example, for coverage or when the SWN should upgrade to a new technology) without fully understanding the challenges faced by the network or the needs of its users. These problems are compounded when the SWN is separated from the (unregulated) retail operations.

Another challenge is that regulators might find it difficult to commit to providing the certainty necessary to ensure efficient levels of investment and innovation, known by economists as "regulatory commitment". This means regulation adds to, rather than removes, uncertainty for investors in a new project. This in itself could increase rather than reduce the costs of funding the SWN, and to make the SWN more reluctant to invest in new projects where returns are uncertain or earned over an extended period of time, as is the case for most mobile network investments. Also, to the extent that the Government has a significant influence in the ownership of the SWN, regulation of the SWN may also raise conflicting objectives: for example, the interests of the Government as owner of the SWN may be to opt for relatively higher wholesale prices to try and maximise the chances of the SWN's commercial success, which may differ from its interests as regulator, to primarily protect consumers from too high prices.

Taking this into account, the SWN will therefore need to be required by the regulator to set prices at cost (*allocative efficiency*); that for a given technology, the SWN will have to be incentivised to provide services at the minimum cost *(productive efficiency)*; and that over time, the SWN will need to be given the incentives to invest and introduce new technologies capable of providing new services which are valued by consumers at the right time and at an appropriate pace (*dynamic efficiency*). This is illustrated in **Figure 31** below.

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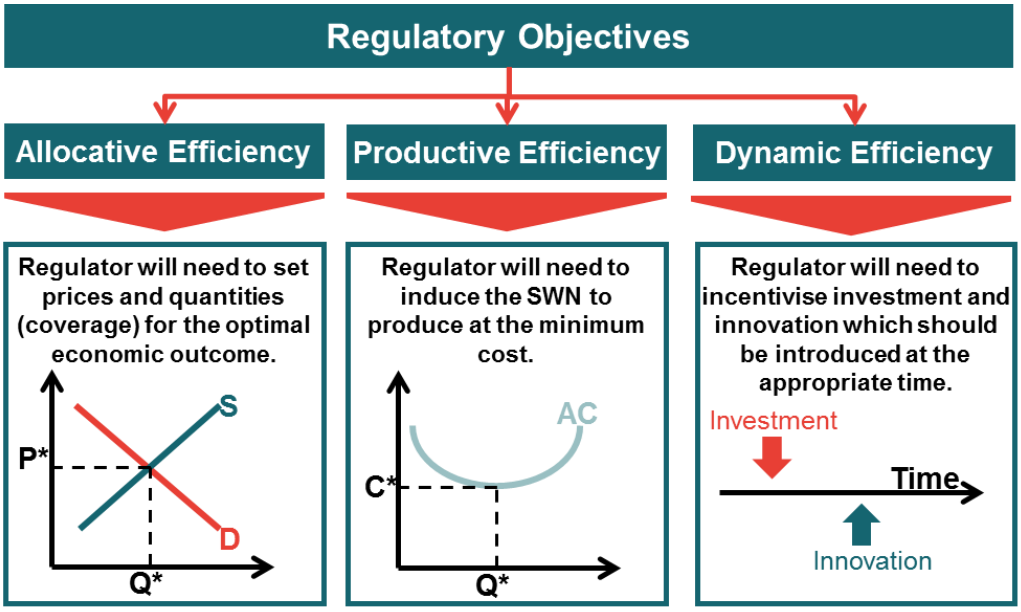
68 *"As a method for obtaining the best deal for consumers, detailed regulation is seen by many to be inferior to systems allowing competition subject to the safeguards of general competition law. Thus Steven Littlechild, in his 1983 report for the British Government on price controls for BT, wrote: 'Competition is by far the most effective means of protection against monopoly. Vigilance against anticompetitive prices is also important. Profit regulation is merely a "stop-gap" until sufficient competition develops"* (see Baldwin and Cave (1999) 'Understanding Regulation: Theory, Strategy, and Practice' Chapter 16 p210)

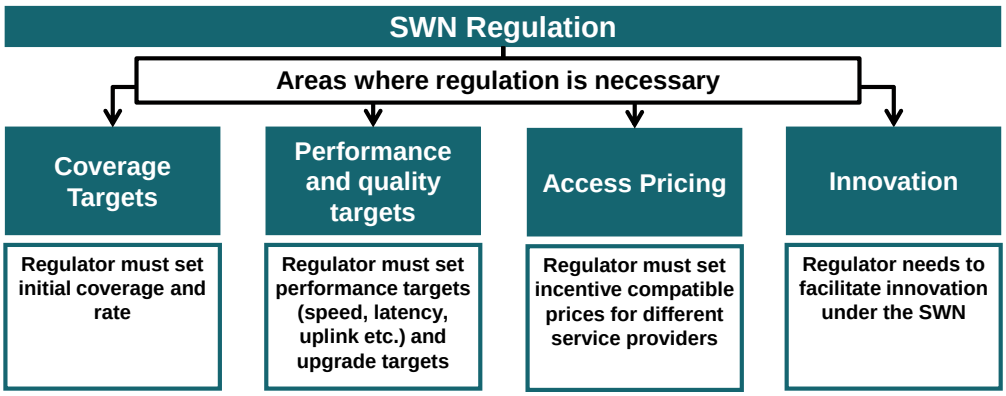
Figure 31. Key regulatory objectives in relation to SWNs



Source: Frontier Economics

The lack of competitive incentives on the network and the desire to see competition in the retail market means that SWNs will require complex regulatory arrangements. Regulators can, for example, set wholesale prices which are intended to encourage the monopolist to improve the efficiency of its operations (e.g. through RPI-X caps), or to encourage retailers to expand their output (e.g. through 'two part' charges). They can also set coverage targets for the SWN in an attempt to accelerate or extend roll out, or require the SWN to upgrade its network at specified dates (e.g. by benchmarking against other countries). They can also define the speeds of the services, or other aspects of the quality of the services to be provided. The areas where regulation will be necessary are summarised in **Figure 32** below:

Figure 32. Areas where regulation of SWN will be necessary



Source: Frontier Economics

Such measures could, if implemented well, go some way towards reducing the concerns of a SWN operating as a monopoly. However, the key question policymakers must consider is whether we could reasonably expect the SWN to be regulated effectively and, even if we could, whether it would outperform network competition.

Coverage targets

Competition drives network coverage in the network competition model. With an SWN, the regulator would need to set initial coverage to be provided, both in terms of the extent of coverage and the rate at which it is to be provided. Since this will determine the funds required for the SWN, and the timing of any returns, the Government or regulator is likely to have to set coverage targets for many years in advance before the SWN can be established.

This will be challenging as the regulator will have to specify the efficient level of coverage without having good information about the future demand for mobile services or the long term costs of the network itself. A common approach in these circumstances is to 'benchmark' against the outcomes of network competition in 'comparable' countries, but in this case, it may not be clear how far network competition will extend (for example, for 4G over 700 MHz). The regulator could delay the establishment of the SWN until this becomes clear, but such a delay would clearly carry significant costs itself.

Even if realistic coverage targets are set, conditions may change. The SWN will often depend on other entities, such as site owners, to fulfil its coverage targets. The regulator would need to set mechanisms to determine who is responsible for failure in case the SWN does not reach its targets. A related issue will be sanctions in case the SWN does not fulfil the targets, as these would need to be set in a way that incentivises the SWN to rectify its potential failures. On the

other hand, merely fining an SWN for non-performance simply reduces the funds that are available for additional coverage.

The experience of the British cable industry provides an example of these challenges. In the 1980s, a large number of monopoly licences were awarded to firms to build cable TV networks in the UK. Each included detailed construction targets (measured in terms of households passed by the network), almost none of which were met. In all cases, the UK Government was forced to renegotiate the coverage targets and to accept significant delays. The monopoly licensees faced no real competitive threats which forced them to build, and the Government had no alternative option than to hope that the monopolists could be persuaded to meet their obligations. A Government establishing an SWN with private funding and ownership takes a risk of finding itself in a similar position.

Performance and quality targets

The regulator will also need to regulate quality or performance of the network services provided by the SWN. Again, the regulator will need to re-create the incentives of competitive markets by selecting the right QoS indicators (those valued by customers), by setting the right targets and by introducing an effective monitoring and enforcement system.

In particular, the regulator would also need to set clear targets with respect to the timing and scope of network upgrades. It is not clear, however, if these targets should be defined in terms of outputs achieved or technology used. For instance, would the regulator require that the average network speed must increase from X to Y in the certain period of time? Or would it require that the X% of the SWN relies on certain technology (e.g. HSPA+) by a certain year?

This creates additional challenges in defining how the timing of the upgrade is determined, as it would likely involve benchmarking against developments in other markets. Again, if the regulator waits until 'comparable' markets have already made their upgrades, then the SWN is likely to be late. If it seeks to establish targets too far in advance (as investors will require), there are risks that unforeseen factors will make the targets appear too demanding or too lax. Either way, they are likely to be inappropriate to the market conditions actually prevailing at the time the target applies.

Access pricing

The regulator would also need to set the access charges to be levied on wholesale customers of the SWN - both at the start and throughout the life of the SWN. Setting efficient access prices in relatively stable fixed networks is challenging itself and there are very few examples of regulated wholesale charges in much more dynamic mobile networks to draw upon. Regulators will need to ensure charges that both:

- allow for competition and innovation in the downstream retail market by providing the right incentives for cost reduction and investment; and
- allow the SWN to properly recover its efficient costs[69].

The regulator will want to ensure that any efficiency gains made by the SWN are passed onto to the retailers and then onto consumers in the form of lower prices. But the regulator cannot assume that the SWN, a monopolist, will volunteer to pass on these savings. Instead, most regulators would set targets for the SWN, allowing it to keep any savings which exceed the target but requiring it to pass on savings up to that point (even if the SWN is not, in fact, able to meet the target). There are several challenges with this, which we discuss below.

- There is a significant challenge in setting access charges while the existing operators co-exist with the SWN.

  Firstly, setting wholesale prices to reflect the actual cost of the SWN will be challenging due to demand uncertainty around overall take up of 4G services. The regulated access prices will inevitably be a function of the demand forecast (given high fixed costs required to build the SWN) and if realised demand is lower than forecast, the SWN will not be able to cover its fixed costs. Moreover, during the co-existence period, the SWN will largely depend on the existing operators to generate sufficient demand for the SWN wholesale services. The lower the wholesale access prices, the stronger the incentive of existing operators to migrate their traffic to the SWN and the lower expected unit cost that the SWN needs to recover through wholesale access prices. This circularity is likely to create additional uncertainty for the SWN's ability to set 'right' access prices allowing it to recover its costs.

  Secondly, as explained above, the regulator is likely to set an 'average' access charge which will apply throughout the SWN network. However, the actual network costs of providing coverage will vary between areas. This means that existing operators may use the SWN to provide 'below cost' access in areas which are otherwise expensive to cover, but will continue to use their own networks to support traffic in other areas. In these circumstances, the SWN will quickly find that it is unable to recover its costs. The regulator may then seek to raise the access charges, only to find that the traffic then migrates onto the existing networks again.

- Setting access prices to mimic the way in which cost savings are passed onto retail customers under network competition is difficult. Under network

69 Wholesale access prices will therefore be a key determinant of the SWNs financial performance, expressed in terms of Return on Investment (ROI) and Return on Assets (ROA). Both of these measures could be used by the regulator to ensure the SWN is earning an appropriate return on its investment.

competition, operators may charge prices that reflect their marginal costs of providing network coverage to users. Marginal cost retail pricing will be much more difficult under a regulated SWN arrangement, since regulated access prices will tend to be 'average cost' prices, intended to allow the SWN to recover its total costs across all customers in a uniform manner. This means that, even if the total costs of the SWN may be lower (which in itself is doubtful), the retail prices faced by users may nonetheless be higher than those they would face under network competition.

- Under network competition, different operators can also differentiate their retail prices to distinguish between different groups of retail customers (since the operator is vertically integrated and controls both its network costs and its retailing operations, including its pricing strategy). Network competition has been extremely effective at achieving high levels of penetration in low income markets, largely because of this ability to differentiate prices according to user demand. Under an SWN, in contrast, the wholesale prices faced by all retailers will likely be the same (and reflect potential regulatory obligations not to discriminate), significantly reducing the ability of retail providers to differentiate their prices. This is likely to affect particularly lower income subscribers, as operators will find it more difficult to offer viable price packages to such subscribers if they have to pay a wholesale price that reflects the 'average' cost of serving all customers. As a result, the SWN is likely to achieve lower penetration rates in the retail market than network competition.

- We recognise that there are ways in which regulators can try to promote greater retail price differentiation – for example, by setting 'two part' access prices which involve a fixed pre-payment for capacity on the network and a lower 'usage based' fee, which is only incurred if the wholesale customer generates usage. This, however, raises other challenges: smaller retailers may find that such fixed fees are a barrier to entry and thus be unable to join the SWN, whilst larger retailers may argue that this involves them assuming too much of the risk of financing the SWN without enjoying the benefits of being a shareholder. This shows not only how complex questions of access pricing are, but also how regulatory objectives and financing objectives are closely interrelated.

- Moreover, setting an efficiency target in a slow moving mature network such as energy or transport is feasible, but setting an efficiency target for mobile networks which are undergoing rapid technological change is significantly more challenging[70]. As noted previously, investors in the SWN will want to

70 We note that some regulators have set RPI-X targets for a single mobile service, call termination, which are intended to capture the kind of efficiency savings we refer to here. These modelling

establish these targets before they agree to invest, and to require the regulator to 'commit' to them for an extended period. Both requirements add to the challenge – the regulator is being asked to determine the costs of a new network before it has been built, and then to commit to targets even if they subsequently prove to be wildly inaccurate.

Challenges of access pricing: Chorus

Chorus is a wholesale only provider of fixed telecoms services in New Zealand, established in 2011 with targets to roll out a network to offer superfast broadband connections to 75% of the population by 2019.

The New Zealand regulator is required to set access prices for some existing copper services by benchmarking against prices in other countries.

When the regulator announced new prices in late 2013, Chorus said that it could no longer meet its commitments to the Government to build superfast broadband as a result of these new prices. The Government commissioned an independent study, which confirmed that although Chorus would face a $1 billion 'funding gap', it could achieve efficiency savings to close $750 million of this gap.

The regulator is now reconsidering the access prices that Chorus will charge in future, this time using a cost model instead of benchmarking. Earlier attempts by the Government to override the regulator failed to secure enough votes in Parliament.

Non-price terms and conditions

Non-price terms and conditions offered to wholesale customers, including issues such as notifications of network disruptions, network recovery and other issues will affect the capacity of the retailers to meet the expectations of their customers. Again, a significant amount of regulatory effort is likely to be required to ensure that the SWN does not favour one set of wholesale customers over another – whether because they are also shareholders in the SWN, are simply much larger customers than their rivals, or for other reasons. Monitoring and detecting such non-price discrimination is notoriously difficult, but will be a key requirement of any SWN.[71]

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exercises have proven to be extremely complex, and the risks of error have been mitigated by the fact that call termination accounts for only a small proportion (less than 20%) of the operators' revenues. Under the SWN proposal, regulators will be setting efficiency targets for all services supplied by the SWN, with much greater risks of error in consequence.

71 Attempts to monitor and eliminate non-price discrimination in fixed telecoms markets have largely failed in both the US and Europe, at least to date. The US abandoned access obligations as a result; whilst the European Commission has recently (2013) announced further measures in attempt to guarantee 'equivalence' or non-discrimination between wholesale customers of fixed networks.

Innovation

We have previously considered the challenges of incentivising network innovation by a monopolist. However, there is another important aspect of innovation which is also a challenge for regulators. Under conditions of network competition, the diverse and varied needs of consumers can be met by different operators in different ways. Each may operate and run its network in slightly different ways in order to develop retail products which fulfil different needs. If one operator fails to address a particular requirement, it is likely that another network will do so instead.

Under the SWN conditions, it might in theory be possible for the SWN to provide a sufficient range of varied wholesale products to allow the various competing retails to meet the needs of consumers in exactly the same way. However, in practice, it will be extremely challenging, if not impossible, for the SWN to do so.

First, there will be technical and practical limitations to offering every retailer the variety of wholesale products that is conceivable under conditions of network competition. In order to offer one kind of service, for example, it may be technically necessary not to provide another (such as if there are interference issues). Or it may simply be too complex to develop low volume scale bespoke wholesale products to meet each and every demand from the wholesale customers.

Second, regulation will find it difficult to facilitate such innovation. The SWN is likely to be subject to various non-discrimination rules which, although they may not in theory inhibit the supply of different products to different wholesale users, will in practice have this effect. Experience from other functionally or structurally separated telecoms models – for example, Openreach in the UK – suggests that the SWN will strongly prefer to supply undifferentiated, mass market wholesale services on identical terms to all parties, and will resist calls to invest in the development of narrower or more specific products to serve particular groups of users. Thus, for example, a significant criticism of Openreach in the UK is that it supplies a range of consumer products on standard terms, but that it has failed to develop high quality business products which are also required.[72]

As a result of these factors, an SWN is unlikely to facilitate as wide a range of retail products as we might expect to see under conditions of network competition, even if there is effective competition between retailers. Competition and choice will instead be restricted by the limitations of the SWN itself, some of

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72 For recent examples of business products requested by UK retailers and operators, but not provided by Openreach, see Frontier Economics report for Vodafone "Passive Access in the Business Connectivity Market" available at http://stakeholders.ofcom.org.uk/binaries/consultations/business-connectivity-market-review/responses/Vodafone_Annex_2.pdf

which will arise from the regulatory arrangements which are required and some of which will arise from the lower incentives to innovate of the SWN itself.

