Broadband for Africa

Policy for Promoting the Development of Backbone Networks

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BROADBAND FOR AFRICA

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Executive Summary

Many countries in Sub-Saharan Africa see ICT as a foundation of long-term economic development. The region has been very successful in increasing access to basic voice communications but there has been no comparable improvement in broadband connectivity. The broadband access gap between Sub-Saharan Africa and the rest of the world is getting wider, just as the gap in basic voice communications is getting smaller. Increasing access to broadband connectivity is therefore emerging as a high priority for policymakers across the continent.

This report focuses on one important part of the challenge – the lack of high-capacity backbone networks. It addresses three specific questions: What role do backbone networks play in the provision of broadband services, what is the current state of backbone network development in Sub-Saharan Africa (and why) and, what can be done to promote the development of backbone networks and thereby stimulate the take-up of broadband services?

There are two reasons why the rate of broadband connectivity in Sub-Saharan Africa is so low: prices are very high and availability is limited. The average retail price for basic broadband in Sub-Saharan Africa in 2006 was US$366 per month, compared with US$6 - US$44 per month in India. Typical prices for entry level broadband services in Europe average around US$40 per month, falling as low as US$12 per month in some European countries. The region also has very limited coverage of the fixed line access telephone networks which have been used to provide broadband access in the rest of the world. The average fixed line penetration rates in the region currently lies below 2% and, in many countries, the number of fixed lines is declining as people switch to mobile telephones.

Despite these historically low rates of broadband connectivity, there is evidence that there is considerable potential for broadband growth in the region. The capacity of international connections to Sub-Saharan Africa is growing and this will increase dramatically as a result of the submarine fiber-optic cables currently under construction in the region. There has been strong commercial interest in licenses for broadband spectrum in countries that have issued them and some of the major regional mobile operators are increasing their strategic focus on data services. However, successful development of mass-market broadband connectivity across the region will require investment across the supply-chain. One potential bottleneck is the supply of domestic backbone network infrastructure. Policy towards these networks is therefore a key component of overall broadband policy and is the subject of this report.

The current backbone network infrastructure in Sub-Saharan Africa is extensive but it is predominantly low capacity, wireless-based infrastructure designed to carry voice communications traffic. The current network infrastructure is not capable of carrying the volumes of traffic that would be generated if affordable broadband connectivity was available on a mass-market basis.

The market structure of the backbone network infrastructure in the region is also constraining the development of the broadband market. It is typically owned by vertically integrated operators that have built end-to-end networks. Competing downstream operators and service providers are therefore not able to obtain access to affordable backbone capacity and so competition in the provision of broadband in the region has not developed as well as in other parts of the world. This limited availability of high-capacity

backbone networks is one of the reasons that broadband is not widely available in the region and remains a niche product, affordable by only a few.

This pattern of network development is the result of a combination of factors. In many countries in the region, the regulatory frameworks actually provide disincentives to investment in backbone infrastructure by limiting the types of infrastructure that can be built and constraining the range of services for which these networks can be used. For example, some countries prevent mobile operators from selling backbone services to other operators on a wholesale basis. This reduces the potential demand for backbone services and therefore limits the incentives to invest in the infrastructure.

Where countries have fully liberalized their telecommunications markets and promoted infrastructure competition, competition among backbone networks has emerged. This investment has focused on the most profitable areas, primarily within major urban areas and on inter-city routes. Cross-border backbone network connectivity is also developing as regional businesses are established and as network traffic patterns are increasingly affected by Internet users, rather than traditional basic voice communications. The majority of the population living outside of these major urban areas is unlikely to benefit directly from backbone infrastructure competition. If backbone networks are to reach beyond these areas, some form of public support is likely to be needed.

A market-based approach is likely to be the most effective means of achieving network development. Private investment in backbone networks can be encouraged by removing regulatory restrictions on private sector investment. These restrictions include limits on the number of licenses, constraints on type of infrastructure that licensees can build and the services that they can provide. The cost of backbone investment can also be reduced by providing access to alternative transport and energy infrastructure. If utility companies such as electricity transmission operators and railway companies are brought within the formal telecommunications license framework, they can become effective players in the backbone infrastructure market. Finally, government can reduce the risk of investment in backbone infrastructure by offering political risk insurance and partial risk guarantees. Countries in the Sub-Saharan Africa region and in others that have taken such steps have seen the private sector invest in backbone network infrastructure. Backbone network competition has proved to be viable and, where it has been established, it has significantly expanded the quantity and quality of backbone capacity availability.

Stimulating backbone network development beyond major urban areas will require more active public support. This support will be more effective if it is provided in partnership with the private-sector. A number of different models for these partnerships have been implemented around the world. These include a) competitively awarded subsidies provided to private operators to build open-access networks; b) partnerships with existing operators to develop open-access networks as consortia; and c) providing financial incentives for operators to develop networks in under-served areas.

This report has focused on backbone networks which form one part of the supply-chain. If it is to be effective, it needs to be placed in the context of overall broadband policy which addresses each part of this supply-chain. If countries in the region are successful in achieving their objectives of widespread broadband connectivity, it will have profound implications for long-term economic development and the delivery of public services.

1 Introduction

Access to advanced Information and Communications Technologies (ICT) services will be a key factor in the economic and social development of Africa. Analysis of economic data at the national level shows that investment in ICT results in a higher rate of long-term economic growth (Roller and Waverman, 2001). At the level of small businesses, research shows that access to basic ICT services can result in sustained increases in the incomes of the poor in developing countries (Jensen 2007). The impact of broadband is harder to quantify because there is less data available. However, evidence is emerging which suggests that access to more advanced ICT services, such as those that required broadband connectivity for delivery, can also have a positive economic and social impact (see, for example, Goyal 2008).

As the understanding of the positive impact of ICT has grown, African governments have begun increasingly to prioritize the ICT sector and focus on providing affordable ICT services to as many people as possible.

"We have high expectations of ICT and its transformative effects in all areas of the economy and society. Communications technology has fundamentally changed the way people live, work, and interact socially, and we in Rwanda have no intention of being left behind or standing still as the rest of the globe moves forward at an ever increasing pace"[1]

This report does not attempt to evaluate the potential impact of broadband on countries in Sub-Saharan Africa. It starts from the assumption that the use of broadband will have a positive developmental impact, as has been shown to be the case for mobile networks. The primary focus of the study is on the supply side and on one component of the supply side, in particular - backbone networks. This is not the only component of the network infrastructure required to support broadband connectivity. Indeed, a sector strategy that focused exclusively on the development of backbone networks and neglected the other components of the market would be unlikely to succeed. However, by focusing the analysis on this one specific topic, this study has been able to analyze in detail the drivers of the current network and market structure in Sub-Saharan Africa and to design a targeted policy response. The study has addressed three specific questions:

(i) What role do backbone networks play in the provision of broadband services?

(ii) What is the current state of backbone network development in Sub-Saharan Africa and why?

(iii) What can be done to promote the development of backbone networks and thereby stimulate the take-up of broadband services?

This report is structured in the following way. It begins with a brief review of the ICT market and consider the extent of demand for broadband and the other ICT services that high-capacity backbone networks make possible. This is followed by a review of the existing coverage of backbone networks in the region, a discussion of how this compares with other parts of the world, and an analysis of the possible explanations for the current pattern of network development. Finally, the report presents a set of policy options that governments in the region might consider in order to promote the development of backbone networks in their countries.

[1] H.E. Paul Kagame, President of the Republic of Rwanda in Government of Rwanda (2006)

2 Demand for broadband in Sub-Saharan Africa

The use of ICT services in Sub-Saharan Africa has grown rapidly over the last ten years. This growth has been overwhelmingly in the mobile phone segment of the sector and has been driven by high levels of investment and competition among operators in the newly liberalized markets. A total of $23 billion was invested in the ICT sector in Sub-Saharan Africa between 1996 and 2006, predominantly by the private-sector.[2] More than half of the population of Sub-Saharan Africa now lives within range of the mobile networks and, by the end of 2007, there were approximately 180 million mobile subscribers in the region (equivalent to 23% of the population) (ITU 2008).

This growth in availability of basic voice services is likely to continue. Network coverage continues to expand and the average revenue per user generated by networks in the region remains three times higher than in countries such as Bangladesh, India, and Pakistan.[3] The price of telecommunications services in Sub-Saharan Africa may therefore still have some way to fall and, as it does, the use of mobile communications is likely to increase. Recent research indicates that, if effective competition among network operators is established, over 90% of the population of Sub-Saharan Africa will be living within reach of the networks (World Bank 2008). By contrast, the rate of growth of telephone penetration in developed countries has declined as markets have reached saturation. The gap between Sub-Saharan Africa and the rest of the world in the availability of voice communications services is therefore shrinking. The gap in access to broadband between Sub-Saharan Africa and the rest of the world is, however, getting wider. Broadband penetration rates in developed countries and many emerging markets are accelerating while growth in Sub-Saharan Africa remains low.

What are the causes of low rates of broadband penetration in the region? Is it due to lack of demand for broadband services or is it that there is demand for it but the industry is unwilling or unable to meet this demand? Or is it that there is potential demand for the services but current prices make it unaffordable to the majority of people living in the region? A detailed analysis of the demand for broadband in Sub-Saharan Africa is beyond the scope of this report. However, we do provide a brief review of evidence indicating that there is likely to be strong demand for broadband connectivity.

Two key factors underlie the very low rates of usage of broadband in Sub-Saharan Africa – high prices and limited availability. Price is a major determinant of broadband take-up (ITIF 2008). Current retail prices for broadband in Sub-Saharan Africa, where it is available, are high by international standards. The average price of basic xDSL package in Sub-Saharan Africa is US$366 per month[4] which is much higher than in other parts of the developing world. Estimates of the price of basic xDSL services in India, for example, lie between US$6 per month (OECD 2006) and US$44 per month (ITU 2007a).[5] Typical prices for entry level broadband services in Europe average around

[2] World Bank PPI database

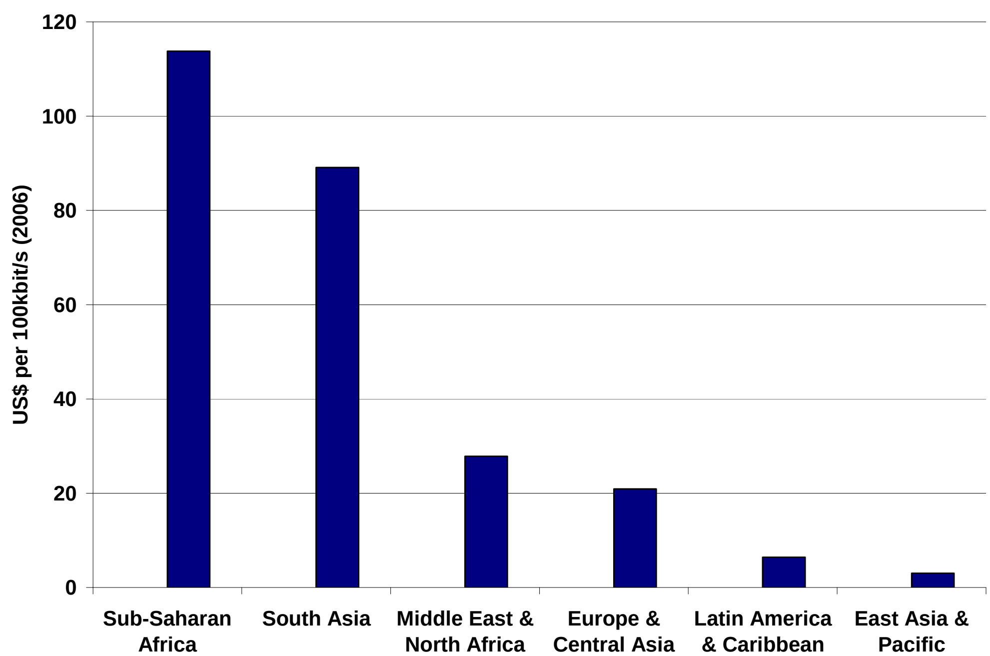
[3] Source: Wireless Intelligence

[4] Population-weighted average of price of lowest cost broadband package. World Bank staff calculations, based on data from ITU (2007a).

[5] The regulatory authority in India reported an average broadband price of between US$12 and US$18 per month (assuming a rate of usage of 3 hours per day) TRAI (2006)

US$40 per month, falling as low as US$12 per month in some European countries.[6] The technical specifications of broadband packages vary among countries, making it difficult to perform precise comparisons of retail prices. One way of dealing with this is to compare the average price per 100kbit/s download speed for the cheapest broadband package. This is done in Figure 1.

Figure 1: Comparison of Regional Average Broadband Retail Prices



Source: ITU 2007a, World Bank staff analysis

Figure 1 shows that the price of basic broadband connectivity in Sub-Saharan Africa is the highest of all the regions. The price of broadband connectivity in South Asia, shown in Figure 1, is also high at US$89 per 100kbit/s per month. However, it is important to note that this high price of broadband in South Asia is primarily the result of very high prices reported for Pakistan and Bangladesh. In India, which accounts for approximately 80% of the population of the region, the price of entry-level broadband in 2006 was US$44 per month.

The second factor lies in the limited availability of the services. The primary means of providing customers with broadband connectivity around the world has been through the fixed telephone line access networks of the telecommunications operators or the cable TV networks. The high rates of coverage of these networks, often combined with a policy of unbundling to facilitate services competition in the market, has resulted in rapid roll-out of broadband services.[7] In Sub-Saharan Africa, the coverage of fixed telephone access networks is very limited with a penetration rate in 2007 of less than 2% (ITU 2008).

[6] Figures are simple average of prices for entry level broadband services in 17 countries in 2004. Bank staff calculations, based on data from European Commission (2005)

[7] See, for example, the case of Sweden, described in Section 4.

Moreover, much of the infrastructure that does exist is of poor quality and not capable of supporting xDSL services without significant investment. Companies wishing to offer broadband have been largely constrained to the limited base of subscribers with upgraded access lines or to using expensive wireless access solutions. Additionally, few countries in the region have successfully introduced local loop unbundling and so the development of xDSL-based broadband access technologies has been further limited by the behavior of incumbent operators that often prevents competing operators from using their infrastructure. Finally, cable TV networks in the region are largely non-existent, leaving no alternative means of providing broadband to customers.

If broadband was more widely available at much lower prices, what would be the likely take-up of services? There is little direct evidence to answer this question from Sub-Saharan Africa itself. In order to get some indication of the likely demand for broadband services, it is necessary to rely on indirect evidence.

The first type of indirect evidence is provided by a service that is widely available - mobile voice communications services. Telephone penetration rates are rising in Sub-Saharan Africa faster than any other region in the world, despite high prices and limited availability in many parts of the region. This provides an indication of the high value that consumers in the region place on communications services in general. It might be expected that customers' high valuations of basic voice services would also apply to broadband connectivity.

The second type of indirect evidence is obtained from looking at other regions where broadband services are more widely available and prices are lower. Broadband penetration rates around the world have risen rapidly over recent years. The current OECD average broadband population penetration rate is 16%[8] but countries such as Denmark, Iceland and Korea have reached rates of over 25%. In developing countries, rates remain very low but are growing fast. For example, the proportion of the population in China using the Internet doubled from 7.9% to 16% between 2005 and 2007 and, of this, over three-quarters of the subscribers used broadband (CNNIC 2008). In India, the number of broadband subscribers is low but is growing at nearly 50% per year (TRAI 2006).

Finally, an indication of the potential demand for broadband in Sub-Saharan Africa can be obtained from recent industry developments in the region. The usage of the internet in Africa is growing rapidly and the ICT industry has responded by increasing the capacity of international internet connectivity in the region. Between 2004 and 2007, the international internet bandwidth connected to Sub-Saharan Africa[9] grew at 96% per year, compared with a global average annual growth rate of 51% per year (Telegeography 2008). The fact that internet usage is growing, despite the constraints imposed by high prices, poor quality and limited availability, is an indication of the potential demand for broadband. The ICT industry is responding to this demand by investing in international infrastructure such as submarine fiber-optic cable projects which are currently underway on both the East and West coasts of the continent.

[8] Penetration rate is defined as the number of subscribers/population. Since many broadband connections are shared (e.g. within families), the proportion of the population with access to broadband is greater than this.

[9] Figure excludes South Africa.

There has also been significant interest by the major mobile operators in upgrading their networks to be able to support data services (Balancing Act 2007) and there has been strong interest in obtaining WiMAX licenses as it has the potential to overcome the access infrastructure bottleneck seen in most countries in the region (Global Insight 2007).

At this stage of market development, it is not possible to say what the future demand for broadband in Sub-Saharan Africa will be and this study has not undertaken a detailed analysis of it. However, there are indications that, if prices were lower and the service was more widely available, demand would be significant. If this is correct, the fact that the private sector has not stepped in to meet this demand may indicate that there is a problem in the way in which the broadband market is functioning. This implies that sector policy should be focused on improving the operation of the market and ensuring that there are no bottlenecks in the network infrastructure. This study has looked at one such potential bottleneck – backbone infrastructure.

3 Backbone networks in Sub-Saharan Africa

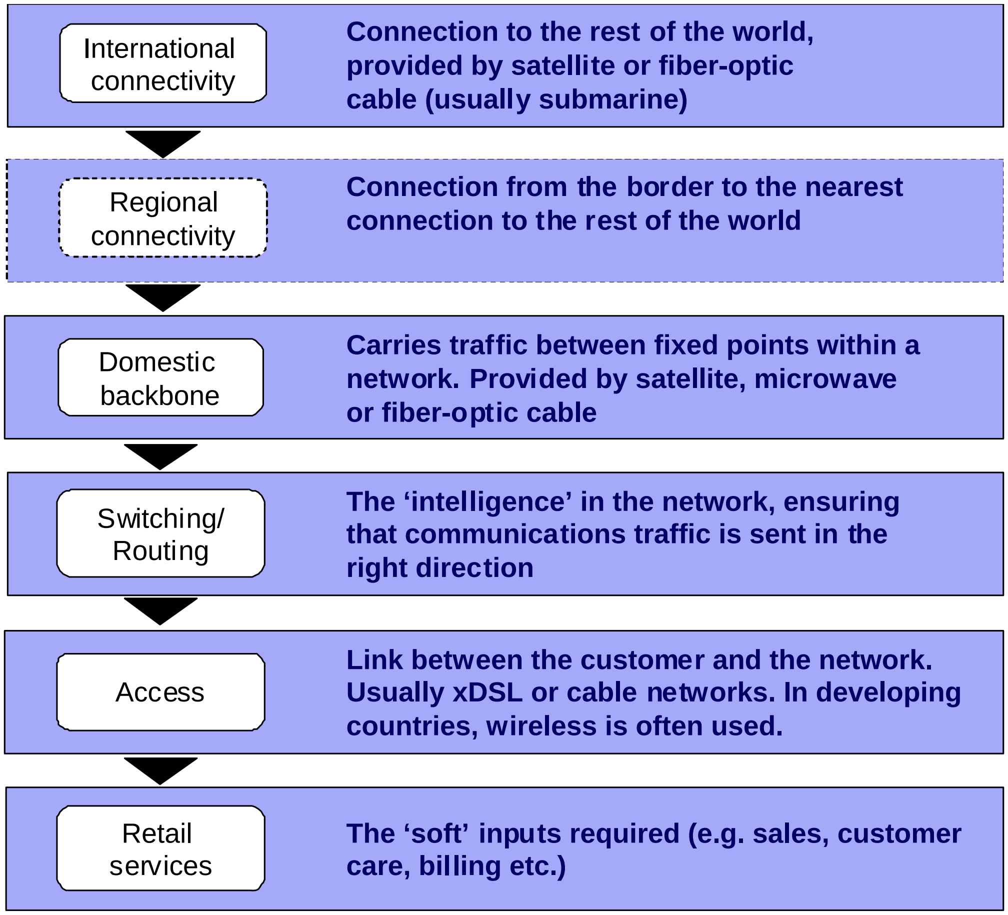
The provision of broadband connectivity to end-users involves several different elements. A problem in any one of these elements will constrain the delivery of affordable broadband services. Domestic backbone networks are one of these elements and there is evidence that the lack of this type of infrastructure is one of the factors underlying the limited growth of broadband in the region. The backbone network infrastructure in Sub-Saharan Africa is characterized by widespread, low-capacity networks generally owned and operated by vertically integrated operators focusing primarily on voice services. Incumbent operators have much less extensive networks and, in many cases, do not play a major role as provider of backbone network services. This situation is different from other regions in world where large-scale investment in backbone networks has resulted in intensive competition and vertical disaggregation of networks, encouraging entry into the downstream market and stimulating the roll-out of broadband services. The underlying causes of this pattern of network and market development in Sub-Saharan Africa are a combination of higher costs, regulatory restrictions and the historical development of the markets.