7.3 Managing risks of failure

In previous sections, we have explained that the challenges in establishing and overseeing the ongoing operations of SWNs are likely to be formidable. We think this explains why the few Government-led initiatives that have been attempted have taken years of negotiation, required substantial financial commitments of public money, and many are yet to yield any clear results.

If SWNs fail before networks are built and customers served, then the costs to society will be the delayed development of mobile services in that country. It will be very difficult for investments in network competition to be made whilst SWNs are under discussion, often because:

- the Government will be reserving most or all of the relevant spectrum for the SWN rather than allocating it to the industry; and
- as explained above, the SWN proposals will introduce significant additional uncertainty about the future development of the overall mobile market in that country.[73]

A different and more challenging situation arises if the SWN is implemented, in whole or part, but then fails to deliver its objectives (see text box below for a recent example from fixed broadband networks). This could arise for a wide variety of reasons, examples of which might include:

- the withdrawal of key investors or refusals to provide further funding to the project (for example, because returns fall below original expectations);
- lack of demand for the services offered by the SWN, either because they fail to meet the needs of retailers or retailers find ways to bypass the SWN;
- disagreements between the regulator and the SWN about targets, including the appropriate level of access pricing; and
- management failure in the SWN leading to network failures.

Failure of this kind in conditions of network competition will normally result in inconvenience and disruption to customers as they are forced to migrate to another network. Although examples are rare, mobile operators that have

73 However, once these discussions end and the SWN proposals are withdrawn, it should be possible for confidence to return to the market and for network competition to proceed vigorously.

become insolvent or otherwise withdrawn from the market have been able to do so without major disruption to users. In this sense, duplication also provides a degree of resilience which is not available in the SWN model. Spectrum and other assets can be transferred to other operators, and capacity added relatively quickly.

The SWN, in contrast, represents a single point of failure for the mobile communications of society as a whole. By its nature, the SWN will not be duplicated by the other networks of the existing operators (assuming these have not already been contributed to the SWN). Any operator seeking to serve the demand normally met by the SWN would first have to build a new network, which is likely to take years rather than months to achieve. In the meantime, users of the SWN may experience service disruption, congestion or other consequences of inadequate investment, poor management or both.

Governments need to think carefully about the implications of the risk of failure in SWNs. One implication is that the owners of the SWN, if they are not the Government itself, are likely to have significant bargaining power because the country now relies upon a single supplier to fulfil a significant part of its communications requirements.[74] In matters of energy security or the supply of other essential services, Governments around the world generally seek to diversify their sources of supply in order to avoid dependency on a single source. In the case of SWNs, however, the opposite is proposed: abandoning the diversity of network competition in favour of a single supplier.

This is likely to mean that the Government would have to underwrite the SWN if it were to fail. If a Government were unable or unwilling to do this, then the risks of catastrophic failure for the society as a whole could be significant. On the other hand, network competition present fewer risks at the outset, while there is no risk that a call would be made on Government funds in the unlikely event of catastrophic failure.

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74 This may be illustrated by developments in Singapore, where the Government originally established a fibre SWN in 2008, with complex ownership separation arrangements between the owner of ducts ('AssetCo') and the passive network operator ('Netco'). In 2013, the regulator, the IDA, approved the reintegration or consolidation of these entities in order to '*enable efficiencies to be realised due to the increased level of integration*' (IDA, para 11, at http://www.ida.gov.sg/~/media/Files/PCDG/Consultations/20130828_LongFormConsoOpenNet/Explanatory_Memorandum.pdf). Commentators suggested: 'with hindsight I would argue that the chosen solution was over-engineered and was unlikely to work in a market where some of the retail competitors ended up with economic interests in some of the theoretically separate upstream entities. In part, this was because an overly complex solution was imported from another market without sufficient regard to the local market conditions and the practical difficulties of achieving de facto ownership separation in a small and concentrated market such as Singapore. Whilst it is too late for Singapore to rethink its regulatory structure in this space, there are lessons for other jurisdictions considering appropriate regulation of subsidised fibre roll-out.' (see http://robbratby.com/page/2/)

7.4 Conclusion

Establishing the SWN will be a challenging task, although SWNs are unproven and there are no working models available anywhere in the world for us to assess. This noted, we think the involvement of the existing operators in both ownership and management of the SWN is likely to be critical to the success of any SWN project. However, involving the existing operators in the establishment of the SWN will make governance very complex.

The one thing we are confident about is that establishing an SWN is likely to involve long and difficult negotiations amongst a wide range of parties. Whilst this happens, no network is being built and investors in the existing operators may withhold any further investments until the outcome of the process is clear.

The lack of competitive incentives on the network and the desire to see competition in the retail market means that SWNs will require complex regulatory arrangements. It is, however, very difficult for regulators to set targets or prices for a network that has yet to be built, particularly in an industry where technology can change in unpredictable ways.

The risk of failure of an SWN seems to us to be substantial. The market conditions might change, making the SWN unattractive for existing operators, the regulatory environment could change, or private investors may simply conclude that they no longer wish to fund the business. In such circumstances, it is likely that the Government would need to take the SWN into public ownership in order to avoid a catastrophic disruption of the mobile communications of the country.

8 Impact of ownership on SWN's performance

Our analysis of the performance of an SWN relative to network competition has so far largely ignored the question of who owns the SWN. We noted in Section 2 that network competitors tend to be privately owned and that the vast majority of the investment in mobile networks around the world has been made by private investors rather than Governments. SWNs could in principle be privately owned, but this would likely increase significantly the costs of financing the SWN and the risks of consumer disruption in the case of failure, and so some element of Government funding or ownership is likely to be required. The Rwandan SWN is a joint venture between the Government and Korea Telecom. The Russian Government proposes to own and operate an SWN, apparently without private sector involvement. The ownership arrangements being contemplated in Mexico, Kenya and South Africa are still under development.

Ownership arrangements may also change over time. In Australia, for example, the previous Government's plan for NBNCo, a fibre based 'SWN' model, anticipated that the Government would sell down its holding to private investors once the project was established. It is possible to envisage similar arrangements with SWNs. In Section 7.1, we suggested that Governments may be tempted to assume greater control of the SWN at the outset, given the challenges of securing agreement amongst a wide range of private investors who might otherwise be asked to fund the project.

In this section, we consider the implications of different ownership arrangements on the performance of the SWN. Some advocates of SWNs appear to be also advocates of public ownership, although there is no necessary relationship between the two. In other words, it is possible to have state-funded network competitors, and also to have privately funded SWNs.

We consider both the challenges that are likely to arise if the SWN is to be privately owned or Government owned and the evidence from other industries of what we might expect these challenges to mean for the overall performance of privately owned and publically owned assets. We consider ownership in terms of:

- private ownership in general, including participation by equipment vendors;
- private ownership by local shareholders and private ownership by large, multi-national companies or investors; and
- Government or public ownership.

We find that private ownership of SWNs is likely to present significant challenges in terms of attracting investors, including the existing operators, to participate. However, the available evidence indicates that privately owned investments are in general, though not universally, likely to be better managed and to perform better

than Government owned assets. An SWN with significant/full Government ownership is likely to be easier to organise, but there is a much greater risk that a fully Government owned SWN will perform less efficiently and may therefore ultimately fail.

Private and public ownership can also be combined, either in the form of conventional joint ventures, "build, operate and design" licences, public private partnerships (under which Government contracts with the private sector to finance and operate the infrastructure) or various other contractual arrangements. Whilst we do not consider these separately, the issues which we identify in relation to private or public ownership will be expected to apply to these arrangements to varying degrees.

8.1 Implementation challenges

8.1.1 Private ownership

An SWN is likely to represent a significant investment which must be substantially funded from the outset and which will then be expected to earn returns for investors over many years. Private investors have shown themselves willing to fund network investments in the mobile industry under a wide variety of conditions of network competition. However, the SWN concept will be unproven and unfamiliar to these same investors.

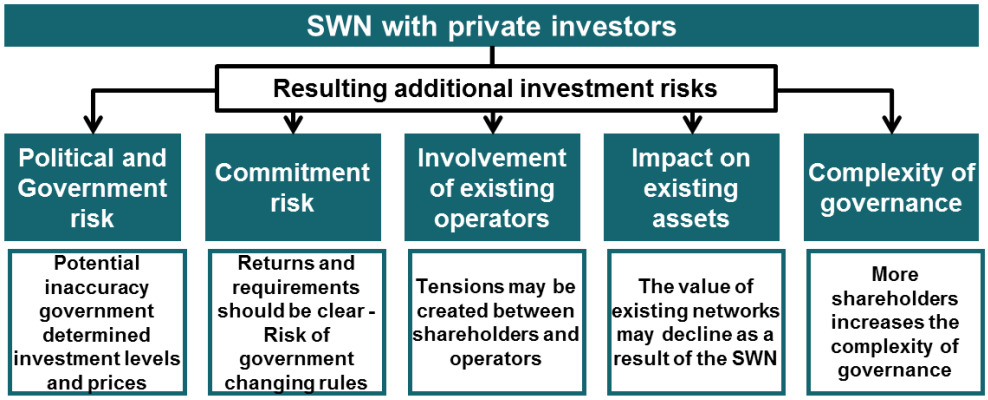
It might be argued that SWNs will actually reduce investment risk since some of the risks of duplication are removed. Uncertainty about whether a network operator will be able to capture a sufficient share of the retail market is removed if all retail demand in the country is to be served by the SWN. As we saw in Section 2, this would be the case if all retail competitors, including all existing operators, were themselves to hold an ownership interest in the SWN, but might not be the case otherwise or if there is an extended period of co-existence.[75]

However, the SWN also introduces a range of new risks for private investors which are not present with network competition, introduced in Section 7 and summarised in **Figure 33** below.

[75] In addition, there might be a lower perceived investment risk if the private investors consider that a Government initiated infrastructure project such as an SWN has a lower risk of failure, as it can potentially rely on the Government as a lender of the last resort. At the same time, as discussed in Chapter 6, there are significant additional risks related to SWN.

Impact of ownership on SWN's performance

Figure 33. Investment risks for private investors in an SWN



Source: Frontier Economics

- **Political and Government risk**: The Government, not the market, will determine the investment requirement to meet coverage and performance targets and will set the access prices which are needed to recover those investments. These will need to be clear and predictable over 10+ years, with no risk of a new Government or regulator changing the rules. It is notoriously difficult for Governments to provide such commitments over a long period of time, resulting in private investors requiring higher returns to reflect the risk of reneging. This creates additional 'execution risk' for investors, as the SWN will represent a 'greenfield' development by a new, untested management team who will have no prior experience of building SWNs (rather than invest in an existing mobile business).

- **Involvement of existing operators:** The involvement of existing operators as shareholders is likely to be essential if the SWN is to succeed and their exclusion will make the SWN much more difficult to fund. However, the involvement of existing operators also makes establishing the initial agreement and subsequently managing the SWN more complex.

- **Impact on existing assets:** the SWN will either represent an additional network competitor or will come to replace the existing networks. However, there may be a long period of uncertainty until it is clear whether the SWN will come to dominate, fail, or simply co-exist with the existing networks. During this period, there is a risk that private investors will be reluctant to invest in either existing networks or the SWN.

- **Complexity of governance:** Having more private shareholders in the SWN will help to diversify risks for all owners, but it will again also increase the complexity of establishing and governing the SWN.

We discuss these issues in more detail below.

Risks for private investors in general

The most significant risk for private investors considering an SWN is likely to be the central role played by the Government or regulator in determining how much and when the SWN must invest in order to achieve coverage obligations or to improve the performance of the network, and then determining the revenues which the SWN will earn from its wholesale customers in order to repay those investments. Rather than returns being determined by the competitive process, both the costs and revenues of the SWN will be a result of regulatory or Governmental decisions, over which private investors may have little influence.

Private investors will therefore wish to fully understand these factors before they commit funds to the project. This is particularly important since the SWN will represent a 'greenfield' development by a new, untested management team who will have no prior experience in building SWNs. Investors will also seek safeguards which ensure that long term commitments are made about issues such as the objectives of the SWN, the governance arrangements, the prices it is to charge to its wholesale customers and the possibility of competition or other changes in the future environment, all of which will affect the likelihood of earning a return on the investment in the future. These may be required over a funding period of 15-20 years.

Therefore, investors will require reassurance that the current Government can make commitments on behalf of its successors, and that the regulator cannot and will not intervene at a later date to change the terms on which the original investments have been made. Without such assurances, private investors are likely to conclude either that the regulatory and political risks associated with participation in an SWN are too great, or that the returns required for them to invest are significantly higher than the Government may expect.

Existing operators and other shareholders in the SWN

Private investors may also wish to see other participants in the venture, partly in order to limit their own financial exposure and partly to improve the prospects of the project. Potential investors are likely to include:

- the existing network operators (which may include TowerCo providers);
- other current and potential retailers of mobile services who will use the SWN;
- global infrastructure funds and other long term investors seeking low risk, predictable returns from regulated assets;
- network equipment suppliers;

Impact of ownership on SWN's performance

- utility and other companies who may be able to contribute assets to the SWN; and
- the Government itself.

New private investors may be reassured if the existing network operators are themselves participants in the SWN, since this may support the alignment of their incentives and the incentives of the SWN, reducing the risk that network operators may otherwise seek to develop or maintain their existing networks to support their retail demand. An SWN which was actively opposed by the existing network operators in a market would present significant risks for most independent investors.

On the other hand, network operators are also likely to want to participate in an SWN on which they will potentially rely on to meet the future needs of their retail customers. Without strong operator representation in the management of the SWN, there is a risk that it will not be responsive to the needs of the market or the retail customers it is ultimately intended to serve. This would reduce the value of the SWN but it would also place existing investments in the network operators (in terms of both their other network and their retail activities) at significant risk, weakening the mobile sector as a whole.

Private sector investors may want to see Government itself participating as an owner in the SWN. They may reason that if the Government is itself a (minority) shareholder, it may be less likely to take actions or allow regulations which might harm the interests of the other owners. Alternatively, they may seek arrangements which would protect their investment (for example by selling their shares to the Government at a pre-agreed price or process to set the price) in the event that the prospects for the SWN proved to be less attractive than they had envisaged (perhaps because the regulatory environment changes). Such arrangements may be necessary to attract private investment, but they are unlikely to be attractive to the Government itself, which will find itself having to assume a greater proportion of the funding and financial risk of the SWN, without necessarily gaining control over the management of the project. However, it is equally possible that private investors will resist the participation of Government in the venture since they may fear that commercial interests of shareholders may be overridden by other, political, interests or that the ownership structure may be unstable if the Government changes at a later date.

In some cases, we are aware that equipment vendors have also indicated an interest in participating in SWNs as a shareholder. We assume this is normally on the basis that the SWN will then procure equipment from this vendor, perhaps on favourable commercial terms. Whilst this may initially appear an attractive arrangement for all parties, there are several issues to consider:

- a wide variety of equipment financing arrangements already exist in the mobile industry and it is therefore not clear to us why an SWN is

necessary in order to secure favourable terms for the supply of equipment;

- even if an SWN is pursued, it is not clear to us why ownership participation by the equipment vendor would be necessary for the SWN to obtain terms which were more favourable than anything it might obtain through arms-length negotiations with third parties; and
- there is a clear risk that the SWN will find itself committed to certain sources of equipment supply which may be more difficult to negotiate or renegotiate if the supplier is itself represented on the Board of the SWN (there is clear risk of a conflict of interest in such circumstances).

Impact of existing operators on the operation of the SWN

We suggested above that the participation of existing operators may be necessary to persuade other private investors to participate in the SWN, but it may also be necessary in general to increase the SWN's chances of success. This is because:

- The SWN is likely to require access to assets of the existing operators (sites, towers and potentially other equipment) if it is to roll out its network efficiently (without distorting competition) and realise the cost savings that are claimed for it. If existing operators have no ownership interest in the SWN, they may not have any incentive to co-operate with the SWN, leading to delays and potentially much higher costs of network deployment.

- Aside from access to existing network assets of the operators, the SWN will need to recruit engineers and managers with telecoms and business experience. In many countries, experienced personnel will be limited, and most are likely to work for the existing operators. If the existing operators have no ownership interest in the SWN, they are unlikely to volunteer staff, training or other resources to assist as the SWN seeks to establish itself. The SWN could try to compete against the existing operators in the labour market, but this will likely raise its costs and may not be successful.

- The SWN must ensure that the retail demand of the existing operators is served by the SWN and not by competing networks. As explained in Section 2 this is likely to determine whether an SWN 'dominates' or fails in the long run. If existing operators have an ownership interest in the SWN, they are more likely to support it and to direct their retail traffic onto the network (they may also be more likely to migrate other network assets to the SWN over time)[76]. If they have no interest in the SWN, other incentives will be

[76] Note, however, that even if an existing operator holds an ownership interest in the SWN, it may still prefer to retain traffic on its own, wholly owned, network. This is because it captures all

required to encourage the existing network operators to retail the network services offered by the SWN rather than trying to compete with it. It is not clear that such incentives could be successfully put in place.

- SWNs are separated from the retail activities of the operators or other wholesale customers which makes it more difficult to co-ordinate between retail and network activities than would be the case for a vertically integrated network competitor[77]. As we have seen, this will affect issues like the timing of network upgrades, and the launch of new retail services which require changes to both the network and to the handsets which retail customers use.