In this section, this situation is reviewed in detail in order to provide a foundation for the policy recommendations outlined in this report. Section 3.1 reviews the role that backbone networks play in the delivery of broadband services. This is followed by an analysis of the current situation in Sub-Saharan Africa in sections 3.2 and 3.3. The drivers of network development in the region are discussed in Section 3.4.

3.1 The role of backbone networks

Supplying communications services involves a combination of different network elements, processing and business services. These can be thought of as the "supply chain". At the top of the chain is the international connectivity that provides the link to the rest of the world. The second level is the domestic and regional backbone networks that carry traffic from the landing point of the international communications infrastructure and within the country. The third level is the 'intelligence' contained in the networks. Below this is the access network that links the core network to the customer. Finally, there are a suite of retail services such as customer acquisition, billing and customer care that allow the business to function. This supply chain is illustrated in Figure 2.

Figure 2: Broadband Communications Supply Chain



In practice, there are many variations on the structure of this supply chain. For example, voice services do not rely as heavily on international connectivity as Internet services. Land-locked countries require an additional element of the supply-chain if they wish to utilize terrestrial communications infrastructure, the regional networks that provide transit services between their borders and the nearest connection to the international submarine fiber infrastructure.

Backbone networks lie at the heart of this supply chain and therefore are an integral component in the provision of broadband connectivity. However, they are clearly not the only component of the chain. A technical or economic problem in any of the elements results in a problem for the provision of broadband connectivity to customers. Any discussion of backbone network policy should therefore be placed in the context of overall broadband policy. This point is discussed further in Section 4 as part of the backbone policy recommendations.

Communications networks operate by channeling traffic from a geographically distributed customer base to local switching or routing nodes where it is directed to other customers, in the case of local voice and data communications, or towards the Internet. In the case of Sub-Saharan Africa, most Internet traffic passes in and out of the region since little Internet content is hosted within the region itself. A backbone network is the part of the network that is used to carry this aggregated traffic between network nodes. The hierarchical nature of communications networks means that the volumes of traffic carried on the backbones are relatively high, even where the customer base is small.

It is not necessary for each operator to have their own backbone network. The interconnection of networks means that one operator can use the backbone network of another through the purchase of backbone network services. In practice, the typical structure of a fully liberalized ICT market is one in which the upstream elements of the market (i.e. the higher levels of the supply chain illustrated in Figure 2) are consolidated into a few large companies with very high-capacity networks, while the downstream components tend to be smaller and more geographically disaggregated. In the United States, this vertical disaggregation results in a three-tier industry structure. Tier 1 is comprised of the very large Internet Service Providers (ISPs) with extensive international communications infrastructure. Tier 2 ISPs are large national companies, also often with their own infrastructure, that have interconnection arrangements with ISPs in other tiers. Tier 3 ISPs are the companies that have a direct relationship with customers and provide the retail services to end-users. Outside of the United States, different market structures have emerged but the general pattern of vertical disaggregation is common with backbone networks services often being provided on a wholesale basis to third-party downstream players. In Sub-Saharan Africa, on the other hand, the structure of telecoms networks is different. Instead of the vertically disaggregated network structure, operators in the region frequently remain vertically integrated with individual operators providing end-to-end services. This has important implications for the development of backbone networks and the provision of broadband connectivity to customers.

Backbone networks have a major impact on the delivery of ICT services in a country. In a typical mobile voice network, the backbone network accounts for approximately 10-15% of the total network costs.[10] For operators providing broadband connectivity, the cost of backbone networks is much more significant. The average cost of backbone networks (i.e. the cost per subscriber) varies enormously depending on where the subscriber is in the network. If they are in urban areas where subscribers are geographically concentrated, the cost of backbone networks per subscriber will be much lower than if they are in smaller towns or even rural areas. For the latter subscribers, the cost of backbone networks will represent a major part of the total network cost of the overall broadband service. In practice, backbone costs will be one of the key determinants of the financial viability of providing broadband services in an area of a country. In the absence of backbone networks aggregating traffic and thereby reducing average costs, broadband services are unlikely to be commercially viable in anything other than the major urban areas of a country.

The potential economic impact of backbone networks lies in this reduction of costs through spreading them over higher volumes of traffic. This benefits all broadband

[10] Discussions with operators.

providers but particularly smaller downstream players who can purchase network services rather than having to build their own end-to-end networks. The potential economic impact is described in more detail in Box 1.

Box 1: Economic Impact of Backbone Networks

The primary economic impact of backbone networks lies in the greater efficiency of aggregating traffic on to high-capacity networks and the corresponding reduction in average costs. This is a function of the fundamental cost characteristics of backbone networks which are illustrated in Figure 3 for a 100km backbone network link.

The practical consequences of this cost structure can be seen in the impact of backbone networks on network costs in an actual network situation. A backbone network was modeled for Nigeria in which the current networks were extended to connect major population centers throughout the country. The economic impact of this network was then modeled to analyze the impact on average costs.

Figure 3: Average backbone network costs

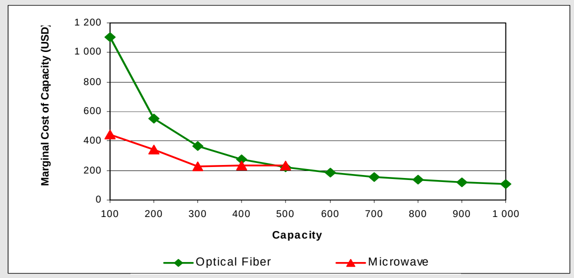
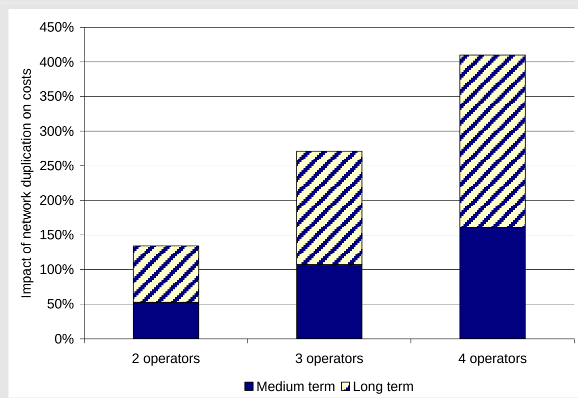


Figure 4 shows how costs increase significantly if traffic is carried over parallel networks of lower capacity, rather than a single higher-capacity network. By aggregating traffic and spreading fixed costs over a larger volume of services, the total cost to consumers is reduced and it is easier for downstream providers to enter the market. In the case of Nigeria, a high-capacity backbone network could result in significant cost-savings, equivalent of up to one-third of the current average broadband retail price of around US$150 per month. The impact on wholesale backbone prices would be even more significant with cost savings of up to 90 percent relative to the incumbent operator NITEL's current wholesale leased line prices.

Figure 4: Effect of traffic aggregation on average costs



Source: ICEA 2008

This analysis of the impact of backbone networks on costs, illustrated for the case of Nigeria in Box 1, is a static picture that does not take into account the dynamic effects of competition. When thinking about the lower average costs of high-capacity networks carrying high volumes of traffic, it is important to set against this the potential inefficiencies associated with the lack of competition that would arise if there were only one backbone network. In the case of Nigeria, one of the reasons that the incumbent operator is able to maintain high wholesale prices for backbone services is the lack of effective competition in the backbone services market. This is a pattern seen in other countries in the Sub-Saharan Africa region and also in other parts of the world where neither competition or regulation are effectively controlling wholesale prices.

3.2 Backbone networks in Sub-Saharan Africa

There are four dimensions to consider in assessing the adequacy of backbone network infrastructure: length, capacity, geographical distribution and network ownership.

3.2.1 Network length

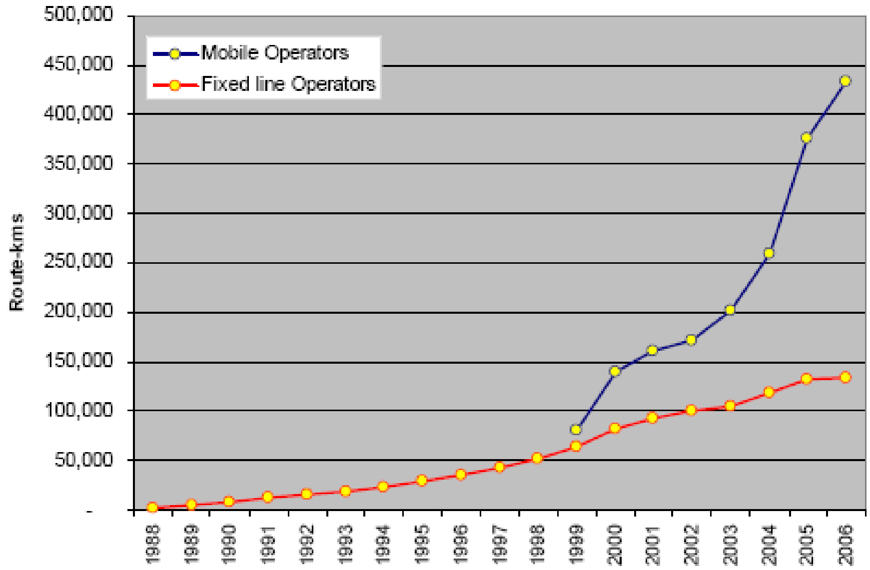
Contrary to common assumptions, there is, in fact, an extensive backbone infrastructure in Sub-Saharan Africa. There is approximately 508,000 km[11] of terrestrial backbone infrastructure (i.e. microwave and fiber-optic cables) operating in Sub-Saharan Africa[12], serving around three-quarters of the region's communications users. The remaining one-quarter of customers are connected to parts of the networks using backbone infrastructure based on satellite links.[13]

Unlike in other regions of the world where fixed telephone operators (usually the current or former state-owned operator) own the majority of the backbone network infrastructure, only 32% of the terrestrial backbone in Sub-Saharan Africa is owned by fixed operators. This figure includes both the formerly state-owned incumbent operators and the new entrants. The remaining 68% of the total backbone infrastructure is owned by mobile operators. Almost all the satellite-based backbone infrastructure is also operated by the mobile operators.

The rapid expansion of terrestrial backbone networks in Sub-Saharan Africa over the last ten years, and the emergence of the mobile networks as the primary backbone network providers are illustrated in Figure 5.

[11] This figure is an underestimate since data was not available for some operators.
[12] Data presented in this section refer to 47 countries of Sub-Saharan Africa. These are all countries in the region except South Africa which was excluded from the analysis because the backbone network infrastructure there is highly developed and is unrepresentative of the pattern of infrastructure in other countries in the region.
[13] The metrics used to measure the extent of backbone networks is typically length (km) and capacity (Mbps). Microwave and fiber networks can be measured this way but measuring the length of satellite links is not a relevant statistic.

Figure 5: Backbone Network Development in Sub-Saharan Africa



Source: Hamilton 2007

This growth has come about as a result of the expansion of the mobile networks in Africa to provide voice, and increasingly, data services. A good example of this is MTN Nigeria which recently announced a $2-billion investment in network infrastructure that will include fiber-optic backbone infrastructure.[14] New operators, targeting the data services market at both the wholesale and retail levels, are also emerging. They are developing backbone infrastructure either as greenfield projects or utilizing existing alternative infrastructure such as rail and electricity network. For example, in Kenya, a fixed network operator Kenya Data Networks has already laid 1900km of fiber optic cable infrastructure to provide advanced data services (see Figure 7). Several governments in the region (e.g. Ghana, Uganda, Kenya, Ethiopia) are also beginning to invest directly in fiber-optic backbone networks.

Most of the backbone infrastructure in Sub-Saharan Africa is wireless. In fact, only 12% of the total terrestrial infrastructure in the region is fiber-optic cable while the remainder is microwave. If satellite-based backbone network infrastructure is also taken into account, the significance of fiber in the total backbone network infrastructure of Africa is even smaller.

This mixture of wireline vs. wireless infrastructure varies considerably among the types of operator. Approximately 99% of the backbone network length of mobile operators in Sub-Saharan Africa is made up of microwave technology with only 1% being fiber. Fixed operators, on the other hand, have much more fiber in their networks, with approximately 40% of the length of their backbone networks built from fiber technologies.

Satellite capacity is normally used for transmission in parts of the countries that are thinly populated; between parts of networks where network coverage is not contiguous; and during early stages of network roll-out into an area. The use of satellites for transmission is increasing rapidly in Sub-Saharan Africa as mobile network coverage expands into

[14] http://mybroadband.co.za/news/Cellular/1518.html, 4 October 2007, accessed 28 May 2008

more thinly populated areas. Satellites serve approximately one-quarter of the total GSM coverage in sub-Saharan Africa. However, this average figure hides significant variations among countries. For example, it is estimated that approximately 89% of mobile network transmission is provided by satellite in Democratic Republic of Congo (DRC) and 48% in Mauritania. However, in smaller countries where population density is higher such as Mauritius and Comoros, satellites do not play a significant role in providing backbone links.

3.2.2 Network capacity

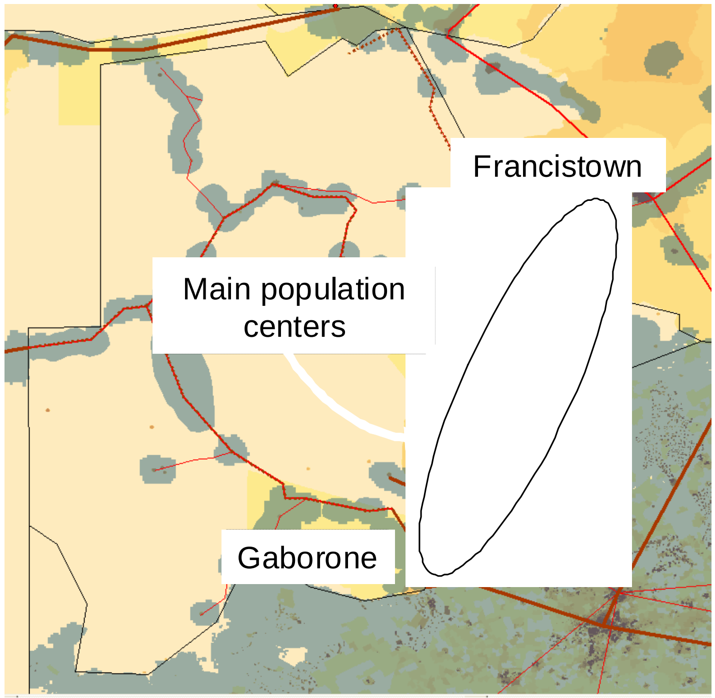
The capacity of a backbone network is determined by the technology on which it is based and the capacity of the transmission equipment that is installed on the network. There are technical and economic limits on the extent that backbone network capacity can be increased but, in practice, the choice of backbone network technology is usually determined by cost structure, rather than technical capacity limitations. For low traffic volumes such as those generated by mobile voice networks, wireless backbone networks are the most cost-effective technology. For higher volumes of traffic, fiber networks are typically the optimum solution.[15] Detailed technical information on the capacity of backbone networks in the Sub-Saharan Africa region is not available since it is usually commercially confidential. However, the predominance of microwave and satellite backbone technologies in the networks provides a clear indication of the limitations on capacity of the networks.

3.2.3 Geographical pattern of backbone networks

The development of fiber-optic backbone networks has been seen predominantly within and between major urban areas and on inter-country routes. The fixed-operator backbone networks currently installed in Sub-Saharan Africa, which comprise the majority of the high-capacity fiber networks, cover only about 21% of the population.[16] This concentration on urban areas is illustrated for Botswana in Figure 6.

[15] This cost structure is discussed in more detail in Section 3.4.1.
[16] Defined as the population living within a radius of 10km of a backbone network node.

Figure 6: Map of Backbone Networks in Botswana

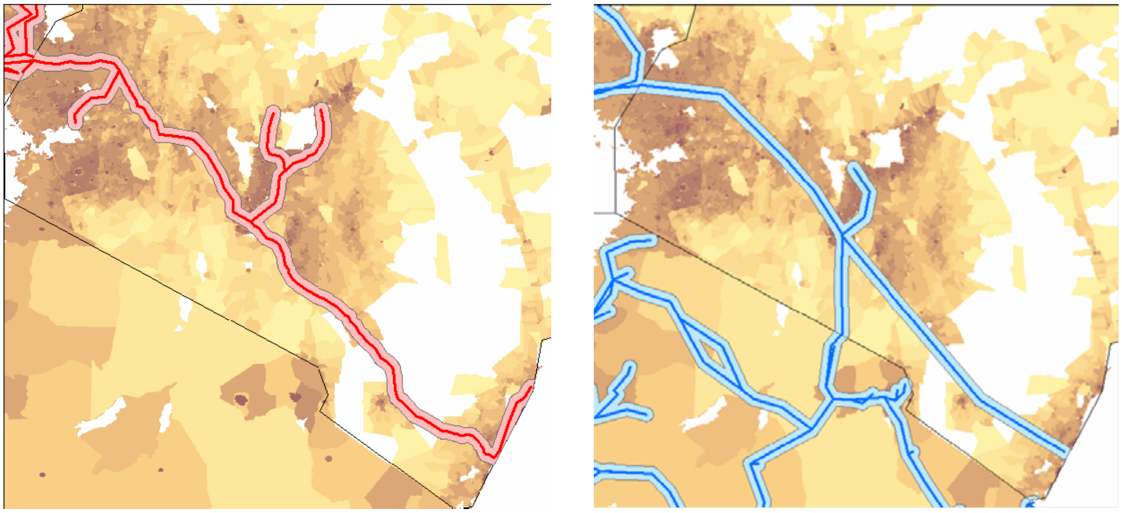


Source: Hamilton 2007.