  If the existing operators own the SWN, there will still be some loss of benefits relative to the situation in which network competitors are fully vertically integrated, but a degree of common ownership between the retail activities of the existing operators and the network operations of the SWN may go some way towards to reducing these losses. This is because information flows within the operators will be easier and more efficient than interactions between the SWN and the retail division of the operators, and also because the incentives of the retailing operations of the existing operators and the SWN are likely to be more closely aligned if they have a common owner.

These are all reasons why the SWN is more likely to succeed if the existing operators are involved in the SWN. However, this creates new challenges, to the extent that existing operators have different interests amongst themselves, and from other types of private shareholder. We consider these challenges in the next section.

Governance issues

Participation by the network operators, or other retailers, will add complexity to the establishment of the SWN. The operators will continue to compete with each other in downstream markets, and some operators may regard the SWN as an opportunity to reduce network disadvantages which they might otherwise have in relation to rivals, whilst such rivals can be expected to require a relatively greater share/degree of control of the SWN for the same reason. The fact that no SWNs have developed through voluntary agreement amongst the existing operators in any national market in the world (so far as we are aware) suggests that this

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wholesale and retail profits in the latter case, but may need to share these with other co-owners in the former.

77 See Section 7.2 for evidence that BT Openreach, a functionally but not structurally separated fixed network business in the UK, has often been criticised by wholesale customers for refusing to meet their demands for new wholesale products, particularly in relation to business services.

misalignment of incentives amongst the existing operators could be a significant obstacle.

Governments may, of course, attempt to force the operators to participate in the SWN, for example, by allocating spectrum in a way which makes it impossible for any individual operator to operate a network that can compete with the SWN in the long term. But it is not clear that coercive measures will lead to the kind of ongoing co-operation and constructive engagement between the existing operators and the SWN which will be required for it to succeed.

Aside from differences of interest between network operators, there will also be differences between the existing operators as a whole, and other categories of investors. Disputes are likely to arise, for example, over the terms on which any existing network assets might be supplied to the SWN, with most shareholders seeking to minimise costs for the SWN but with the owners of those assets seeking to maximise the price paid. Similarly, those investing only in the SWN will seek to maximise returns to the SWN itself and will be likely to favour setting high access charges to the retailers in order to do so (although we assume that the actual levels of access charges will be set by the regulator rather than the shareholders, shareholders may seek to influence the regulatory process). Existing network operators with retail activities, on the other hand, may seek to pay lower access charges to the SWN (where they must share returns with other owners), preferring to recover higher margins in the downstream retail market (where they own all the operations).

The situation will be even more complex if some network operators are investors in the SWN, but some are not (or if different operators have different levels of exposure to the SWN through different shareholders). In these circumstances, those network operators that are investors are likely to argue that they should be able to obtain advantages from their participation which are not available to their non-participating competitors. The SWN will therefore need to determine how to incentivise and reward existing network operators for their participation in the SWN, whilst ensuring that this does not harm competition in the downstream retail market from those operators who do not choose to participate.

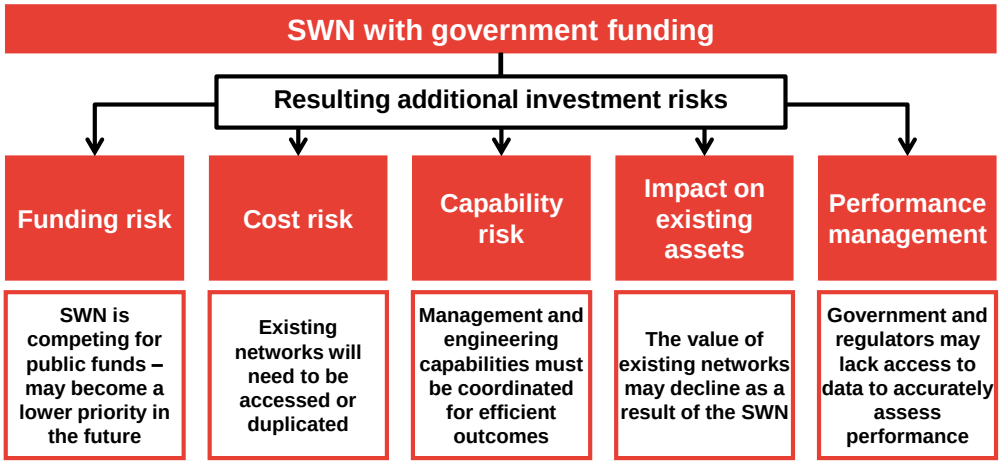
8.1.2 Public ownership

Given the challenges of persuading the private sector to participate in an SWN outlined above, it may be considered that the best way to fund SWNs is to use public funds rather than private investment and for the Government to own and operate the SWN itself. However, this presents other challenges of its own which are discussed in this section.

A Government funded SWN introduces a range of risks not present under private ownership. In particular:

Impact of ownership on SWN's performance

Figure 34. Investment risks for Government in an SWN



Source: Frontier Economics

- **Long term funding risk:** The SWN will have to compete for public funds alongside other Government priorities. Government priorities may change, resulting in underinvestment in the SWN.

- **Risk of excluding existing operators:** The SWN must secure access to assets of existing operators on reasonable terms or duplicate with its own infrastructure. It must also secure management and engineering skills to operate the network and run business professionally. And it will need the existing operators to migrate their retail demand onto the SWN in order to generate wholesale revenues to repay Government loans. All of these steps require the co-operation of existing network operators, which is much more difficult to obtain if the SWN is owned by the Government rather than the operators themselves.

- **Performance management:** Government and regulators are unlikely to have access to all necessary data to accurately assess and improve operational performance of the SWN.

Some of the risks which can arise in private financing an SWN are, of course, removed if the SWN is owned by the Government. In this case, the interests of private shareholders can be largely disregarded, although concern that the SWN will adversely affect the value of existing investments in the mobile operators remains. Since the SWN will rely upon these operators to be major wholesale customers of the SWN, the Government cannot wholly disregard the incentives faced by the private owners of the existing networks, even if it is to finance the SWN itself.

We discuss some of these key risks related to Government owned SWNs in more detail below.

Access to public finances

The most immediate challenge for a publically funded SWN is likely to be the size of the funding requirement, which could be a significant proportion of the Governments total expenditure. An SWN is a national mobile network which is likely to involve ambitious coverage and performance targets that should at least match those normally achieved by network competition. This is likely to require hundreds of millions, if not billions, of dollars to finance.[78] Depending on the state of Government finances, this could potentially affect the credit rating of the Government's debt, and thus the overall cost of borrowing of the country.

Governments may own some assets which can assist the SWN. The most important will be spectrum but may also include public buildings and land to provide sites for towers and masts. These may help reduce the costs of the SWN (although of course the Government will be forgoing revenues which it might otherwise have obtained if it had auctioned the spectrum to the existing network operators instead), but they will remain very significant. Governments will need to be able to explain to voters, lenders or other international institutions such as the IMF or World Bank, why scarce public funds are being applied to building mobile communications networks which are clearly financeable by private investors elsewhere in the world.

The Government's commitment to financing the SWN will also have to persist over many years, since roll out of the network is likely to take a number of years and it may take longer still before the network is profitable at an operating level and can begin to repay debt or otherwise be refinanced. Governments in all countries find it notoriously difficult to ring fence funds for projects, with the result that the SWN is likely to have to compete for continued funding against other demands on the public finances. As the case study of NBNCo in Australia, presented in Section 7.1, shows, there can be no assurance that subsequent Governments will remain committed to the SWN project. If they are not, the original objectives will not be met and the network will need to be modified, sold to private investors or transferred back to the existing network operators.

Risks of excluding existing operators

In Section 7.1, we discussed the advantages of having the existing network operators participate as shareholders in the SWN. Public ownership excludes that

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78 KT are investing USD 140 million in the LTE network for Rwanda, this is equivalent to 5.5% of Rwanda's 2013/14 budget. (Rwanda budget is USD 2.55 billion see http://www.grantthornton.co.ke/uploads/East%20African%202013%20Budget%20Bulletin.pdf p 21)

possibility, and so means that the SWN will face the very significant risks that arise if the existing network operators do not co-operate. Governments may nonetheless seek to 'coerce' operators into co-operating with the SWN (for example, by compulsory purchase of operator assets or legal obligations to share assets or to buy services from the SWN). A 'coercion' approach is unlikely however to provide a *sustainable* basis for success of the SWN, as it will reduce the chances of longer-term alignment of the incentives of the existing operators and the SWN.

In short, without support from existing operators, the SWN may find it difficult to develop its business. In most countries, there is a limited pool of resources with engineering and operational skills, most of whom are already employed by the operators. The Government could seek to recruit new personnel from outside the country, or may seek to sub-contract the entire operation to a third party vendor or a foreign operator, but this will also involve delay and risk. The SWN will also need to acquire or lease assets from the existing operators if it is to minimise its costs, but the operators may prove reluctant sellers. Finally, the existing operators will be the SWN's biggest wholesale customers. If the operators refuse to use the SWN and seek to maintain their traffic on their existing networks, the SWN will almost certainly fail (or the Government will have to continue subsidising the venture far into the future). Alternative retailers may emerge to use the SWN if the regulatory environment were to allow, but they are unlikely to be as large as the existing operators, may take time to develop and would be very unlikely to generate enough revenue to sustain the SWN.

Performance management of public SWNs

The available evidence also suggests that, even if funds can be found, publically managed firms will tend to suffer from conflicting objectives and poor management. Privately owned monopolies have strong incentives to minimise costs and maximise returns to shareholders. Local managers will be held to account by global shareholders with extensive experience of other markets and ability to benchmark performance with the best in the world.

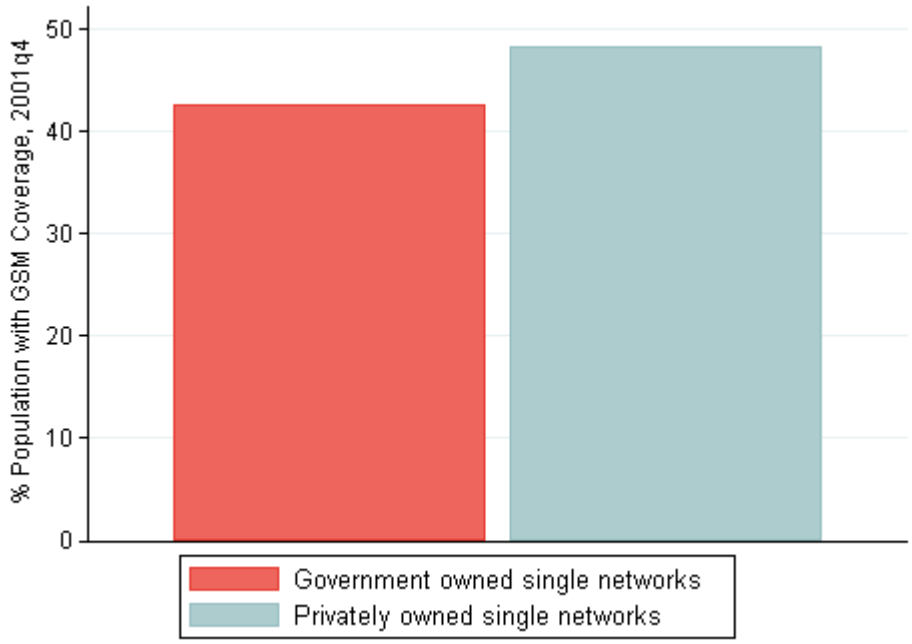
Publically owned monopolies typically have few such incentives, with limited information about performance and little access to evidence from other countries with which to compare. If the SWN also lacks access to the expertise held within the existing network operators, then it will be more challenging for Government, civil servants, regulators or the employees of the SWN itself to assess its performance and ensure continuous improvement.

8.1.3 Performance of privately and publically owned assets in the mobile sector

In Section 3.2, we showed that countries with single networks tend to have lower coverage than countries with network competition. In those countries with single

networks, some of the networks are state-owned and some are privately-owned. We have therefore considered how the coverage in single network countries depends on the ownership structure.[79] As indicated by **Figure 35** and **Figure 36** below, the evidence is consistent with population but especially area coverage being lower in single network countries where the network was owned by the state. Whilst such data needs to be interpreted cautiously, as there are likely to be a number of other factors affecting population and area coverage, the evidence is consistent with state-owned networks achieving lower levels of coverage, with possible reasons including a lack of funding, poor management and weak incentives to roll-out the network.

Figure 35. Impact of ownership on population coverage in single network countries

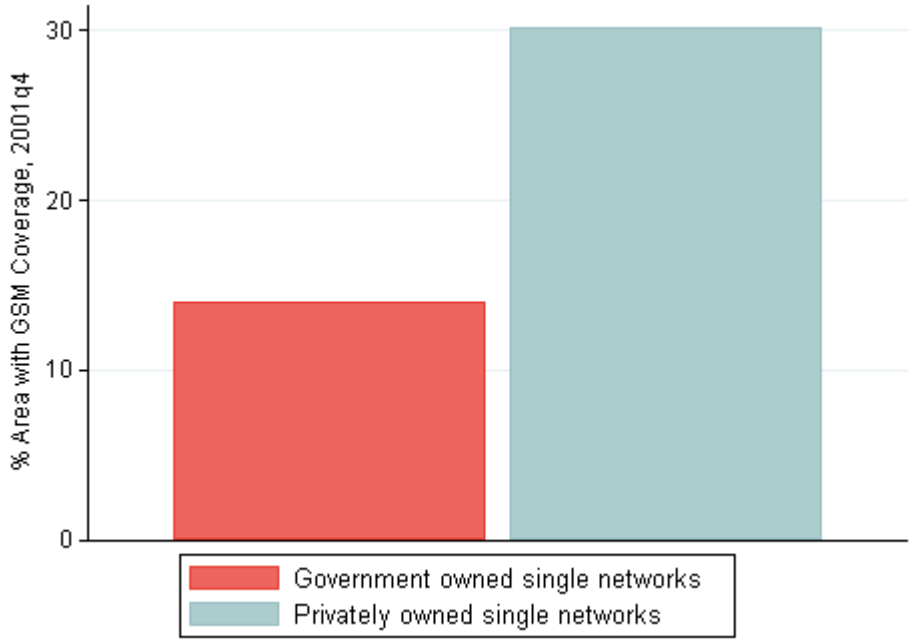


Source: Frontier analysis using GSMA data

[79] We have excluded single network countries where the network is partly state-owned and partly privately-owned. However, as a sensitivity check we have added these countries to our sample by classifying countries according to the majority shareholder. For example, a network where the state owns more than 50% is classified as state-owned. When we add these additional countries to our sample, we still get similar results.

Impact of ownership on SWN's performance

Figure 36. Impact of ownership on area coverage in single network countries



Source: Frontier analysis using GSMA data

8.2 Conclusion

We have considered the challenges that are likely to arise if the SWN is to be privately owned or Government owned. We have also considered how this is likely to affect the performance of the SWN.

We find that private ownership of SWNs is likely to present significant challenges in terms of attracting investors, including the existing operators, to participate. However, we also find that privately owned investments are likely to be better managed and to perform better than Government owned assets. Government ownership of SWNs is likely to be easier to organise, but there is a greater risk that a Government owned SWN will perform badly and may ultimately fail.

9 Alternative ways to meet SWN objectives

As argued above, one of the main concerns claimed to be addressed by SWNs is the cost of network duplication and the consequent limitations on rural coverage provided under network competition.

We have shown that, in practice, network competition has produced faster and more extensive network coverage than national monopoly networks. We have also explained that even if competing networks are not viable in some areas, the alternative need not be an SWN.

This section considers the aforementioned alternatives, and others, to SWN that might be used by operators and Governments to extend network coverage in rural areas. In doing so, we recognise that network competition may not always deliver the coverage results which policymakers require. We also recognise that network competition can be imperfect and may give rise to other concerns, such as a lack of effective competition in retail markets. These depend greatly upon the specific context of the individual market in question, and so we do not attempt to propose alternative approaches to those issues in this report.

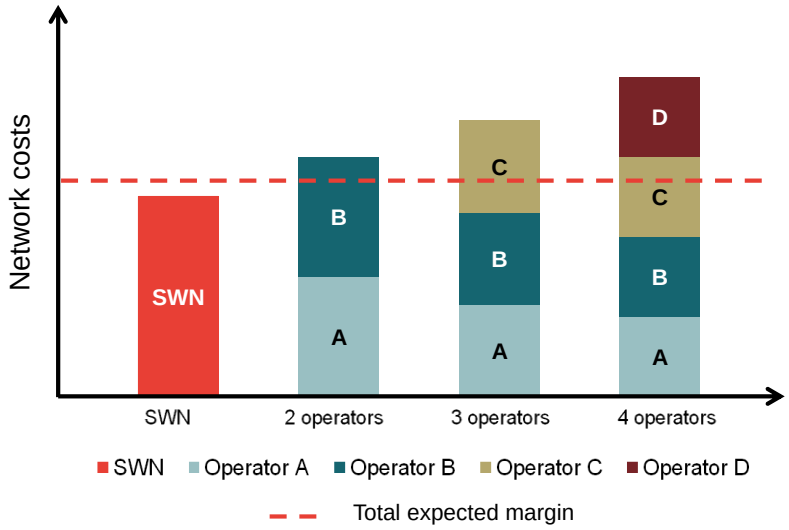
9.1 Alternative ways to achieve efficiencies from reducing network duplication

Under network competition, operators are able to capture cost efficiencies through 'first mover' rollout in remote areas, and network sharing agreements between operators. This leads to levels of coverage that are comparable to what SWN could potentially achieve (on a like for like basis), but without foregoing any of the other benefits of network competition considered in this paper. We discuss these in more detail below.