The population of Botswana is heavily concentrated in the Southeast part of the country, as indicated by the shaded area in Figure 6. This is also the area where the backbone networks are concentrated (as shown by the red lines in the map). The pattern of backbone network development therefore closely matches the population centers and the transport corridors that link them.

This concentration of backbone network development is increased through the effect of infrastructure competition in the few countries where markets have been fully liberalized. In these countries, entrants have focused their backbone network construction in the same areas that the incumbent operator already has its network. The effect has been to increase the amount of backbone infrastructure available in these areas without benefitting other parts of the country. This is illustrated in Figure 7 for the case of Kenya where there are two major backbone network operators – Telkom Kenya and Kenya Data Networks.

Figure 7: Competitive Backbone Network Development in Kenya



Kenya Data Networks (KDN) **Telkom Kenya**

Source: Hamilton 2007

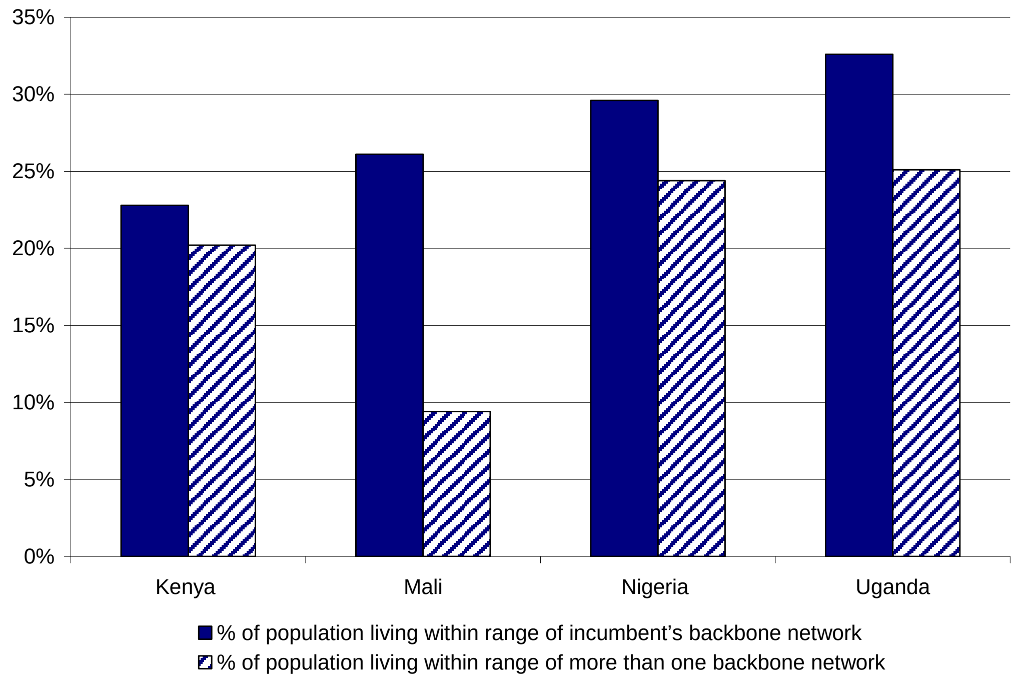
Figure 7 shows how the fiber network of the entrant, KDN, closely follows the existing network of the incumbent, Telkom Kenya, along the main corridor linking Mombasa with Nairobi and on to the Uganda border. Rather than increasing the geographical coverage of backbone networks, infrastructure competition in Kenya has increased the availability of these networks in core urban areas. Outside of these areas, customers only have access to basic voice services provided through the mobile networks, rather than the high bandwidth services that the fiber networks are capable of supporting.

Figure 7 also illustrates another feature of the way in which high-capacity backbone networks develop when there is infrastructure competition. In addition to providing connectivity between urban areas within a country, they also often focus on cross-border linkages. In the case of the networks in Kenya, the cable infrastructure of both KDN and Telkom Kenya extends to the Kenya-Uganda border where it interconnects with infrastructure in Uganda.

This pattern of network competition in urban areas and on inter-urban routes is seen in other countries in Sub-Saharan Africa that have established effective infrastructure competition. There are also many other examples of where private investment in cross-border connectivity is developing as a result of infrastructure competition. In West Africa, some of this network development is driven by operators in land-locked countries requiring access to the SAT-3 submarine fiber-optic cable. A similar process is underway throughout the Eastern and Southern Africa region where cross-border connectivity is developing. This is partly driven by the future development of submarine fiber-optic cables off the coast.

The result of this investment in backbone networks and the emergence of infrastructure competition is that, in these countries, some customers do find themselves living within range of more than one competing fixed backbone network but this is only a minority of the population. This is illustrated in Figure 8, which shows the proportion of the population living within range of the incumbent operator's backbone network and the proportion living within range of more than one fixed operator backbone network.

Figure 8: Population Coverage of Incumbent and Competing Networks



Source: Hamilton 2007

Figure 8 shows two significant features of backbone network coverage in the four countries. The coverage of the incumbent fixed operators' networks is quite limited at only 23% to 33% of the population. It also shows that competition among the fixed operators with fiber networks only benefits the limited proportion of the population that lives within range of more than one fixed fiber network.

3.2.4 Backbone network ownership structure

In the majority of cases in Sub-Saharan Africa, backbone networks are used only by the operators that built and owned them. Wholesale markets in backbone capacity are poorly developed, there are few examples of joint ventures on the construction and operation of terrestrial backbone networks and there is little sharing of backbone network facilities. There are, however, some exceptions to this general observation.

- *Legal and regulatory requirements.* In some countries, mobile operators have been required by law or regulation to use the incumbent's network for backbone services. This was the case, for example, in South Africa until the new Electronic Communications Act came into force in 2005. Following the change in the legal framework, there has been a rapid growth in backbone networks as operators have invested in competing fiber-optic infrastructure.[17]

[17] This is discussed in more detail in Section 3.4.4

- *Small operators entering the market.* There are cases of new mobile operators entering the market and purchasing backbone capacity from existing operators, either the fixed line incumbent or the existing mobile operators. An example of this is Kasapa, a small CDMA mobile operator in Ghana, which purchases backbone network services from Tigo, the second-biggest mobile operator in the country.[18]

In countries that have fully liberalized their infrastructure markets, some wholesale networks have emerged through the impact of market forces. For example, wholesale backbone networks, known as “carrier networks”, have been established in competitive markets such as Kenya and Nigeria. These operators provide long-distance backbone services on a wholesale basis to other operators. However, in both countries, some of the mobile and data operators continue to self-provide their own backbone networks.

In several countries in Sub-Saharan Africa, other infrastructure networks such as railways and electricity transmission networks have developed fiber optic communications networks and are operating as carrier networks. The record of success of such networks is variable. In Ghana, for example, the electricity transmission network operator, Volta River Authority (VRA), has not been successful in commercializing its fiber-optic communications networks. On the other hand, in Uganda the electricity transmission network does sell capacity to telecommunications operators along certain routes. These successful examples of wholesale backbone networks show that wholesale markets for backbone capacity are feasible in Sub-Saharan Africa. The fact that they are underdeveloped across the region as a whole is an indication of the forces that constrain them.

3.3 Backbone networks in other regions

The structure of backbone networks in Sub-Saharan Africa described above has some similarities to the networks in other regions but also some significant differences. The pattern of concentration of networks in urban areas and on inter-urban routes is common to most countries. However, in other respects, the pattern of network development in Sub-Saharan Africa is quite different. The incumbent operators’ networks in Sub-Saharan Africa are limited in extent whereas, in other parts of the world, they are typically the largest networks by length in other countries. Also, the pattern of vertically integrated operators and only limited wholesale selling of capacity is not typical of more advanced ICT markets. Sections 3.3.1 to 3.3.3 consider three benchmark comparisons in more detail.

3.3.1 Backbone networks in Europe

In most European countries, the incumbent operator typically owns and operates a backbone network that covers the majority of the country and sells wholesale backbone services on regulated terms. There are also typically multiple competing operators providing services in major urban areas and on inter-urban routes. This pattern of network infrastructure competition was recently noted by the European Commission in its review of competition in core backbone infrastructure services:

[18] See Section 3.4.4 for a more detailed discussion of the example of mobile operators in Ghana.

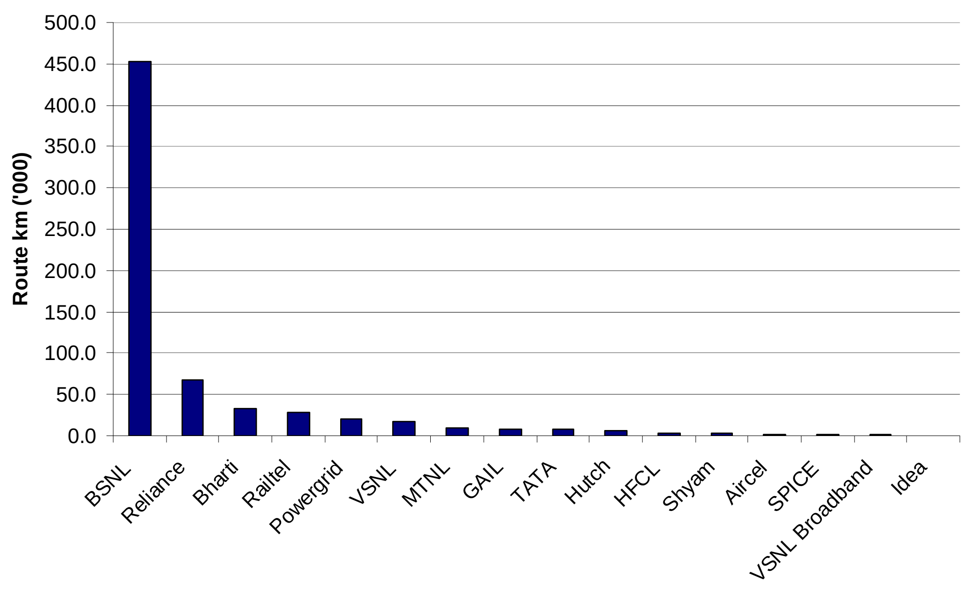
"In some Member States, the core network infrastructure of the incumbent operators has been duplicated and alternative operators started offering trunk leased lines to third parties in competition with the incumbent." (European Commission 2007)

The current pattern of backbone networks is the result of the historical evolution of the markets. Infrastructure was developed by state-owned incumbent operators obliged to provide services throughout the country, including rural areas that may not have been commercially viable on their own. Following market liberalization, these operators were required to provide backbone services on regulated terms. New operators entering the market focused on the most profitable segments of the country that were the urban areas and the inter-urban routes. Other parts of the country were served by the incumbent operator, providing backbone services at regulated prices so these areas were not commercially attractive to new entrants. The end result is a pattern of network development in which there is a concentration of competition on some routes while there is very little if any competition in peripheral areas.

3.3.2 Backbone networks in India

The pattern of backbone network development in India is similar to that seen in Europe. The incumbent operator, which remains state-owned, has a very extensive backbone network and has been required to cover most of the country. It is also required to provide wholesale backbone services (i.e. leased lines) on regulated terms. Since market liberalization, multiple network operators have entered the market and compete across the full range of services. At the same time, these network operators have also built out backbone networks and are competing to provide backbone services. The resulting distribution of network routes is similar to that seen in Europe, as shown in Figure 9.

Figure 9: Fiber-Optic Backbone Network Length in India



Source: TRAI 2006

BSNL, the state-owned incumbent operator in India, has undertaken an extensive roll-out of its backbone network as part of a government policy to ensure that all exchanges are connected by fiber-optic cables. This, together with its former monopoly status, helps to explain why its network is so much larger than those of the other companies. There are many other companies operating fiber-optic backbone networks in the country and some of these, such as that of Reliance, are quite large. However, these operators have focused on the major urban and inter-urban routes and therefore the total length of their networks is substantially less than that of the incumbent's.

3.3.3 Backbone networks in Morocco

There are currently three major backbone network operators in Morocco: the incumbent Maroc Telecom, Meditel (major mobile operator) and Maroc Connect (ISP, recently awarded a general telecommunications license). The two entrants obtain backbone network capacity, dark fiber and duct-space from two alternative infrastructure operators: the Office National des Chemins de Fer (ONCF), the national railway carrier, which has a nationwide infrastructure of about 1100 km; and Office National d'Electricité (ONE), the national power company, which has a nationwide infrastructure of aerial fibers of about 4 000 km.

This pattern is also the result of market liberalization that has progressively introduced infrastructure competition resulting in rapid growth in broadband services. Recently, A company called Marais has also entered the Moroccan backbone network market. Marais is one of Europe's largest developers of optical fiber-based network infrastructure, specializing in the design, build and operation of backbone fiber networks. In Morocco, Marais is reproducing the successful carrier's carrier model by deploying 1000km of fiber-optic cable network. The fiber optics links Rabat-Tanger, Casablanca-Marrakech and Casablanca-Agadir are expected to be established in June 2008. Agreements have been reached with Wana and Meditel for use of fibers on the Rabat-Tanger link.

3.4 Understanding backbone network roll-out in Africa

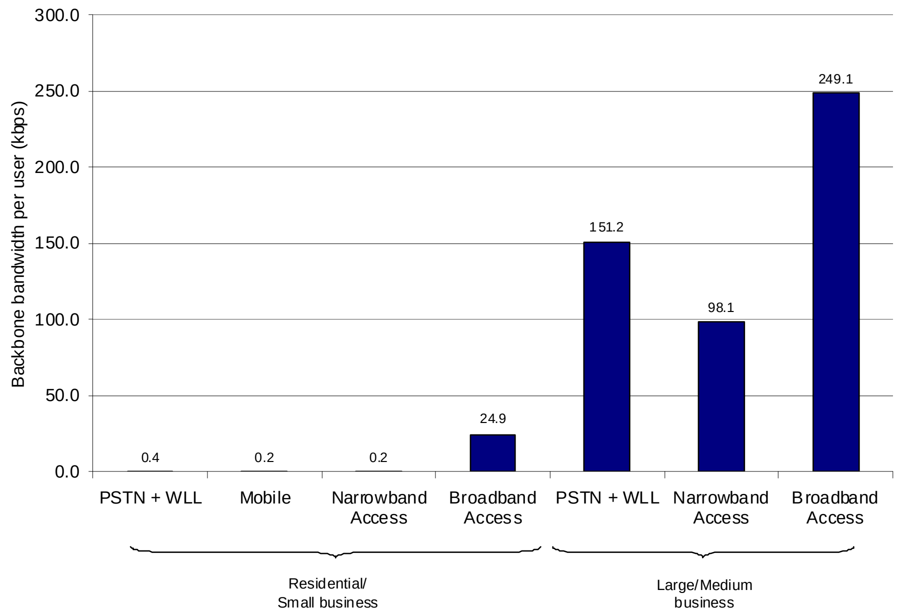
This section contains a discussion of the causes underlying the pattern of network development in Sub-Saharan Africa. This provides the foundation for the policy recommendations developed in Section 4. The focus is on explaining four of the significant characteristics of backbone networks in Sub-Saharan Africa:

- The low capacity of the networks;
- Geographical concentration of backbone networks on urban areas and inter-urban routes;
- Development of regional connectivity; and
- Limited aggregation of traffic on backbone networks through a wholesale market or through network-sharing.

3.4.1 Low backbone network capacity

Most of the backbone network infrastructure has been designed to carry voice traffic which requires much lower bandwidth than broadband data services. This difference in backbone network capacity requirements is illustrated in Figure 10 which compares the average backbone capacity per user required on backbone networks for each of the typical services supported by the network, based on current norms for service quality in the region.

Figure 10: Optimum Backbone Technology Choice



Source: ICEA 2008, World Bank staff analysis

Figure 10 shows how backbone networks dimensioned to carry voice traffic require much lower capacity than those carrying broadband traffic. As the networks in Sub-Saharan Africa have been developed primarily to target the voice market, only limited capacity is needed. This is one of the reasons that the networks have been built mainly using wireless technologies, since the network costs are determined partly on the capacity required. The other reason lies in the geographical distribution of the customer base which, in Sub-Saharan Africa is highly rural with large distances between population centers. The way these two factors interact to determine optimum network technology choice is illustrated in Figure 11.

Figure 11: Optimum Backbone Technology Choice

		Capacity		
		<8Mbps	8-450Mbps	>450Mbps
Distance	<100km	Satellite/ Microwave	Microwave	Fiber-optic
	>100km	Satellite	Microwave/ Fiber-optic	Fiber-optic

Source: ICEA 2008

Figure 11 indicates that backbone networks designed to support low bandwidth services, such as mobile telephony and wireless technologies are the preferred choice of backbone network technology.

A second reason for the predominance of wireless technologies in backbone networks in Sub-Saharan Africa relates to the nature of the cost structure. 60%-80% of the costs of fiber networks are in the civil works associated with laying the fibers. These costs do not vary with respect to the volume of traffic that the network carries. In fact, the only costs in fiber networks affected by capacity are the costs of transmission equipment, which typically comprises less than 10% of the total cost of the network.

The cost structure of wireless backbone networks is very different. A much lower proportion of the total costs is fixed with respect to the capacity of the network, so total costs are more directly affected by the volume of traffic carried. The cost of wireless networks is therefore more scalable. This is an important reason why, in an uncertain market during the early stages of network development, operators are more likely to invest in wireless-based backbone networks than in fiber-optic networks, even if from an ex-post point of view, it might have been cheaper to use fiber.

A consequence of this scalability is that operators are less likely to have excess backbone network capacity than might have been the case if they had invested in fiber networks.[19] This has implications for the market in backbone services because the marginal cost of capacity on a network in which there is large margin of spare capacity is much lower than on a network that is scalable. Operators with spare capacity have a strong commercial incentive to sell that capacity and, since its marginal cost is low, any competition among operators could be expected to reduce prices. An operator with a predominantly microwave backbone network, on the other hand, is likely to install the amount of capacity that it requires to meet its own traffic needs. If it were to decide to sell backbone capacity on a wholesale basis, additional capacity would have to be installed. The

[19] It is worth noting that this is changing. The commercial success of mobile operators in Africa, the increases in traffic arising from a growing customer base and shift in strategy towards more data services mean that they are now considering investment in fiber-optic networks which would once have been considered to be too risky.

operator has less of an incentive to enter into this market and, if it did, competition with other operators would be less likely to drive prices down as quickly or as far.