9.1.1 'First mover' advantage

In every country, there will be areas where total demand – and hence expected revenues and margins – is not enough to support two or more operators rolling out their own networks. As shown in **Figure 37**, under the '2 operators' scenario, if operators A and B both decide to rollout – and each takes half of the subscribers, revenues and available margins – then both operators will not be able to be profitable. This lack of certainty may discourage entry in such areas. To the extent that an SWN could have lower costs than the two networks (we have already discussed why this should not necessarily be expected) through less duplication, the SWN could find it profitable to enter into this area.

Figure 37. In some areas, total expected margins may not support multiple operators, each with their own network



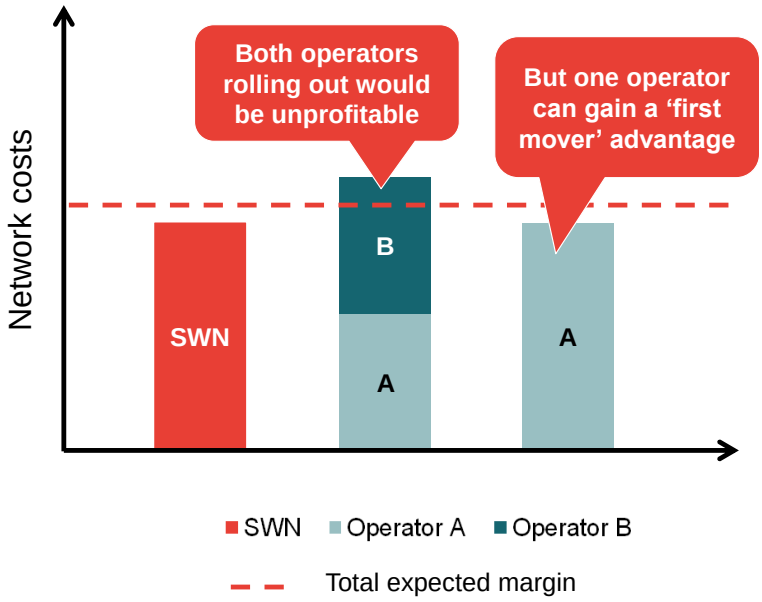
However, this does not mean that only an SWN would rollout in such an area. Rollout may still be possible in a competitive market with multiple players. For instance, in the above described scenario, it may be possible for one of the two operators to gain a 'first mover' advantage by being the first operator to rollout. This is because once one operator has rolled out, it would be unprofitable for any other operator to follow.

For the first mover advantage to hold, there must be a degree of 'information symmetry'. This means that:

- once one operator has rolled out, the other operator(s) knows that any subsequent rollout would be unprofitable; and
- the 'first mover' knows that its own rollout will result in the reaction described above, making its rollout decision profitable.

If this holds, then one operator will be able to gain the 'first mover' advantage, and the area will be covered. This is illustrated in **Figure 38** below.

Figure 38. Any area that is viable to cover under an SWN scenario may also be viable in a competitive market with multiple operators if one operator gains a 'first mover advantage'



The 'first mover' advantage is observable in a number of countries around the world, where there are multiple mobile networks competing in urban areas while some rural population is covered by one 'first mover' network[80]. The 'first mover' advantage, however, tends to become less significant over time as more areas become economically viable for multiple networks, often as a result of network sharing agreements discussed below.

9.1.2 Network sharing agreements

The scenario described above contains an element of uncertainty. The first mover may be unsure as to whether rolling out will be profitable. This is because if there is subsequent rollout from any rival operator, there will not be enough margin available for both operators to breakeven. This may result in both operators being reluctant to make the first move, uncertain that it will pay off. In this case, the area will not be covered under the network competition model.

[80] For example, in Brazil, Vivo's 3G population coverage was more than 10 percentage points above its rivals in 2012Q4 (Vivo – 86%, Oi – 73%, TIM – 72%, Claro – 70%). In Rwanda, MTN's 3G population coverage is significantly ahead of its rivals. In 2014Q1, MTN's 3G population coverage was 71% compared to 47% for Tigo and 12% for Airtel. In 2013Q4, the market leader in Morocco, Maroc Telecom had a significantly higher 3G population coverage than Meditel (73% compared to 52%). Source: GSMA Intelligence.

However, this uncertainty can be avoided if operators engage in a network sharing agreement that decreases the cost of rollout for both operators and makes the coverage increase in remote areas viable. We define 'network sharing' as:

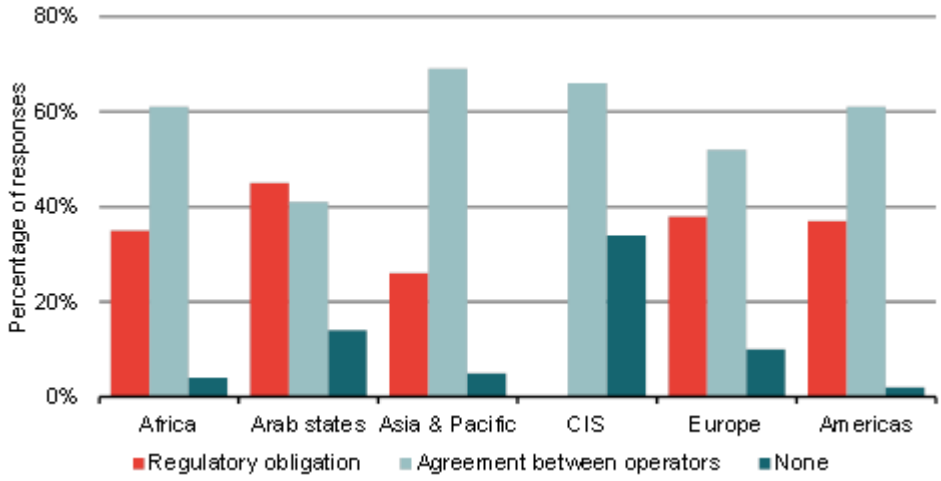
- an agreement (either through agreement amongst the operators, the establishment of a new joint venture or via outsourcing to a third party) between operators to share elements of their respective mobile networks in some areas of the country;
- typically involving two parties rather than all existing network operators;
- a voluntary agreement negotiated on commercial terms between operators rather than required by Government (although may be subject to regulatory approval);
- typically including some of the 'passive elements' such as towers, backhaul facilities, power units and other structures, and/or may also include the sharing of some of the 'active elements', such as radio transceivers and other elements of the radio access network, including radio spectrum ; and
- often arising from the combination or rationalisation of existing networks, but may also include agreements to jointly extend coverage to new areas.

Network sharing agreements between operators are common in mobile markets around the world. In all EU-27 member states[81] and in countries outside of Europe, such as India, Pakistan and Brazil[82], there is some form of network sharing in place. Furthermore, a recent study by ITU indicates that sharing of mobile network sites is widely used around the world and that voluntary sharing is the most common form in the majority of regions, see **Figure 39** below. Moreover, as shown in Section 5.1 network sharing agreements can lead to significant cost savings, further highlighting the point the SWN is unlikely to lead to significant cost savings from removing duplication, beyond what can be achieved through network sharing agreements between existing operators.

81 RSPG/BEREC research and survey among regulators (see http://rspg-spectrum.eu/_documents/documents/meeting/rspg25/rspg11-374_final_joint_rspg_berec_report.pdf).

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

Figure 39. Trends in mobile network sites sharing (2013)

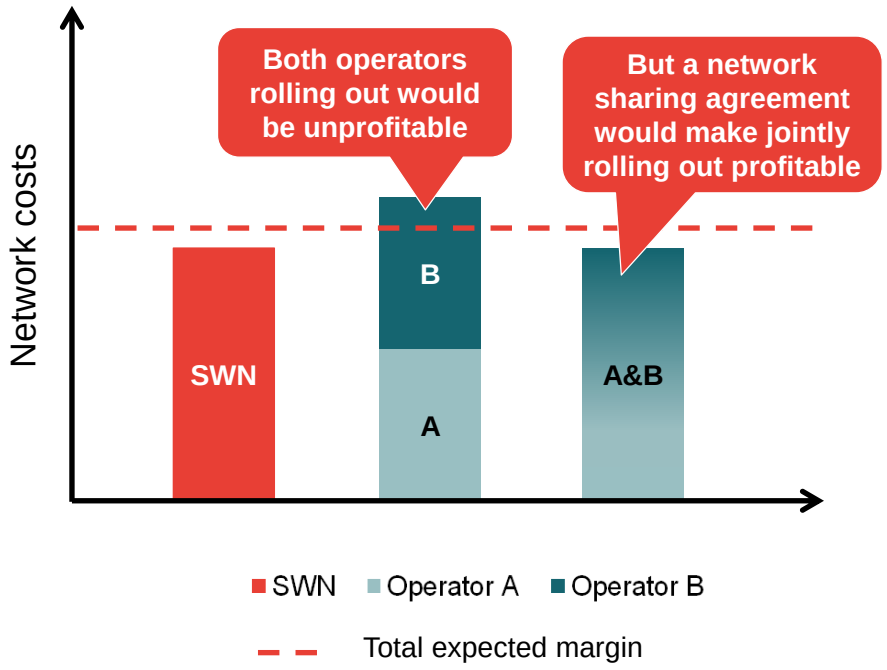


Source: ITU[83]

The impact of network sharing arrangements on coverage is illustrated in **Figure 40** below. As can be seen, such arrangements enable mobile operators to extend their coverage to areas where it would not be profitable for each one of them to expand into individually.

83 Mobile Infrastructure Sharing: Trends in Latin America (see https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/CostaRica/Presentations/Session8_Daniel%20Leza%20-%20Mobile%20Infrastructure%20Sharing%20-%2012%20March%202014.pdf)

Figure 40. Network sharing agreements may enable operators to jointly rollout in an area that may otherwise not be covered



Network sharing is therefore widely recognised as **facilitating faster roll-out and increased coverage** in rural areas[84,85]. Indeed, MNOs regularly mention faster roll-out of their network as one of the main reasons for entering a network sharing agreement[86]. Also, regulators within Europe[87,88] and outside, such as in India and Pakistan[89] have allowed network sharing agreements because it fosters

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

85 Booz&Co: Telecom Infrastructure Sharing Regulatory Enablers And Economic Benefits (see http://www.booz.com/media/file/Telecom-Infrastructure-Sharing.pdf)

86 Examples from Coleago Consulting "Network Sharing business planning": 3UK and T-Mobile (2007) in the UK, SaskTel and Bell (2009) in Canada, Vodafone and Orange (2007) in Spain, Yoigo and Telefonica in Spain. (see http://www.coleago.co.uk/fileadmin/user_upload/Downloads/Network%20Sharing%20Overview%20Coleago.pdf)

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

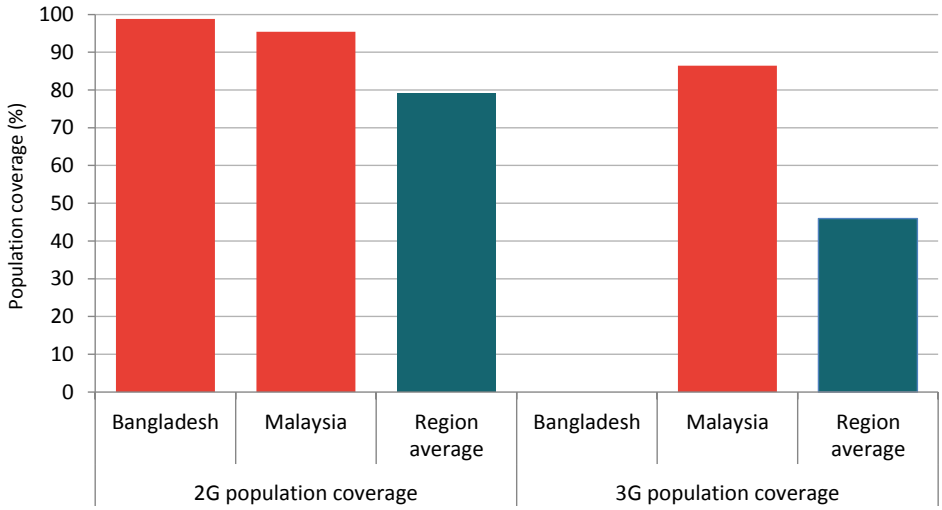
88 Vodafone: Network Sharing in Vodafone (see http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/06/Vodafone1.pdf)

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

Alternative ways to meet SWN objectives

faster roll-out of new technologies and increased coverage in rural areas. Other examples of successful network sharing include Malaysia and Bangladesh. Both countries are consistently outperforming the regional average in terms of 2G mobile coverage, and Malaysia showing similar positive outcomes in relation to 3G coverage, see **Figure 41** below.

Figure 41. Mobile coverage in Bangladesh and Malaysia (2013)



Note: The regional average for 2G penetration is calculated based on the available data from Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam, Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka. The regional average for 3G penetration is calculated based on the available data from Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Afghanistan, Iran and Sri Lanka.

No data is available for Bangladesh, as the 3G spectrum in the 2.1 GHz band was only allocated to mobile operators in August 2013.[90]

Source: Frontier Economics based on the GSMA data.

90 See http://www.mobileworldlive.com/grameenphone-starts-bangladesh-3g-drive

Effect of network sharing on rural coverage

- **Spain**: In 2007, Vodafone and Orange entered a 3G RAN sharing agreement in rural areas. In particular, this involves towns with less than 25,000 inhabitants in 19 provinces across Spain. The agreement as of 2007 would allow both operators to "*increase coverage by around 25%, while reducing the estimated total number of sites needed by around 40%*"[9192].

- **Pakistan**: In 2006, Ufone and Telenor joined a network sharing agreement. The deal was expected to deliver 50% CAPEX reductions and to expand coverage of highways and sparsely populated towns. Later, a third operator Warid joined the agreement.[93]

- **UK**: T-Mobile and Three formed a venture company called "Mobile Broadband Network Ltd" to share their 3G RAN. The agreement was expected to lead to significant increases in rural and urban coverage. In particular, it was expected to lead to 98% coverage, which is 18% more than the regulatory requirement.[94]

- **Malaysia**: They have been at the forefront of network sharing in South-East Asia. The leading operator, Celcom, has been 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[95]. Celcom has also been engaged in the sharing of active elements (including spectrum) with Altel since 2013. Altel will be leveraging on Celcom's network as an MVNO to achieve national coverage until it rolls out its own 4G network[96]. Among

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91 TeleGeography news item (see http://www.telegeography.com/products/commsupdate/articles/2007/10/12/orange-and-vodafone-make-3g-network-sharing-pact/).

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

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

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

95 Operators' response to Frontier data request.

96 SoyaCuincau Article "Atel to invest RM1b in 5 years to roll out LTE network" (see http://www.soyacincau.com/2014/04/23/altel-to-invest-rm1b-in-5-years-to-roll-out-lte-network/).

further network sharing arrangements in Malaysia, the second largest operator, Maxis, has been sharing infrastructure and spectrum with REDtone since 2012, claiming that it will enable them to fast track their roll-out of 4G services. According to these companies, the deal 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.

- **Bangladesh**: There has been a range of nationwide passive network sharing agreements in recent years since it became a regulatory requirement in Bangladesh in 2008. The main objectives of infrastructure sharing are cost savings, operational efficiency and environmental considerations.[97] In addition, some operators believe that network sharing agreements would lead to faster roll out of networks[98] and increased coverage.[99] While the sharing of infrastructure itself is mandatory, prices are to be commercially agreed and operators generally welcome the regulatory push towards more network sharing[100].

The evidence on the number of network sharing deals that have been implemented in recent years, compared to SWNs, indicates strongly that network sharing deals are typically much **less challenging than SWNs**. This is primarily because network sharing often involves fewer parties – normally two operators relative to SWNs – and those parties usually have a shared commercial objective (e.g. to use network sharing to match the coverage of another stronger competitor). This is not the case with an SWN, where the different SWN users are likely to have diverging objectives as explained in Section 7.1. In addition, network sharing does not require ongoing regulation, as is required with SWNs.

Network sharing and dynamic benefits of competition

Most importantly, network sharing typically **does not involve any loss of incentives to innovate or upgrade**, (which is the central disadvantage of SWNs) for at least three reasons:

97 Bangladesh Telecommunication Regulatory Commission "Guidelines for Infrastructure Sharing" (see http://www.ictregulationtoolkit.org/Documents/Document/Document/3813).

98 Celluar-news article "Bangladesh Operators to Share Network Infrastructure" (see http://www.cellular-news.com/story/Operators/41777.php).

99 TeleGeography article "GrameenPhone and Warid sign infrastructure sharing agreement" (see http://www.telegeography.com/products/commsupdate/articles/2010/11/08/grameenphone-and-warid-sign-infrastructure-sharing-agreement/).

100 Celluar-news article "Bangladesh Operators to Share Network Infrastructure" (see http://www.cellular-news.com/story/Operators/41777.php).

- Many network sharing arrangements are formed to compete with another (often stronger) network that is not part of the new sharing arrangement. Network competition therefore remains between the shared network and the other networks, with existing incentives unaffected.

- Many network sharing arrangements are limited, often by regulators, to those parts of the network which are less central to innovation (for example, to 'passive' elements only, or to the access rather than the core network). Those parts of the network that drive innovation will remain outside the agreement and will be subject to the same competitive pressures as before. Regulators will seek to ensure that the network sharing arrangement allows the parties to introduce these new innovations and upgrades without co-ordination with competitors.

- Even if some parts of an operators' network are shared, others are not and remain subject to full network competition. To the extent that mobile operators offer and advertise a 'national' service, innovations and upgrades will be expected to be available nationally as well.

The consequence of these factors is that network sharing allows the industry (and Government) to obtain a significant proportion of the benefits claimed for SWNs, but without losing any of the benefits associated with network competition, provided a significant degree of network competition remains.

We have shown in this section that under the network competition model there are efficient ways to reduce costs of network duplication and achieve wider coverage, including in remote areas. Below, we discuss policy measures designed specifically to address objectives of wide mobile coverage, which could be considered as a more efficient alternative to SWNs.

9.2 Policies to address coverage objectives

Previous sections of this report have shown that network competition, generally privately financed, has been and continues to be a highly efficient means to extend coverage and access to telecoms services. As shown earlier, in most countries in the world, competitive mobile networks have overtaken fixed networks and have become the primary communications tool for billions of users. There are, however, some areas that it may not be profitable for anybody to serve, either on a first mover basis or by employing network sharing.

Whilst some argue that this may create a role for SWNs, there are a number of policy instruments that retain the advantages of the network competition model but still allow the extension of coverage to areas that would not otherwise be served. This section considers those policies.

In particular, we consider three main groups of policy instruments:

Alternative ways to meet SWN objectives

- imposing network roll-out targets as licence conditions of mobile licences, which are awarded through auction;
- identifying one or more providers to give additional coverage after the award of the licence, for example, through competitive tendering for the infrastructure roll-out necessary for the provision of universal access services;[101] and
- other potential policy measures which are effectively designed to either reduce the private cost of coverage, or increase the expected revenues that could be earned by an operator providing 'additional' coverage.

Below, we discuss each in turn. We show that network coverage obligations, as licence conditions in licences awarded through auctions, are likely to be more effective and practical than other 'ex post' measures, particularly in markets where regulatory capacity may be limited.

9.2.1 Network roll-out target in licence conditions

If a regulator is concerned that an operator may not, absent intervention, extend the network fast or far enough, it could impose a licence obligation on the licensee to do so.

These obligations are typically imposed as conditions in operating licences, which are commonly awarded through a competitive tendering process.

Such roll out / coverage[102] obligations set out the scope of coverage and the timescales on which it is to be achieved. In setting such coverage obligations, policy makers 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, to the extent that those coverage obligations require it to build in areas which it would not otherwise choose to do so (because they would not be profitable). This difference can therefore be seen as the amount the Government is willing to contribute to paying for the roll-out of services in areas that would not be served, absent the obligation.

This approach, of regulators mandating network rollout and coverage obligations when they issue new mobile licences, is widely used in Europe, the US and in

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101 Universal service and access policies also include obligations in relation to the provision of services to all customers willing to pay a regulated price (affordable) on *existing* networks. These contrast with investment/ network infrastructure obligations to build new networks and upon which services *will* be provided. This sub-section deals with available public policies in relation to the latter set of obligations.

102 Coverage refers to the proportion of a country's area or population covered by the network. Roll out refers to the speed with which such coverage is provided from the date of licence award. Unless otherwise stated, however, a "coverage obligation" in this context refers to both.

emerging markets[103]. 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, and so on). The exact drafting of a coverage obligation will need to vary between markets according to the demand and cost characteristics of the market concerned. For example, in 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 under two years, all licensees had met their coverage obligations in specified districts and were freely allowed to use the frequencies they purchased in the 800 MHz band in all federal states[104].

Regardless of how the obligation is specified, a further 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.

- **One operator:** Licence coverage obligations could be imposed only on a sub-set or a single operator. 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 obligation. In this case, the sole network provider in the remote areas may have to allow others to roam on the network to facilitate competition. For example, in Sweden in 2011, an obligation was placed upon one licensee in the 800 MHz auction to provide service of at least 1Mbit/s 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 winner to spend SEK300 million (EUR34.2 million) on covering homes and businesses in remote areas of the country[105]. Similarly, the UK 4G auction

103 In its 2009 Global Information Technology report, the World Economic Forum made the observation that almost all of the new licenses issued in emerging markets had already stipulated some type of rollout and coverage requirement in the last two years (2006 and 2007). (see http://www3.weforum.org/docs/WEF_GITR_Report_2009.pdf)

104 Bundesnetzagentur article (see http://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2012/121126CoverageRequirement800MHzBand.html)

105 Net4Mobility will be required to serve 25% of premises on the list in 2012 and 75% of the premises in 2013. Thereafter, the company is required to add coverage for specific premises until the SEK300

only included a coverage obligation on one block of 800 MHz spectrum, as did the Norwegian 4G auction[106]. As only one licensee is affected, the overall impact on proceeds to the Government should be less.

There are other examples where licences have been awarded through a beauty contest rather than an auction and hence where bidders have been asked to compete on the commitments they would make to coverage or speed of roll out[107]. This is one way Governments may attempt to address the 'information asymmetry' referred to earlier – in this case, the bidders themselves rather than the Government will set the coverage targets. On the other hand, the bidders may not have strong incentives to commit to particularly challenging targets, or may commit to challenging targets to win the licence but may then seek to justify why they have not adhered to them.

Coverage targets in licensees face similar challenges associated with setting coverage targets for SWNs. For example, regulators will have to monitor and enforce the targets, and devise incentive mechanisms to ensure compliance. This is not always easy – there are mobile licensees who have subsequently had to renegotiate or revise coverage targets which proved overly ambitious or where other factors intervened. On the other hand, under network competition, the regulator is less reliant upon the licensee to deliver its objectives than under an SWN scenario, where the SWN is the only network available to the regulator. A regulator might credibly threaten to withdraw the licence of a network competitor that fails to meet its coverage targets (since those users on the network could switch to others), whereas no regulator can credibly threaten to withdraw the licence of the SWN (since all users in country would then be denied service with no alternative available).

9.2.2 "Ex post" competitive tendering for infrastructure roll-out

In the first set of options described above, operators take account of the cost of roll-out in their licence bids. The risks for investors can be anticipated. On the other hand, imposing a binding coverage obligation on a licensee after the licence has been awarded represents an unforeseen 'tax' on the operator, which is likely to deter investment and reduce the prospects for further network investment.

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million commitment has been exhausted. (see http://www.analysysmason.com/About-Us/News/Newsletter/Swedish-spectrum-auction-fails-to-generate-German-bid-prices/).

106 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". Ofcom "Ofcom announces winners of the 4G mobile auction", February 2013

107 For example, in the Sweden, France and Norway for the 3G licence allocation process.

One option available to Governments in these circumstances is to fund the net cost of additional coverage with public funds. Such public funding can be minimised if the Government offers the contract through a competitive tender (auction) and awards to the lowest bidder for the public subsidy.

The scope of the auctions can differ across countries, with this depending on the characteristics of each market, the funding available and the objectives of the Government intervention. In some instances, the auction may cover the roll-out of passive infrastructure (towers and backhaul) on which all operators can then install equipment (i.e. RAN). This approach has been adopted in the UK and Singapore for example[108]. In other countries such as Australia, the auction was concerned with the deployment of the full RAN. In Malaysia, the recently launched auction allows bidders to bid for either the installation of tower and infrastructure or the combined provisions of the network and universal services[109].

The readily available funding options for infrastructure projects, include the:

- Government budget (i.e. general taxation and public funds); and
- existing universal service fund.

To the extent that projects, such as rollout of broadband networks in rural areas, are expected to deliver significant social and wider economic benefits[110] beyond the users of the services, there would be strong reasons to consider the funding of infrastructure projects through an allocation of existing general taxation to such projects. This funding option has been adopted, for example, by both the French and British Governments who have contributed funding for passive infrastructure such as towers to support the extension of mobile coverage to areas that were not currently served. It has also been adopted in the US where, through an auction process, mobile operators were also able to receive funding to increase their road-miles of coverage in rural areas[111].

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108 Analysys Mason "Swedish spectrum auction fails to reach German bid prices" (see http://old.culture.gov.uk/what_we_do/telecommunications_and_online/8757.aspx)

109 SKMM "Invitation to register interest as universal service provider" (see http://www.skmm.gov.my/skmmgovmy/media/General/pdf/RFP_-T3E_(Phase-1)_140314.pdf)

110 For example the lowering of the costs of delivering public services by enabling more of the delivery to take place on-line, or wider economic benefits through the support of the creation of economic activity (for example facilitating trading of agricultural goods by improving the availability of better/more up to date price information) that would not otherwise be possible.

111 Under this scheme launched in 2012, the mobile operators are required to deploy 4G services within three years, or 3G service within two years, accelerating the migration to 4G. See http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-161A1.pdf http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-12-641A1.pdf

Using unallocated universal service fund levies to support mobile operators to extend mobile network rollout could be another option[112]. To the extent that mobile operators have contributed to these funds in the past, any unallocated funds could help in the roll out of mobile infrastructure in non-economical areas. Most publically funded coverage projects require the winning bidder to make its network facilities available to others, either by allowing site sharing or national roaming, or both. In Europe, this is generally a condition of regulatory approval for such schemes under the so called State Aid rules.

9.2.3 Other options

A final set of policy options to increase coverage would look at either reducing the private cost of coverage, or increasing the expected revenues that could be earned by an operator from providing 'additional' coverage, so as to close the "access gap" for that provider, but without providing explicit compensation.

Granting an operator a local monopoly over a particular area for a given period, to entice a single private operator to roll-out network in remote areas, is an option to reduce the cost of coverage to the operator. This is because revenues to the operator will be more certain, allowing it to recover the fixed costs of roll out. There are, however, a number of disadvantages with this approach. In practical terms, this policy entails defining carefully the areas to be served under a monopoly and the length of the monopoly rights to avoid protecting investment from competitive pressures in areas which could become commercially viable as technology and demand change over time.

Another policy instrument is to stimulate demand in rural areas, for example, by promoting m-Government applications, and offering training to users or direct subsidies to users. By stimulating demand, this could again increase the profitability of serving these areas. Its merits are likely to be country specific. It will depend on the size of the affordability gap, the number of low-income users in remote areas and how the expected revenues will make an investment profitable for the operator.

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112 The majority of universal service funds (USFs) have been set up by Governments in developing countries. They typically provide financial assistance for meeting targets for telephony and Internet services, and support 'vanguard' users such as schools, libraries, and commercial start-ups. The earliest funds concentrated on subsidizing fixed network expansion in remote, high-cost areas; however this was before mobile networks offered lower cost and commercial solutions for such regions. Some UASFs have built up resources well in excess of their capacity to organize competitions and allocate subsidies. "Universal Access, How Mobile Can Bring Communications to all"GSMA (See http://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/universalaccessexecutive.pdf.)

9.3 Conclusion

Earlier in this report, we have shown that network competition is able to produce faster and more extensive network coverage than monopoly networks. This includes extending coverage to rural areas, where competing operators rely on 'first mover' advantage or network sharing agreements, to decrease the cost of rollout in less profitable remote areas.

Extending mobile coverage beyond commercially viable areas will generally require some form of Government intervention. However, for all the reasons stated earlier in this study, the SWN is unlikely to be the best approach. In this chapter we have identified other, less intrusive ways to increase rural coverage without foregoing any of the benefits of network competition.

In particular, coverage obligations imposed at the time of the licence award have a good track record in supporting objectives for faster roll out and greater coverage. They need to be imposed carefully however, and designed to ensure that operators can meet these targets. They should also be supported by other Government policies which can lessen the costs of roll out.

Annex 1: The history of network competition in the development of mobile markets

In this section, we show that network competition is the most common model under which mobile markets around the world operate and that there has been increasing adoption of this model over the past 30 years.

Network competition has delivered enormous benefits to consumers, in terms of increasing the availability and take-up of mobile services, reducing prices and promoting innovation. Mobile networks have played a key role in connecting people in remote areas of countries, who previously may only have been connected over poor quality fixed line infrastructure. We also show that the mobile sector provides large benefits to the wider economy.

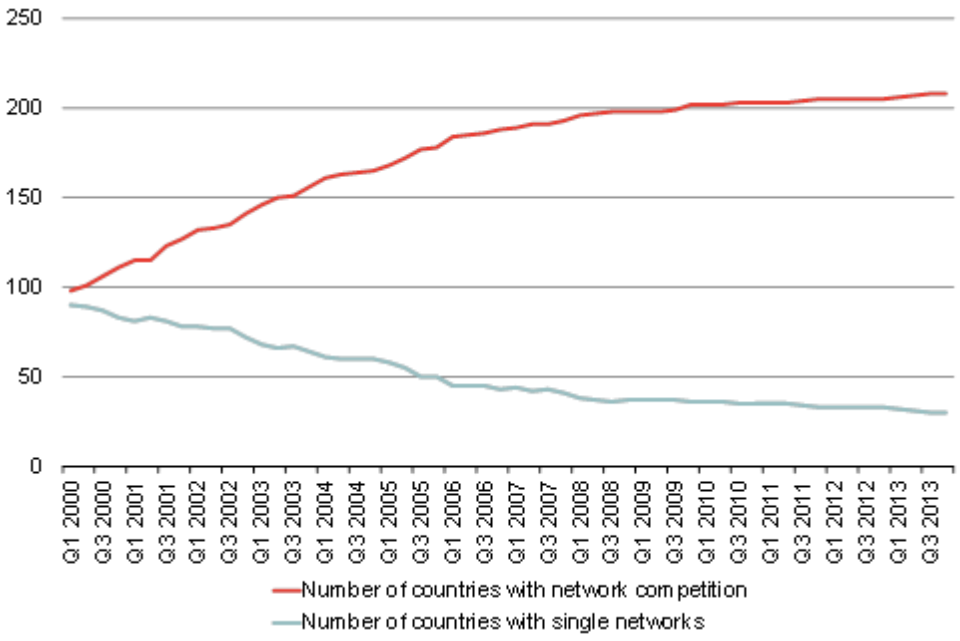
Network competition is the preferred model in mobile world markets today

The vast majority of countries around the world have network competition in their mobile markets. This partly reflects the fact that policymakers have actively tried to promote network competition, as they consider it to be the best way of ensuring that the mobile sector delivers consumer benefits and helps support the wider economy.

At the start of the century, there were an almost equal number of countries with network competition and single networks (see **Figure 42**)[113]. However, since then, there has been a significant move towards network competition. There are now only 30 countries with single networks, with many of these countries being very small.

113 The total number of countries reported in each quarter changes slightly over time. This is because some countries did not have any mobile operators in 2000.

Figure 42. Number of countries with network competition and single networks



Source: GSMA intelligence database

In the section below, we show that network competition has delivered many favourable outcomes, including rapidly increasing take-up, falling prices, widespread coverage, significant innovations and wider benefits to the economy.[114]

The mobile sector has delivered significant benefits to consumers and the wider economy

During the time period in which countries have moved to network competition, mobile markets across the world have delivered significant benefits to consumers and the wider economy, particularly in developing countries. As we show in this section, mobile network competition has:

- increased take-up rapidly;
- led to falling prices;

114 For example, Lehr (2014) stated that "Mobile competition promotes allocative, productive, and dynamic efficiency. Consumers benefit from expanded choice, improved quality, and lower prices. Competition forces firms to adopt industry best practices in order to survive. That means adopting business process and technical innovations that lower costs." (see http://apps.fcc.gov/ecfs/document/view?id=7521094967)

Annex 1: The history of network competition in the development of mobile markets

- provided coverage to the majority of the world's population and territory;
- delivered significant innovations (we show this in Section 4);
- played a key role in connecting people in countries with a poor quality fixed network; and
- provided considerable benefits to the wider economy.

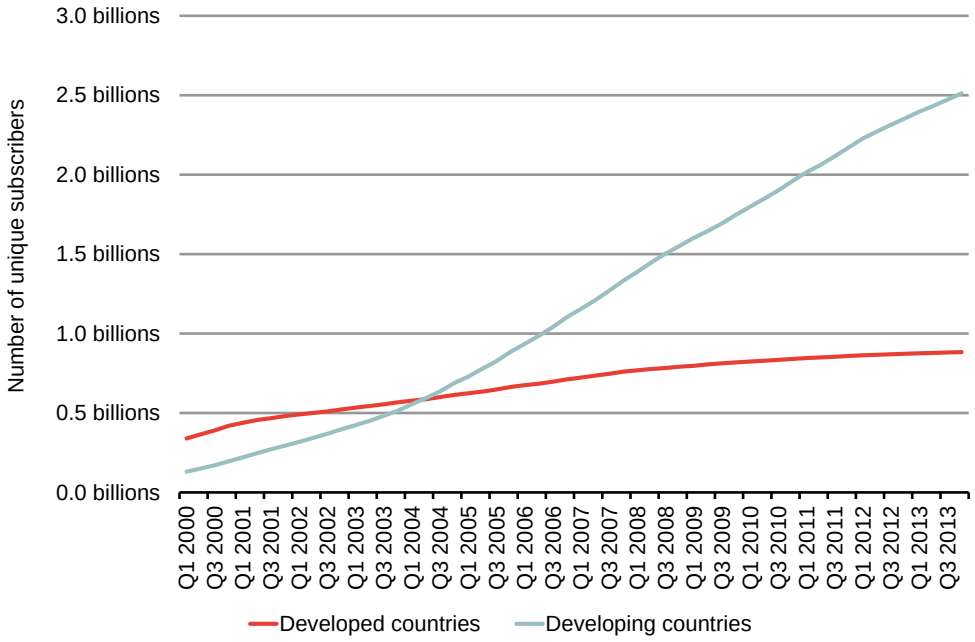
Take-up has increased rapidly

Since 2000, the number of unique mobile subscribers[115] has almost trebled in developed countries from 339 million to 884 million. The growth in developing countries is even more staggering, where the number of subscribers has increased from 131 million to more than 2.5 billion. This trend shows no sign of slowing down. The dramatic increases in take-up can be explained by the extensive roll-out of mobile services, the significant increase in the quality of services on offer and falling prices. These factors are explained in more detail below.