3.4.2 Geographical concentration of backbone networks

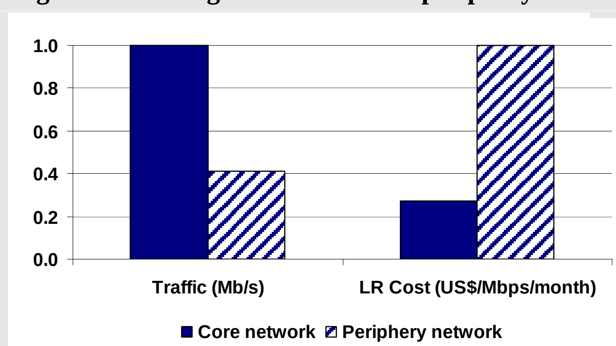
Backbone networks are concentrated in urban areas for commercial reasons related to both the demand for services and the cost of providing them. People in urban areas have higher incomes and there are more businesses that create demand for ICT services and therefore, more traffic on backbone networks. Consequently, revenues are concentrated in urban areas. At the same time, the fixed costs of networks mean that the average cost of providing services to people living in urban areas is lower than in rural areas. There is therefore a strong commercial incentive for networks to focus on urban areas and high traffic routes between urban areas. The geographical concentration of these users in these areas also affects the costs of backbone networks since network length is a major driver of overall costs. This effect is illustrated for the case of Burkina Faso in Box 2.

Box 2: Backbone Network in Burkina Faso

An economic analysis of a backbone network in Burkina Faso was carried out to analyze the impact of backbone networks on costs. The starting point of the modeling exercise was the current and planned backbone network infrastructure in the country. Extensions to this network were then modeled to provide services into the smaller towns in the country. The modeled network has a basic star topology with Ouagadougou as a central node and is shown in Figure 12. The links shown in green constitute the Core network (i.e. the existing or planned network links) and those in blue represent the network extensions that would be needed to reach all of the 14 main cities. The analysis of demand and traffic flows on this backbone network show that 75% of the total traffic is carried on the core network, although it serves fewer cities and is shorter in total length. This has a direct impact on average costs because the average cost is primarily determined by the amount of traffic carried by the network. This is shown in Figure 13 which compares the traffic and the costs between the core and the periphery of a backbone network (the scale is normalized to allow both comparisons on the same chart). The chart shows that the traffic levels are much higher on the core network than the periphery and that the costs are much lower. The two figures are closely related since total costs are largely fixed and therefore the average cost is primarily a function of the volume of traffic being carried on the network.

Figure 12: Burkina Faso network map

Figure 13: Average costs in core vs. periphery



Source: ICEA 2008

This geographical concentration of networks is consistent with the experience of countries outside the Sub-Saharan Africa region. The United Kingdom, for example, began market liberalization in 1984 with the licensing of a second operator. In a review of the leased line market (i.e. the market for capacity on backbone networks) carried out in 2004, the regulatory authority OFCOM concluded that on intra and inter-urban routes, the backbone market was highly competitive, particularly for the very high bandwidth services. In the areas where competition among networks does exist, the incumbent operator, BT, retained around 75% of the market share for low bandwidth leased lines services (64Kbps to 8Mbps) but less than 10% of the market for very high bandwidth services (155Mbps and over). However, in the 50% of the market that lies outside of these areas, BT was the sole supplier of backbone services

"…none of the other communications providers intend to expand their trunk network coverage within the next year or so… such expansion would be too costly and time consuming…" (OFCOM 2004)

The pattern of concentration of backbone network infrastructure seen in Sub-Saharan Africa therefore appears to be following the pattern of network development seen in countries that liberalized earlier. However, one key difference between network infrastructure markets in Sub-Saharan Africa and many other regions is that incumbent operators have not been able to fulfill the function of "backbone network of last resort".

3.4.3 Regional connectivity

The development regional connectivity, which was illustrated for the Kenya-Uganda region in Figure 7, is driven by two factors. First, much of international communications traffic is intra-regional since personal and business linkages are often maintained within a geographical region. One market response to this has been the development of regional retail packages in which customers face reduced rates for calls within the region and pay local call charges when roaming within the region (Global Insight 2006). Such retail offers are likely to stimulate intra-regional traffic that will strengthen operators' incentives to interconnect their networks directly. The second factor relates to the increase in the relative importance of Internet traffic as the primary driver of network development. The majority of Internet traffic generated by customers in Sub-Saharan Africa is international since most Internet content is hosted outside of the region. Operators are able to route this traffic between countries in which they operator in order to take advantage of economies of scale in the international gateway. This effect will be significantly increased when international submarine fiber-optic connectivity in the region improves. These cables land only at specific locations along the coast and all traffic being carried on them has to be routed through these locations. Operators in land-locked countries wishing access submarine fiber-optic cable infrastructure therefore need regional connectivity to access them. Even operators in countries with direct access to submarine fiber-optic cables may wish to develop regional backbone networks in order to provide access to alternative landing points on the submarine cable in order to provide back-up routing.

As broadband connectivity in the region increases and the volume of data traffic being carried by the submarine fiber-optic infrastructure goes up, cross-border routes will become more profitable. This pattern of cross-border backbone network development which is already emerging is likely to develop further.

3.4.4 Limited aggregation of traffic on high-capacity backbone networks

A key feature of the development of backbone networks has been the failure of markets to aggregate traffic onto high-capacity networks. As there are strong fixed costs in backbone networks, this would reduce average costs and therefore be a more efficient network structure. Given this, it is reasonable to expect that this type of market and network structure would emerge as a result of market forces, as has been the case throughout developed countries and in many emerging markets where high-capacity upstream networks have emerged to carry traffic.

There appear to be two types of factors constraining the development of high-bandwidth backbone carrier networks in Sub-Saharan Africa. The first relates to the regulatory environment, while the second relates to the stage of market development.

Although there is considerable variation in the details of the regulatory frameworks relating to the construction and operation of backbone networks across the region, in general, they do not actively encourage the development of backbone networks and, in many cases, they actively constrain it.

In many countries, mobile operators are allowed to build their own backbone networks for the provision of services to their own retail customers but they are not allowed to sell backbone services to other operators on a wholesale basis. This effectively prevents the development of a market in backbone network services because the operators are not allowed to carry traffic other than that generated from serving their own retail customers. This restriction limits the opportunities for taking advantage of economies of scale in network infrastructure and reduces the incentives to invest in high-capacity backbone networks. As a result, the mobile operators have built their own networks that operate in parallel with each other and there is very little consolidation of traffic onto core backbone networks. An example of this situation is Burkina Faso where the regulatory structure for the sector was laid out in the Telecommunications Act of Dec.4, 1998. This framework allowed entry of wireless networks under the authorization from the Telecommunications Minister and these operators were permitted to develop their own backbone networks. However, the framework prevented these operators from selling backbone services to each other or to third parties. A similar restriction applied to other infrastructure networks considering entering the wholesale backbone services market. These regulatory restrictions reduced the incentives for operators to invest in backbone networks and, as a result, network investment has focused on lower-capacity wireless networks.[20]

One way of encouraging investment in backbone networks is to issue “carrier” (i.e. wholesale-only) licenses. Such licensees would be permitted to build backbone networks and then sell capacity to other operators such as mobile operators or ISPs. The advantage of this approach is that it encourages investment and competition specifically in the backbone segment of the market. It also avoids problems of discrimination by the backbone network among retail operators. Such carrier networks are a common feature of backbone network markets in developed countries in which there are typically several companies that have built networks and provide services on a purely wholesale basis to other operators.[21] The potential opportunity for these types of operators is shown in Kenya, where KDN has developed 1900km of fiber network infrastructure, and in Nigeria, where there are over 20 licensed fixed operators, including two national carriers and seven national long-distance operators developing high-capacity backbone networks.

In order for a market in backbone network services to develop or for network-sharing arrangements to be established, contractual arrangements among the different parties need to be developed for leasing terms, billing, quality of service etc. Such contracts are

[20] This framework is currently under review by the government.

[21] This is not usually a direct result of the licensing structure but, rather, the result of commercial business decisions on market segmentation.

particularly important in the case of backbone network services because they form an integral part of the purchasing operator's business. If the backbone network does not perform in the way specified in the contract, the purchasing operator's network does not function and it is unable to provide services to its retail customers. This is such an important issue that purchasing operators are reluctant to depend on such transactions unless they are confident that the contracts can be enforced. In Ghana, for example, mobile operators reported major problems with the network services provided by the backbone network operator, Voltacom, due to an unannounced price rise of 200%.[22]

A different kind of regulatory structure also exists in the region that is constraining the development of backbone networks. This is a structure in which operators are required to use the backbone network of the incumbent operator. In Botswana, for example, prior to the recent revision of the sector legislation, the mobile operators were required to purchase backbone services from the incumbent, Botswana Telecommunications Corporation (BTC), if it was able to supply.[23] On the one hand, this arrangement has the effect of aggregating traffic onto a single backbone network so it had the potential to achieve economies of scale. However, by creating this structure through regulatory rule rather than through the operation of market forces, operators which might otherwise have invested in backbone networks were prevented from doing so and network competition could not emerge. Consequently, there were few constraints on BTC's pricing or the quality of service which it delivered which caused problems for downstream users (Ovum 2005).