115 Focussing on the number of unique subscribers avoids double counting subscribers who have multiple SIM cards, which is common in many countries. Also, in many developing countries, it is common for multiple individuals to share a single mobile phone. As a result, the estimate of 2.5 billion 'subscribers' in developing countries could be an underestimate of the true number of individuals using mobile phones services

Annex 1: The history of network competition in the development of mobile markets

Figure 43. Take-up over time



Source: GSMA intelligence database

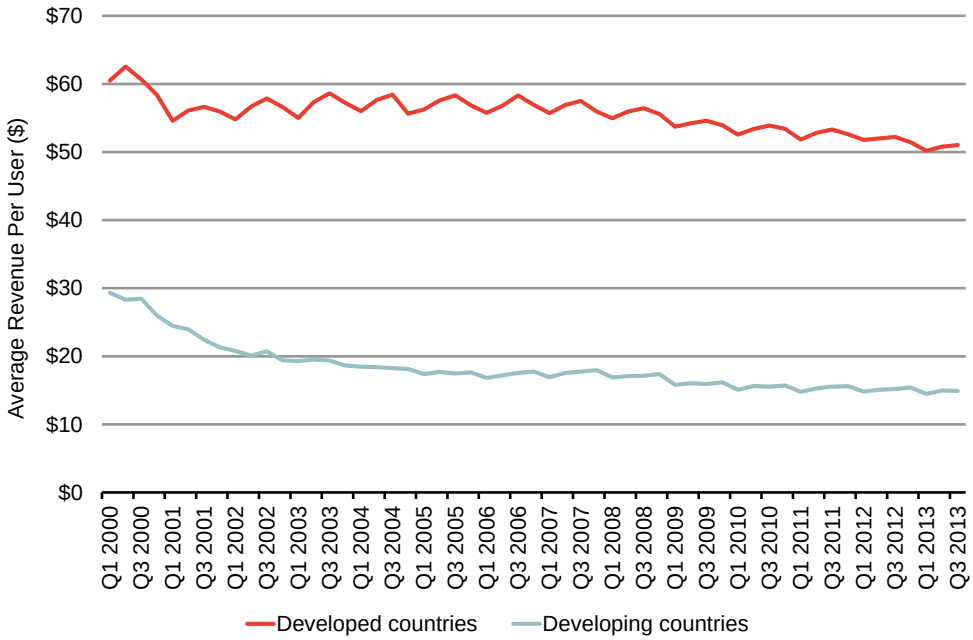
Prices have fallen

Since 2000, ARPUs [116] have fallen across the world. The fall is particularly stark in developing countries, where ARPUs have fallen by around half (see **Figure 44**). This helps explain the dramatic increase in mobile take-up over the period. Competition has produced a wide range of different pricing plans in each market to suit different needs.

116 Average Revenue Per User.

Annex 1: The history of network competition in the development of mobile markets

Figure 44. ARPUs over time (per month)



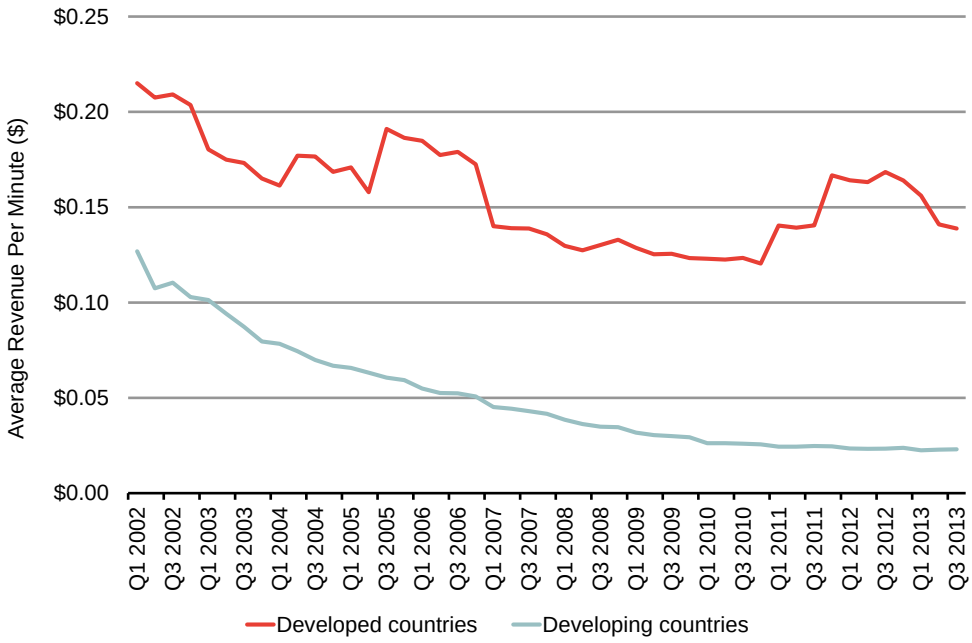
Source: GSMA intelligence database

While there has been a fall in ARPUs, usage has also increased significantly since 2000. This means that mobile users are paying less and getting a great deal more. Data usage has increased exponentially. And voice usage has increased too, with the average number of minutes per connection increasing from 178 to 290 per month (a 63% increase) since the early 2000s[117].

The average revenue per minute (ARPM) has fallen in both developed and developing countries. The fall in developing countries is particularly large, where the ARPM has fallen from 13 cents per minute to 2 cents per minute.

117 GSMA intelligence database.

Figure 45. Average Revenue Per Minute (ARPM) over time



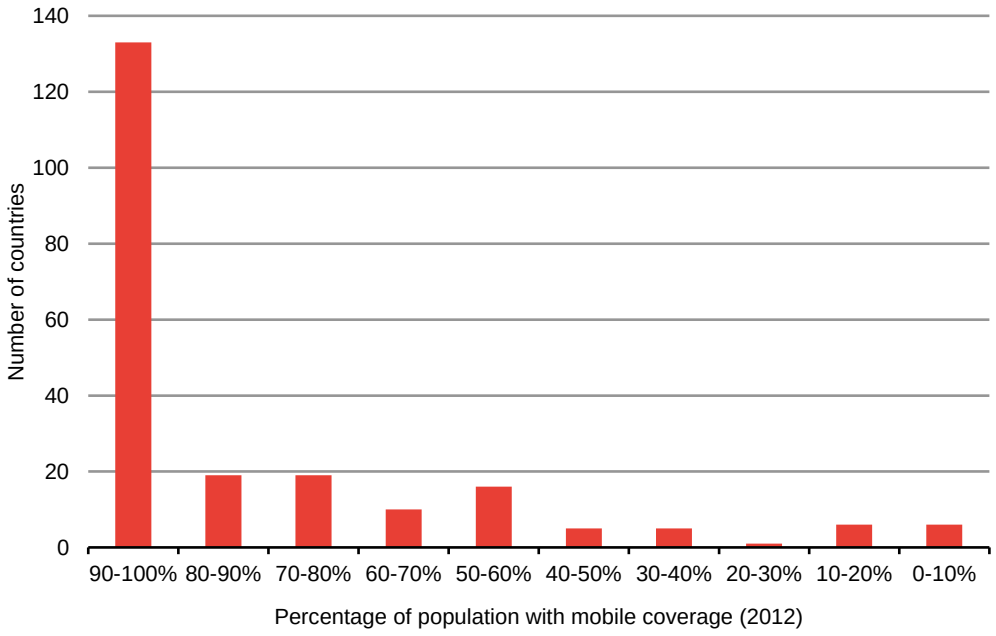
Source: GSMA intelligence database

The majority of the world's population have mobile coverage

As shown in **Figure 46**, the majority of the world's population lives in countries with at least 90 per cent mobile coverage, as of 2012. Many of these countries are estimated to have 100 per cent population coverage.

Annex 1: The history of network competition in the development of mobile markets

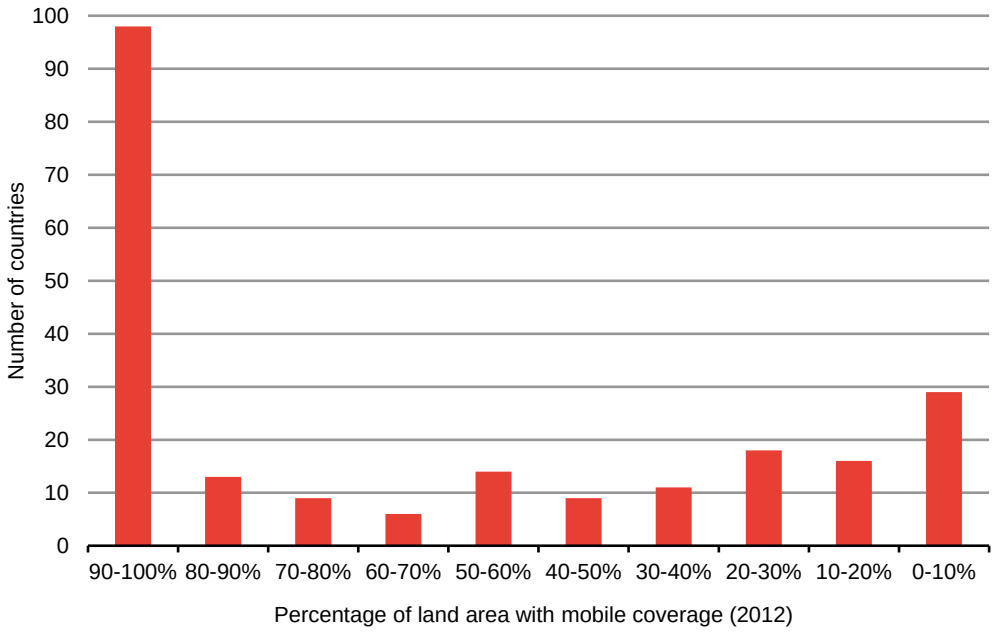
Figure 46. Mobile coverage across countries (2012)



Source: GSMA data

Similarly, as shown in **Figure 47**, in most countries, a large proportion of the land/area also has mobile coverage.

Figure 47. Mobile land area coverage across countries (2012)



Source: GSMA data

The mobile sector is particularly important in countries with a poor quality fixed network

The mobile sector has played a crucial role in many developing countries where the fixed-line infrastructure is often underdeveloped. The wide availability of mobile services has allowed these countries to avoid having to upgrade their fixed infrastructure. Without mobile, many consumers in emerging markets would have been left with no form of telecoms services at all[118]. The following figure shows that the ratio between fixed and mobile take-up varies greatly between regions.[119] For example, fixed line take-up is virtually non-existent in Africa.

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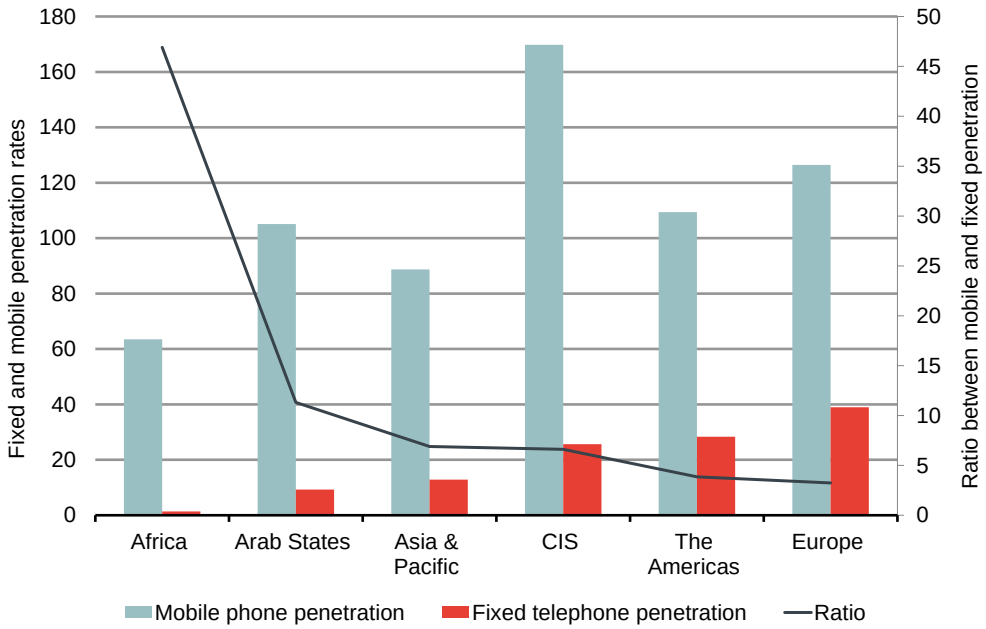
118 Studies such as those by Sridhar and Sridhar (2004) and Torero Choudhary and Bedi (2002) show that the benefits of fixed lines also applies to mobile networks in developing countries with limited fixed networks (see Sridhar and Sridhar (2004), "Telecommunications Infrastructure and Economic Growth: Evidence from Developing Countries", Working Paper 04/14 (New Delhi: National Institute of Public Finance and Policy and Torero Choudhary and Bedi (2002) "Telecommunications Infrastructure and Economic Growth: A Cross-Country Analysis" available at: https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=lasm2003&paper_id=159)

119 Mobile take-up and fixed take-up are not directly comparable, as most households will not have more than one fixed line, whereas they may well have several mobile phones. However, it is still reasonable to compare the ratio between mobile and fixed take-up across regions. Variation in household sizes across regions is only able to explain part of the differences in the ratios.

Annex 1: The history of network competition in the development of mobile markets

Figure 48. Mobile take-up compared to fixed-line take-up (2013)



Source: ITU

In many countries, mobile telephony acts as a substitute for fixed networks, enhancing the economic growth potential of the country.[120] Lee at al (2009) examined the effect of mobile phones on economic growth in Sub-Saharan Africa. They find 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.[121]

The mobile sector has provided considerable benefits to the wider economy

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[122], which helps create jobs, increases tax revenues and boosts the local economy. Capital investment by mobile operators amounts to an estimated $200 billion per year.

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

121 Proparco "Private Sector and Development" (see http://www.proparco.fr/webdav/site/proparco/shared/ELEMENTS_COMMUNS/PROPARCO/Revue%20SPD%20vraie/PDF/SPD4/RevueSPD4_Mobile_Phone_UK.pdf).

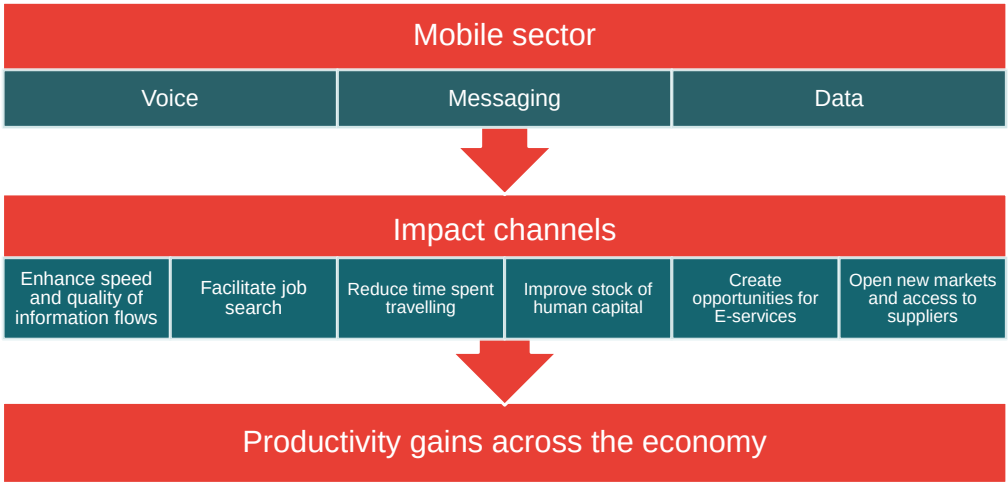
122 World Bank (see http://databank.worldbank.org/data/download/GDP.pdf).

Annex 1: The history of network competition in the development of mobile markets

Many studies have quantified the impact of the mobile sector on economic growth, particularly in developing countries. 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 is between 0.8 and 1.2 percentage points for developing countries.[123] A GSMA study showed that the mobile sector contributed 3.7 per cent of GDP in Latin America[124]

Considering only the direct impact of the mobile sector on GDP, jobs and investment will understate the total impact of the mobile sector on the economy, as it also generates significant positive spill-over effects on other sectors. As shown in **Figure 49** below, the mobile sector will have a positive impact on nearly every sector in the economy through several impact channels.

Figure 49. Impact of the mobile sector on the wider economy



Source: Frontier analysis

Studies suggest a 10% increase in mobile penetration increases Total Factor Productivity in the long run by 4.2 percentage points. The benefits in total productivity arise as mobile telephony increases worker productivity which has an impact on business productivity through improved information flows, efficiency of mobile workers, reduced travel time and costs and other time and cost savings.[125]

123 GSMA (see http://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf)

124 GSMA (see http://www.gsma.com/newsroom/gsma-mobiles-impact-latin-americas/#.UzBgkX9FCmQ)

125 GSMA (see http://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf)

Annex 1: The history of network competition in the development of mobile markets

Annex 2: Summary of existing SWN proposals

In this section, we provide a market overview and a summary of the SWN proposals in those countries that are known to be considering or in the process of implementing some form of SWN. The five countries are Mexico, Rwanda, Kenya, Russia and South Africa.

The information on the SWN proposals is based on published documents or press releases/media reports, as well as more detailed discussions with some of the affected parties. We cover, where possible, the details of the proposals such as spectrum use, the involvement of public companies and time horizons, and then also discuss the main motivations and positions on the SWNs scope and format. The following table summarises the SWN proposals in each of the five countries.

Table 3. Summary of SWN proposals

Country	Spectrum	Ownership	Timing/details
Mexico	700 MHz	Existing operators will not have a share in the network or influence the operation.	Construction aimed to begin in 2014 and end in 2018.
Rwanda	800 MHz and 1.8 GHz	Joint venture with South Korean operator KT	Construction to begin in 2014 with targeted access of 95% of the population by 2017.
Kenya	700 MHz and 800 MHz	Public Private Partnership	Held up by difficulties in negotiations with private suppliers.
Russia	700 MHz and 800 MHz	State ownership	Withdrawal of spectrum allocated to current operators for SWN.
South Africa	2X10 MHz of 800 MHz and 2x20 of 2.6 GHz band[126]	Public Private Partnership	Original proposal withdrawn. Government re-considering its options.

Source: Published documents, press releases and discussions with affected parties

Mexico

The Government in Mexico has made constitutional changes to try to foster competition in the telecommunications and broadcasting markets. As part of this, they propose the deployment of a shared public network for broadband access and mobile telecommunication services. The construction of this network is intended to begin before the end of 2014 and the network should be operational

126 The spectrum allocation in South Africa is based on the original proposal of the regulator (ICASA). Our understanding is that this proposal is currently being re-considered by the Government.

by 2018. The SWN will rely on 90 MHz of the 700 MHz band.[127] The regulatory reform bill states that it will consider both public and private investment. In either case, providers of telecommunication services will not be allowed to own a share or influence the operation of the shared network[128]. The SWN will have access to the CFE's[129] fibre backbone network, as well as any other Government-owned utilities that are required for the purposes of installing and operating the SWN. The SWN will provide only wholesale services in unbundled form. If an existing operator were to buy wholesale services from the SWN, that operator will only be allowed to resell these services to third parties under the same conditions it enjoyed from the SWN. The network will be operated with non-discriminatory access and competitive pricing.[130] The exception to this is the preponderant player[131], who will only gain access to the shared network with prior approval of the IFT[132] and they will also determine the terms and conditions of any such agreement. We understand from stakeholder interviews that there will be an obligation imposed on the SWN to reach 98% of population coverage. A Cofetel[133] study suggests that this can be achieved with around 8,200 cell sites.

We understand that the main rationale for introducing an SWN in Mexico is to promote **competition** and increase **investment**. The Congressional declaration of purpose of the Constitutional changes held in June 2013[134] states the necessity of making the Mexican telecommunications sector more competitive. It mentions the construction of the SWN as one of the measures to achieve this objective. According to interviews with the regulatory stakeholders, there is also a concern that continuing with the status quo will not provide Mexicans with universal connectivity, as envisaged in the constitutional reform. It is forecasted that the

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127 We understand that the Constitution guarantees the "optimal use" of the 700 MHz and 2.5 GHz bands. Although it is currently not explicitly intended, the SWN might also use the 2.5 GHz band in the future.

128 We note that transitory article 16.IV of the constitutional reform leaves some room for interpretation.

129 Comisión Federal de Electricidad.

130 What is meant by competitive pricing is not explained fully, although the provisional article 16 of the constitutional reform states "It will work to ensure that the pricing policy of the shared network boosts competition and ensures reinvestment of profits for the modernisation, growth and universal coverage."

131 The constitutional reform defines the preponderant player as the operator who has a market share of at least 50%.

132 Instituto Federal de Telecomunicaciones.

133 The Federal Commission of Telecommunications (former regulator prior to the setting up of the IFT) published a report with the title "Opciones regulatorias para el uso óptimo de la banda de 700 MHz en México" in May 2013.

134 http://cdn.presidencia.gob.mx/reformatelecomunicaciones/Iniciativa-de-Reforma-en-materia-de-telecomunicaciones.pdf

Annex 2: Summary of existing SWN proposals

demand for 4G services will increase substantially in the future and the concern of public authorities is that without more investment, it will come to a capacity crunch soon. They believe that the SWN is a reliable way to provide the much needed 4G capacity. The creation of the SWN would also kick-start a wholesale market,[135] which is expected to decrease the risks and costs for new operators to enter the market. As a result, there will be a dramatic increase in the number of MVNOs which in turn will make the Mexican retail market more competitive and lead to lower prices for consumers.

The decision is based on the Cofetel study[136], which estimates significant benefits in terms of GDP, consumer surplus and fiscal surplus from the construction and implementation of a single wholesale network. The study suggests that the wholesale model would allow more efficient access to rural areas, as a single network would achieve lower costs. Wholesale operators would be able to reduce their costs and pass this on to consumers and act as low cost platforms to new participants. They value this impact as having a 12-16% reduction in retail prices in the Mexican market.

Rwanda

In a joint venture with the South Korean operator KT, the Rwandan Government is building a new LTE network, which will be allocated 800 MHz and 1800 MHz spectrum and will be available for access by all wholesale-only operators.[137] KT will control the management of the firm with an exclusive licence for 25 years and the Rwandan Government is set to provide financial and administrative support.[138] Under the terms of the contract, KT Corp will invest USD140 million, while the Rwandan Government's 25 year-term equity investment will comprise of the provision of access to its national fibre-optic networks and spectrum.[139] Construction of the network should begin by the end of 2014 and targets for the network include access by 95% of the population by

135 The SWN therefore exists alongside private networks.

136 See footnote 133.

137 http://www.myict.gov.rw/fileadmin/Documents/DRAFT_NATIONAL_BROADBAND_POLICY_FOR_RWANDA_7.22.13.doc

138 http://www.telegeography.com/products/commsupdate/articles/2013/03/11/kt-corp-to-build-lte-network-in-rwanda/

139 http://www.telegeography.com/products/commsupdate/articles/2014/01/30/rwanda-signs-agreement-with-kt-to-improve-online-services/

2017 (with broadband penetration rate of at least 40%) and universal access by 2020.[140]

The rationale for a national network is that it should enhance broadband coverage and speed. The Government seem to believe a national network will allow Rwanda to achieve affordability and adoption of broadband by reducing costs to end users and supporting innovative forces that drive increased usage through better content and applications. It is also suggested that it will promote availability of broadband services especially in the rural and remote areas.[141]

Suk-Chae Lee, former CEO and Chairman of Korea Telecom, pointed out that developing countries should take advantage of broadband because they are not impeded by legacy industries and suggests that the way to finance this is through a public-private partnership model as they are doing in Rwanda.[142]

Kenya

Kenya's national broadband policy contains details of a wholesale open access wireless broadband network to be built in Kenya via a Public Private Partnership approach. It is suggested that this would use 700 and 800 MHz spectrum bands.[143] [144] The arguments for the proposal suggest that this would avoid duplication of infrastructure and efficiently use spectrum. The Government and private partners' would build, own and operate the networks which would offer wholesale capacity to new and existing service providers.[145]

The proposed objectives of the policy are countrywide broadband connectivity, high quality, affordable services throughout the country, economic growth as a result of increased penetration and improved "general social well-being.[146]

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140 http://www.myict.gov.rw/fileadmin/Documents/DRAFT_NATIONAL_BROADBAND_POLICY_FOR_RWANDA_7.22.13.doc

141 http://www.myict.gov.rw/fileadmin/Documents/DRAFT_NATIONAL_BROADBAND_POLICY_FOR_RWANDA_7.22.13.doc

142 http://www.wired.co.uk/news/archive/2013-10/29/rwanda-4g

143 Kenya National Broadband Policy National Spectrum Policy Guidelines for Spectrum Policy (see http://www.information.go.ke/wp-content/uploads/2014/03/DraftSpectructionPolicy.pdf)

144 Rething-Wireless article "Bleak outlook: Kenyas open access LTE plan" (see http://www.rethink-wireless.com/2012/03/15/bleak-outlook-kenyas-open-access-lte-plan.htm)

145 Humanipo article "open-access best model for kenyas LTE deployment" (see http://www.humanipo.com/news/30829/open-access-best-model-for-kenyas-lte-deployment-ericsson/)

146 Kenya National Broadband Policy National Spectrum Policy Guidelines for Spectrum Policy (see http://www.information.go.ke/wp-content/uploads/2014/03/DraftSpectructionPolicy.pdf)

Annex 2: Summary of existing SWN proposals

Reports suggest that from 2011, the Government has been proposing a 'fast track' rollout of 4G LTE, implemented through a public-private partnership framework. Under this framework, the Government will provide frequencies, whilst mobile network operators will provide the capital investment.[147] The LTE consortium will cover 98% of the country.[148]

There have been difficulties with cooperation of the mobile providers since the plan was proposed. In 2012, reports suggested that Safaricom objected to the decision to roll out the network in the 2.6 GHz band. They felt that starting with the 700 MHz band would be more efficient. This suggests that agreement between the Government and multiple providers has not been smooth and, as a result, in 2013 Safaricom pulled out of the deal suggesting that it was taking too long. Recent reports confirm that the Government is still committed to going ahead with the LTE roll out, with more details to be released soon.[149,150,151]

Russia

The Ministry of Communications has decided to withdraw previously allocated spectrum from telecommunications companies and transfer them to a new State owned company for a new national LTE network. [152] The network would include frequencies in the 700 and 800 MHz bands.[153] The Ministry says it will invest in rolling out 30,000 base stations and the state-owned network will be available to all operators at Government regulated tariffs.[154]

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147 AllAfrica article "Kenya: State Says Plans for 4G Network Still On Course" (see http://allafrica.com/stories/201401260138.html)

148 Capital FM article "Consortium model best for Kenya's LTE deployment" (see http://www.capitalfm.co.ke/business/2013/05/consortium-model-best-for-kenyas-lte-deployment/)

149 Keyna National Broadband Strategy (see http://www.cck.go.ke/links/consultations/current_consultations/The_National_Broadband_Strategy_.pdf)

150 Rethink-wireless article "bleak outlook: Kenyas open access LTE plan" (see http://www.rethink-wireless.com/2012/03/15/bleak-outlook-kenyas-open-access-lte-plan.htm)

151 Rethink-wireless article "safaricom quits shared LTE project Kenya" (see http://www.rethink-wireless.com/2013/11/08/safaricom-quits-shared-lte-project-kenya.htm)

152 Maravedis-bwa article "russia revives notion of shared 4g network" (see http://www.maravedis-bwa.com/templateemail/newsletters/071613/russia-revives-notion-of-shared-4g-network.html)

153 Maravedis-bwa article "russia revives notion of shared 4g network" (see http://www.maravedis-bwa.com/templateemail/newsletters/071613/russia-revives-notion-of-shared-4g-network.html)

154 Developing telecoms article "russian state owned 4g network could oust licence holder" (see http://www.developingtelecoms.com/business/regulation/4710-russian-state-owned-4g-network-could-oust-licence-holders.html)

This change has been prompted by concerns that operators have taken a "formalistic" [155] approach to rolling out new LTE infrastructure by concentrating only on the most profitable areas. Over the first year since the auction, operators built less than 1,000 base stations; this is vastly smaller than the proposed 30,000 the Ministry proposes to roll out through the new national LTE network.[156]

The Ministry has been concerned that the companies who won the spectrum auction have been focusing on coverage in larger cities, resulting in multiple overlaps and without regard for the quality of service. Additionally, the Ministry has been underfunding development of advanced technologies (4G) in order to extract more profit from GSM and 3G networks and the Ministry believes that spectrum has not been distributed efficiently.[157][158]

South Africa[159]

In December 2011, ICASA – the South African communications regulator – released proposals[160] to industry stakeholders on its plans regarding the (then) upcoming licensing of the 800 MHz and 2.6 GHz spectrum bands to be made available following the digital switchover.[161] (As discussed below, these proposals were subsequently withdrawn).

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155 "Mincomsvyaz decided that the winning bidders have taken a formalistic approach: over the first year they have only built less than 1,000 base stations and have been developing only the most vacant "upper" band of 2.5-2.7 GHz. The ministry concluded that they are not interested in hurrying the process. First, each operator is building its own infrastructure which results in "multiple overlaps". Second, in pursuit of quick profits they begin with coverage in larger cities without due regard to quality of service. Third, they deliberately underfunded development of "advanced technologies" (LTE), trying to get all they can from the existing networks (GSM and 3G). And finally, the ministry doesn't think that the frequencies are distributed efficiently: instead of the "standard 5 MHz" each operator received two bands of 7.5 MHz. That means that over 30% of the scarce frequency resource is not utilized"(see http://www.interpretermag.com/ministry-of-communications-takes-away-operators-frequencies-to-build-an-lte-network/)

156 Interpreter magazine "Ministry of communications takes away operators frequencies to build an LTE network" (see http://www.interpretermag.com/ministry-of-communications-takes-away-operators-frequencies-to-build-an-lte-network/)

157 Interpreter magazine "Ministry of communications takes away operators frequencies to build an LTE network" (see http://www.interpretermag.com/ministry-of-communications-takes-away-operators-frequencies-to-build-an-lte-network/)

158 Maravedis-bwa article "Russia revives notion of shared 4G network" (see http://www.maravedis-bwa.com/templateemail/newsletters/071613/russia-revives-notion-of-shared-4g-network.html)

159 Based on a call with Vodacom, MTN and GSMA on 3 April 2014.

160 Government Gazette 15 December 2011 – notice 911 of 2011

161 It is not yet clear when the digital switchover will happen. However, we understand from industry sources that it may not occur within the next two years.

Annex 2: Summary of existing SWN proposals

The proposals referred to wider Government policy objectives regarding universal access for broadband (although the proposals predated the Government's 2013 national broadband plan 'South Africa Connect'[162]).

Referring to conditions in 2011, ICASA said that while South Africa had a population of 49 million people, there were only 4 million fixed lines in the country[163] – with the majority in urban areas. It recognised that while the lack of fixed line infrastructure was an obstacle in achieving universal access, mobile technologies may likely play a key role – in combination with fixed technologies – in achieving the Government's targets.

ICASA proposed to create a new mobile entity that would be mandated to roll out to underserved areas, and operate as a wholesale provider only.

The plans proposed to assign this new operator, which was required to meet local-ownership criteria, a portion of high demand spectrum made available in the coming years including part of the Digital Dividend. In particular:

- 2 x 20 MHz in the 2.6 GHz frequency band; and
- 2 x 10 MHz in the 800 MHz frequency band.

However, exact details of the proposed 'wholesale open access network' were limited. Details on timing, ownership structure, funding, linkages between fixed and mobile, and the wider implications on spectrum were not clear.

The process was ultimately suspended after an 'Invitation to Apply' was issued by ICASA in relation to high-demand spectrum but no spectrum was assigned.

In the intervening period, the (then) Department of Communications published not only South Africa Connect but also, in January 2014, a National Integrated ICT Policy Green Paper. The National Integrated ICT Policy Green Paper raised more general questions about the approach to spectrum, and called for further investigation into the issue.

Also, in May 2014, there was a change in Cabinet in South Africa. The Government has announced a new Department of Telecommunications and Postal Services, along with a change to the responsibilities of the Department of Communications, and a new Minister of Communications.

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162 In South Africa Connect, the Government set ambitious targets for broadband access. Targets from the plan include: (i) 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; and (ii) 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.

163 More recent estimates report the population in South Africa at around 53 million (Statistics South Africa, Mid-Year Population Estimates 2013) and the number of PSTN lines at 4.4 million (TeleGeography GlobalComms 2013).

The new Minister of Telecommunications and Postal Services has announced that "the Government is committed to an open access regime", indicating that the concept remains on the agenda.[164] Furthermore, we understand that ICASA's strategic objectives for 2015-2019 include:

- issuing an Invitation to Apply for 800 MHz, 2.6 GHz and also 700 MHz spectrum in 2014/15; and
- drafting an internal report on the costs and benefits of open access regulation of copper, fibre and wireless access networks.

We understand that the Department of Telecommunications and Postal Services is in the process of undertaking a feasibility study to consider the costs and benefits of various approaches to open access networks. It is not clear whether ICASA's initial proposal – or a reworked version – remains as one of the options.

164 Address by the Honourable Minister of Telecommunications and Postal Services, Dr Siyabonga Cwele on the occasion of the Budget Vote Speech, 16 July 2014

Annex 3: Theoretical benefits from spectrum aggregation

Proponents of SWN argue that another potential benefit of a single wholesale network is the ability to deploy the available spectrum in a given band in one block, rather than divide this spectrum among a number of competing operators. Such aggregation can bring a number of theoretical benefits with current LTE technology. However, these benefits are unlikely to be major in reality, especially given the way in which the mobile sector is currently developing.

Overall, we would estimate that spectrum efficiencies may lead to an additional increase in capacity of the order of 10% in dense urban areas where the network is traffic constrained and the full amount of spectrum is deployed, which themselves are likely to be a relatively small part of the total cost of the network. In comparison, dynamic efficiencies resulting from network competition are likely to lead to much larger gains in spectrum efficiencies across the network. In the past decade alone, spectrum efficiency has increased by around tenfold, i.e. 100 times the potential gain from spectrum aggregation. While future direct gains in spectral efficiency may be limited by physical constraints, capacity in competitive markets is likely to continue to increase at a similar rate to meet growing demand, through a range of network innovations.

Spectrum aggregation in LTE networks

For LTE, technology carriers are of variable bandwidth, being made up of a number of sub-carriers. Typically, carriers are deployed at 2 x 5 MHz, 2 x 10 MHz and 2 x 20 MHz widths.

Where multiple operators are allocated spectrum in a single band, the result can be that each operator has less than 20 MHz. For example, for the 800 MHz 'digital dividend' spectrum, 2 x 30 MHz of spectrum is available. In many countries, this has been allocated across three operators, with each operater getting 2 x 10 MHz[165], and thus each able to offer a single 10 MHz carrier. If all spectrum in this band was allocated to a single operator, for example, an SWN, this operator would be able to offer a 20 MHz carrier, as this is the maximum size of an LTE carrier.

The rest of this Annex explains the theoretical benefits from spectrum aggregation and why these benefits are likely to be minor in reality.

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165 In some jurisdictions, a single operator has obtained large allocations (i.e. 2 x 20 MHz) and, in others, operators have received smaller allocations (i.e. 2 x 5 MHz).

Higher peak bandwidth

Larger carrier bandwidths such as 20 MHz result in high peak user bandwidths, for example when all of the capacity (physical resource blocks) in a band can be assigned to a single user.

Peak bandwidth that can be offered to a single user is one of the 'headline' benefits of LTE technology. However, the benefit of such an allocation to a single operator in terms of higher potential bandwidth for individual users is likely to be relatively small for a number of reasons:

- **The benefits only apply when there are a low number of simultaneous users**. While larger carrier bandwidths can offer high peak bandwidths to a single user, in a loaded network, there are likely to be a relatively large number of simultaneous users who share the carrier bandwidth and so the bandwidth available to each user will be smaller. To the extent that an SWN will have more users, the average bandwidth per simultaneous user is likely to be similar under an SWN with all spectrum allocated, compared to the equivalent spectrum being allocated across multiple competing networks.

- **The majority of applications will not need to use high bandwidths**. Applications are and will be designed to be used across a wide range of network conditions. Even in countries with very good coverage networks, 4G coverage will not be universal. For those areas that do have 4G coverage, peak bandwidth available will vary depending on where within the cell the user is, the number of simultaneous users and the size of the carrier.. As such, it is unlikely that developers will develop applications that require very high bandwidths or that those applications that require consistently very high bandwidths will have high penetration.

- **Very high bandwidth services will be prohibitively expensive for most users**. The prices for end user services will reflect the costs of delivering these services. Very high bandwidth services delivered by 20 MHz carriers will use up much of the available capacity in a cell, to the exclusion of other users. This means there will be a significant opportunity cost corresponding to high bandwidth services (the potential revenues from the other users excluded from the available capacity). This means that high bandwidth services would only be affordable for a small group of customers (almost by definition as they would be willing to pay to exclude other users), if any.

- **Any benefits are less likely to apply in urban areas**. In urban environments, where high data users are most likely to be located, competing network operators are more likely to roll out networks based on higher frequency spectrum where 2 x 20 MHz of spectrum will be available.

Annex 3: Theoretical benefits from spectrum aggregation

As such, in urban areas, competing network operators will be able to compete in terms of peak bandwidth with a hypothetical SWN.

- **Future technologies will make spectrum fragmentation less of an issue**. The future evolution of LTE and LTE Advanced allows carrier aggregation. This allows carriers in different non-contiguous frequency bands to be used simultaneously by an individual user. So, for example, 10 MHz carriers in the 800 and 900 bands could be aggregated to provide an effective 20 MHz carrier for a given user. This will reduce the impact of any fragmentation of spectrum in individual bands.

Overall, while headline peak user bandwidth is an effective marketing tool, and may be valuable in niche applications for most users and operators, the key advantage and differentiator will be the overall capacity of the network rather than the peak bandwidth available to a single user.

Larger carriers providing increased spectral efficiency

LTE has variable width carriers made up of a number of sub-carriers at different frequencies, with the sub-carriers grouped together in frequency and split by time to form individual physical resource blocks. There are a number of reasons why the efficiency of carriers vary by the size of the carriers used:

- The proportion of frequency required for 'guard bands' is higher for 1.4 MHz carriers;
- Overheads are a proportionately higher fixed cost of low bandwidth services;
- There are theoretical gains in efficiency for larger carriers due to frequency domain packet scheduling (FDPS); and
- Capacity pooling can allow for higher utilization of available capacity for a given quality of service (QoS).

We discuss these points in more detail below.

Guard bands

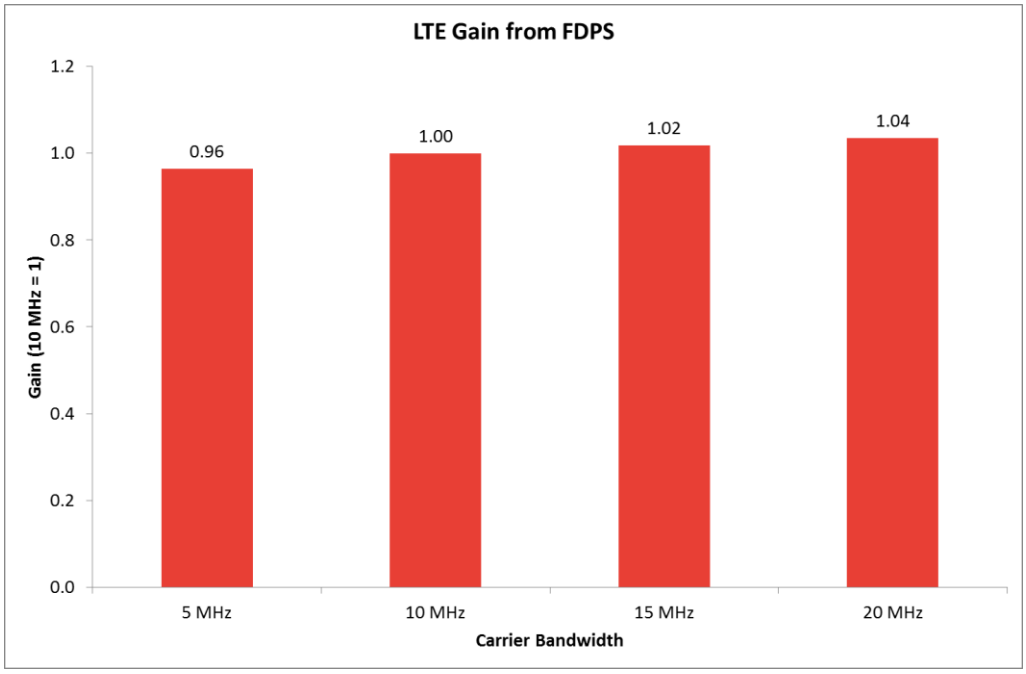
The last effect only makes a difference between 1.4 MHz carriers and larger carriers, with 1.4 MHz carriers being significantly less efficient, with 23% of spectrum being used for guard bands for 1.4 MHz compared to 10% for 3, 5, 10, 15 and 20 MHz carriers. However, 5 MHz carriers are generally the minimum used for commercial rollout and as such SWNs will not have any advantage compared to competitive networks.

Frequency Domain Packet Scheduling

Under FDPS, resource blocks are dynamically allocated between the users within the cell according to the throughput required and the signal quality. As the signal quality by sub-carrier will vary across the carrier and by user, there are potential efficiency gains by optimising the assignment of physical resource blocks between subscribers. The variation in signal quality, and hence the potential gains due to optimisation, will increase as the number of active subscribers increases and the carrier width increases.

As a result, where mean bandwidth per simultaneous user is relatively low (i.e. there are a relatively high number of active users) throughput is non-linear with wider carriers providing a small proportionate gain in throughput as shown below.

Figure 50. FDPS Gain



Source: Based on Holma and Toskala LTE for UMTS 2nd Edition Table 10.18

This indicates that the spectral efficiency of 20 MHz carriers with current LTE technology could be around 4% greater than 10 MHz carriers, i.e. an SWN with a single 20 MHz carrier provides 4% more capacity than two competing operators with 10 MHz carriers each.

Overheads

The radio access network provides a link between base stations and mobile subscribers at a physical level, with the capacity at this level determined by the

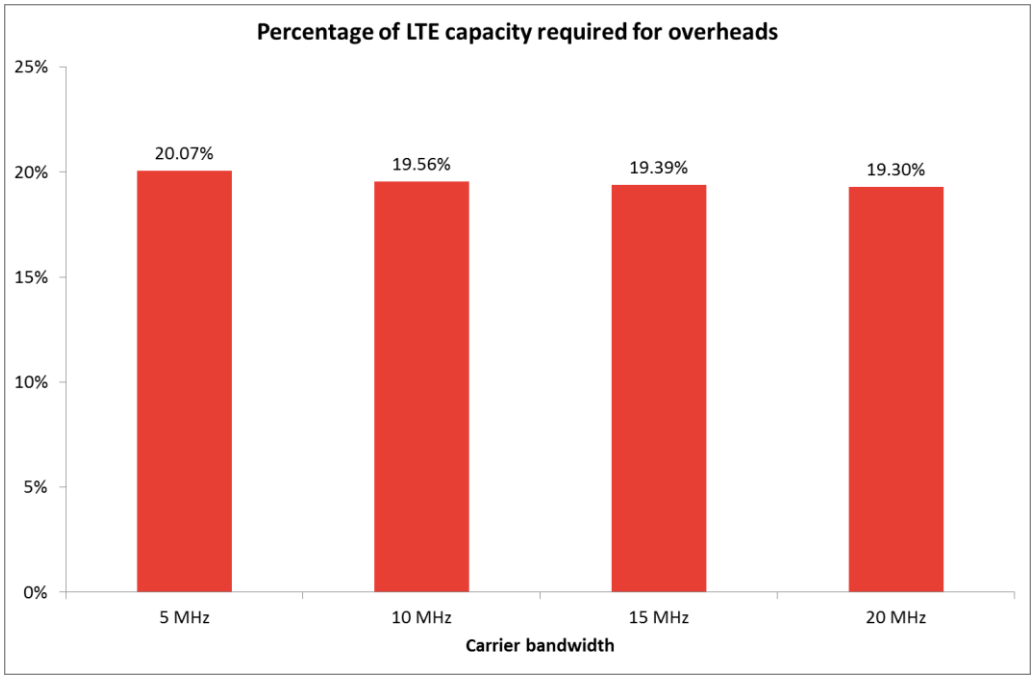
Annex 3: Theoretical benefits from spectrum aggregation

amount of spectrum. However, not all of the capacity at a physical level is translated to user capacity due to the need for some of the capacity to be used for network management, session management, error correction, etc.

Overheads are likely to have some fixed elements, which do not change as the physical capacity increases and some variable elements, which increase proportionally with the physical capacity. For example, in GSM technology, one time slot (out of eight) on the first carrier deployed was required for signalling capacity. Subject to sufficient signalling capacity being available, a second carrier could be deployed, with all eight time slots used for user data. In this case, with a single carrier, the capacity used for signalling was 12.5% of the available timeslots, while for two carriers, only 6.25% of timeslots are used for signalling. Therefore, with additional frequency, allowing additional carriers, a greater proportion of capacity can be used for user data.

Ofcom in the UK provides estimates of the proportion of physical link capacity used for overheads for difference widths of carriers. These are given below:

Figure 51. Overhead by carrier width



Source: Ofcom

The difference between resources consumed by overhead functions between 10 MHz carriers and 20 MHz carriers is so small as to have negligible impact on throughput per MHz.

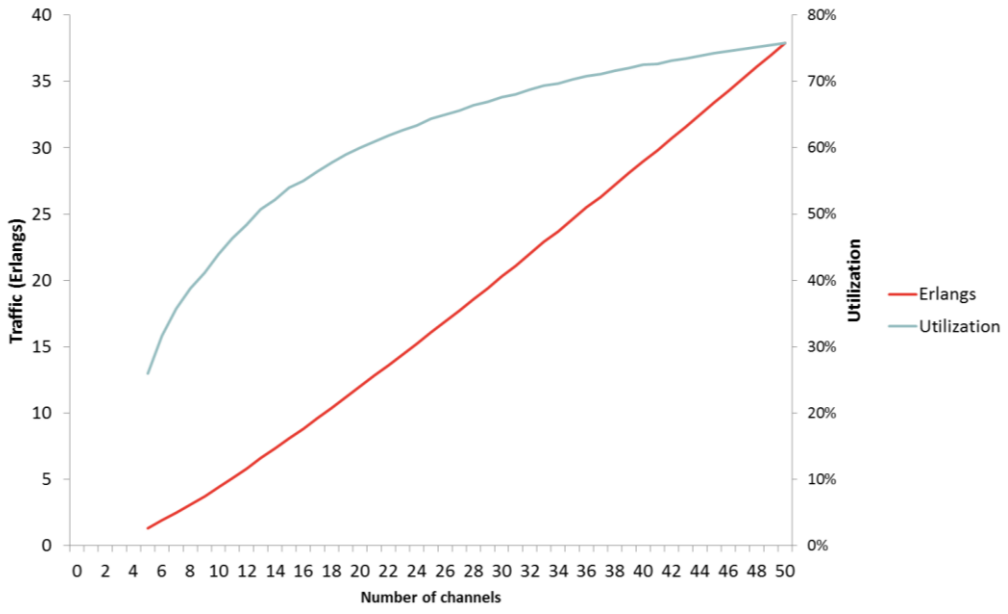
Annex 3: Theoretical benefits from spectrum aggregation

Capacity pooling effects

Traffic theory shows that the relationship between offered traffic at a given quality of service and capacity is non-linear. For example, the Erlang B formula shows the intensity of traffic (measured in Erlangs) that can be handled at a given quality of service (defined as the blocking rate) for a given capacity (measured as the number of channels/trunks).

At low capacities, a proportionately smaller level of traffic can be carried per channel at a given level of blocking, i.e. the level of utilization of the available capacity is relatively low. At larger capacities, a greater volume of capacity per channel can be carried, i.e. the utilization can be greater. Thus, doubling capacity more than doubles the level of traffic that can be served at a given level of quality of service.

Figure 52. Relationship between capacity and traffic at constant quality of service



Source: Frontier Economic

Consequently, if there is a fixed amount of capacity, the most theoretically efficient way of using this capacity is as a single pool rather than dividing the capacity into two or more pools, even if these two pools served equal amounts of traffic, as each of these pools would have a lower potential utilization at a given QoS. This means that if traffic is spread over a number of competing networks rather than delivered by an SWN, the level of utilization that can be achieved when delivering a given QoS is lower.

These effects are greater where the number of available channels is lower, i.e. for a given level of capacity,there are a smaller number of active users each using a

Annex 3: Theoretical benefits from spectrum aggregation

greater proportion of the available capacity. As a result, the smaller the number of simultaneous users, the greater the potential gains from combining capacity in a single pool.

The effects are also greater for delay intolerant, 'real time', services than services which are tolerant of delays, such as best effort packet data.

However, in modern mobile networks, the potential gain from pooling spectrum in a single trunk is relatively small for a variety of reasons:

- **Large number of simultaneous users**. In the traffic constrained part of the network, the overall capacity available to each operator is large compared to the average usage of each subscriber, such that there is less benefit from increased pooling of capacity (i.e. there are a large number of simultaneous users).

- **Real time services represent a falling percentage of total traffic**. The volume of real time, delay intolerant services such as a voice services, is relatively stable while the increase in demand is for delay tolerant 'best effort' services such as Internet access.

As a result of these two factors, the potential gains from pooling capacity would be expected to be relatively small.

Conclusion

There is a small potential theoretical gain in capacity for larger carriers. However, in real world situations, the actual improvement in capacity across the network will be smaller than this:

- **Low frequency spectrum is mainly used to provide coverage**. Much of the network served by low frequency spectrum will be coverage driven rather than capacity constrained, e.g. a 2 x 10 MHz carrier in each sector will provide sufficient capacity so the additional capacity available with 2 x 20 MHz would not be used.

- **Larger blocks are available at higher frequencies**. In traffic constrained parts of the network, operators will use both high and low frequency spectrum. As there is typically more spectrum available at higher frequencies, operators will be able to deploy 20 MHz carriers at the high frequency. As LTE does not currently provide for carrier widths higher than 20 MHz, an SWN with access to, say, 2 x 60 MHz of bandwidth could only deploy 3 x 20 MHz carriers. Thus the overall increase in bandwidth is far less.

  Future technologies will make spectrum fragmentation less of an issue. The greater efficiency of wider carriers is specific to current LTE technologies. In LTE Advanced, it will be possible to deliver much wider

carriers by aggregating component carriers delivered across a number of frequency bands. This will allow competing operators with fragmented spectrum holdings to deliver the benefits of wider carriers, further reducing any benefits due to SWNs' access to whole bands of contiguous spectrum. Thus the theoretical increase in capacity moving from 10 MHz carriers to 20 MHz with current technology carriers due to spectrum aggregation is likely to be only relevant for a short period.

Annex 3: Theoretical benefits from spectrum aggregation

Annex 4: Sensitivity checks of our econometric analysis

Re-running the regressions for a different time period

In our main specifications, 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 single networks have a detrimental impact on coverage or take-up (see **Table 4** and **Table 5**).

Table 5. Regression results for take-up, 2005q4

Table 4. Regression results for coverage[166], 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

166 *** p<0.01, ** p<0.05, * p<0.1

Annex 4: Sensitivity checks of our econometric analysis

Table 5. 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

Annex 4: Sensitivity checks of our econometric analysis

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 roll-out 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 6**, **Table 7**, **Table 8**), when we include urbanisation and political risk, we still conclude that single networks have a detrimental impact on coverage and take-up.

Annex 4: Sensitivity checks of our econometric analysis

Table 6. 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

Annex 4: Sensitivity checks of our econometric analysis

Table 7. 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

Annex 4: Sensitivity checks of our econometric analysis

Table 8. 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

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