The second reason for the lack of aggregation of traffic onto backbone networks lies in the stage of market development in most countries in Sub-Saharan Africa. Operators face a trade-off when deciding whether to allow competing operators to use their backbone networks. One the one hand, by doing so, they increase their revenues and utilize spare capacity on their networks. On the other, they may lose some competitive advantage by allowing other operators to effectively increase their network coverage faster than they would if they were required to build their own networks. The result of this trade-off is that direct competitors in growing markets typically cannot reach agreement on the use of each others' backbone networks and this difficulty is often exacerbated by a failure of the regulatory authority to facilitate commercial negotiations or to impose regulatory interconnection obligations on operators. In Uganda, for example, Infocom, an ISP, reports that it was unable to negotiate an interconnection agreement with MTN and UTL, the two biggest network operators, on the use of their backbone networks. Although Infocom does not offer mobile voice services, the use of VoIP to provide voice services by "data service providers" and the presence by MTN and UTL in the data services market means that these operators may have seen Infocom as a competitor and therefore prevented the operators from reaching agreement on the sale of backbone services. Infocom therefore had to find an alternative solution to obtaining backbone network services. It ultimately reached agreement to purchase capacity on the electricity transmission network's optical fiber that operates as a wholesale backbone operator in certain areas of the country. This case illustrates a key aspect of the operation of these

[22] Ghana High-level Roundtable Workshop, 10 May 2006

[23] Data operators were able to sell backbone capacity to ISPs for the provision of data services but were prevented from selling such capacity to be used for carrying voice traffic. ISPs were also prevented from providing VoIP services to customers. These constraints have been removed in the new framework.

markets. Where operators compete in the downstream (i.e. retail) market, they are less likely to trade backbone network services than where there are backbone networks that specifically target the wholesale market.

The exceptions to this rule are also instructive. For example, in Ghana, one mobile operator Tigo provided backbone services to another operator, Kasapa. This was justified by Tigo on the basis that their target markets were different (Kasapa was targeting low-end price-sensitive customers) and the network technologies used were also different (Kasapa has a CDMA network while Tigo has a GSM network). It was felt that the additional revenues generated by selling spare backbone capacity wholesale to Kasapa outweighed any loss in competitive advantage.[24]

[24] Source: World Bank staff discussions with operators.

4 Backbone policies for Sub-Saharan Africa

Two themes emerge from our analysis of backbone networks in Sub-Saharan Africa. First, the majority of countries in the region have introduced some degree of infrastructure competition in the telecommunications sector. However, only a few have fully liberalized their markets in a way that is likely to stimulate the development of a competitive market among backbone network operators. This is constraining markets from achieving economies of scale and has limited the development of the downstream ISP and data services markets. And second, where backbone network development has taken place, it has been concentrated on urban areas and on inter-urban routes. This pattern is fully consistent with the experience of developed countries that have also seen infrastructure competition emerge only in limited areas of the country. Even full and effective competition is unlikely to result in backbone networks extending beyond these core areas.

Policy towards backbone network development in the region has to address both of these themes if it is to be successful. This policy has two complementary components:

- Create an enabling environment for infrastructure competition through fully liberalizing markets to encourage infrastructure competition and to allow aggregation of traffic onto higher-capacity networks.
- Stimulate roll-out in underserved areas, especially in rural areas and in small towns.

Within each of these elements, there are a number of different policies that governments could adopt. These are summarized in Table 1 and explained in more detail in the sections that follow.

Table 1: Summary of Policy Options	
Create an enabling environment for infrastructure competition	**Stimulate roll-out in underserved areas**
Remove regulatory obstacles to investment and competition • *Remove limits on the number of network licenses* • *Encourage the entry of alternative infrastructure providers* • *Remove constraints on the backbone services market* • *Improve the regulation of backbone networks* **Reduce the cost of investment** • *Facilitate access to passive infrastructure.* • *Promote infrastructure-sharing.* **Reduce political and commercial risks** • *Risk guarantees and political risk insurance* • *Demand aggregation* **Promote effective competition in the downstream market** • *Promote downstream competition through effective regulation.*	**Competitive subsidy models** • *Provide operator(s) with subsidy to build and operate a network in currently underserved areas of the country. Services provided in these areas on a non-discriminatory basis.* **Shared infrastructure/consortium models** • *Provide operators with incentive to cooperate in the development of backbone infrastructure in currently undeserved areas of the country where infrastructure competition is not commercially viable* **Incentive-based private-sector models** • *Provide operators with an incentive to build networks in currently underserved areas through reductions in USF contributions or sector levies.*

4.1 Create an enabling environment for infrastructure competition

A key lesson from this study is that many countries in Sub-Saharan Africa do not provide incentives for private investment and competition in backbone networks. In many cases, there are direct disincentives against it. By effectively promoting private investment into backbone networks, governments are likely to achieve the policy objectives for urban areas and on inter-urban routes. They will also reduce the overall financial burden on the pubic sector of ensuring that widespread affordable broadband is made available. Investment and effective competition among backbone networks would also allow market forces to aggregate traffic onto higher capacity networks, which will reduce costs and stimulate downstream investment and competition among ISPs and other data users.

This policy of promoting infrastructure competition to support the development of backbone networks is fully consistent with the experience of developed countries. For example, the OECD in a 2006 report observed that “Opening markets to facilities competition and the rapid development of technology have resulted in highly competitive backbone markets in most OECD countries. The development of geographically dispersed IXPs [Internet Exchange Points] in larger countries has further assisted the development of a competitive market" (OECD 2006). In the same report, the OECD also observed a similar effect in developing countries. "The same competitive forces that have driven down the cost of telecommunication are now at work with broadband access to the Internet. From early 2004 to mid-2005, average broadband prices fell 75% in India. For example, a 256kbps xDSL connection with 400 Megabytes of data transfer included, is available from Bharat Sanchar Nigam Limited (BSNL) for less than USD 6 per month." (OECD 2006)

Multiple policy initiatives are needed to effectively create this enabling environment for infrastructure competition. They can be divided into four groups.

4.1.1 Remove regulatory obstacles to investment and competition

- *Remove limits on the number of network licenses.* In many countries that have nominally "liberalized" their network markets, there is actually a formal or informal limit on the number of licenses that are issued (World Bank 2008). There is little economic justification for such a limit since many types of network do not require scarce resources. This is particularly true for wireline networks that do not use radio-spectrum. The experience from around the world indicates that markets can successfully support multiple network operators. Experience also indicates that, where multiple licenses have been issued, operators are willing to invest substantial amounts in wireline network infrastructure.
- *Encourage the entry of alternative infrastructure providers into the backbone network market.* Electricity transmission networks, pipelines and railway networks have a major cost advantage in the development of fiber-optic backbone networks. In practice, many of the infrastructure networks already have fiber-optic cables laid as part of their internal communications systems on which there is substantial unused spare capacity. By encouraging these (usually state-owned) networks to establish operating companies to run the fiber assets and by licensing them, they can be brought into the formal telecommunications market as providers of backbone capacity. This has been successful in some countries in Sub-Saharan Africa such as Uganda and Zambia although not in others (e.g. Ghana). Whether or not such companies are successful in becoming commercial backbone network operators using their backbone networks appears to depend on differences in the institutional environment (i.e. whether the company is given sufficient incentives and freedom) and in their managerial capacity, rather than the technical characteristics of the networks.
- *Remove constraints on the backbone services market.* Many countries in the region impose constraints on the activities of operators with backbone networks and those that use them. These constraints include restrictions on the sale of network services and requirements to purchase backbone network services from specific operators, usually the state-owned incumbent operator. Removing these restrictions would allow operators to buy and sell backbone services to and from whichever operator they wished. By doing so, traffic could be consolidated, providing an incentive to upgrade networks to fiber-optic cables and thereby reducing average costs and improving quality of service.
- *Improve the regulation of backbone networks.* One of the key constraints on the development of the market in backbone network services has been the difficulty in

enforcing contracts and service level agreements. The ability to enforce legal contracts in commercial courts in most African countries is unlikely to improve significantly over the short term. However, the sector regulator can improve the situation by taking a number of different measures:

- establishing clear regulations on interconnection at the backbone level;
- amending licenses if necessary to increase the enforceability of such rules;
- setting out effective quality controls and a clear dispute resolution procedure; and
- collecting accurate quality of service information to facilitate the workings of the market and to facilitate dispute resolution.

Regional approaches to regulating backbone network infrastructure may also be a way of improving the quality of regulation, particularly as regional businesses and networks emerge in Sub-Saharan Africa. Governments might, for example, reach a regional agreement on principles of open-access regulation or on the way in which a specific kind of multi-country network is regulated. One example of this type of approach is the telecommunications-related commitments that countries make when joining the WTO. These commitments have introduced a limited degree of cross-country harmonization in the way in which the telecommunications sector is regulated. Further agreements of this type could be established at the regional level.

By entering into this type of mechanism, governments may be able to provide some reassurance to investors that they will not face excessive political risk originating at the national level. However, regional approaches to the governance of the telecommunications sector have proved very difficult to implement in practice. Even in the European Union, where there has been a strong move towards harmonization of sector regulation in the context of general economic and institutional integration, telecommunications sector regulation remains the responsibility of national regulatory authorities.

Regional approaches to capacity building and technical assistance for regulatory authorities in dealing with backbone networks are likely to be easier to achieve than regional regulatory harmonization and may therefore be a more effective way of improving the quality of regulation. Examples of this type of approach include developing regional benchmarking data on prices and quality of service for backbone network services, standard Reference Interconnection Offers (RIOs), standard license terms and conditions. There are already many different regional associations of regulatory authorities in Sub-Saharan Africa and these potentially provide a basis for such regional approaches to regulating backbone networks.

The best example of the impact of changes in the way the backbone services market is structured and regulated is the United States. A brief summary of the history of backbone network development there is given in Box 3.

Box 3: Backbone Network Development in the United States

Before 1974, the U.S. AT&T had an effective monopoly on the telecommunications market. In 1984, AT&T was split up to create competition in the U.S. market for telecommunications. The breakup of AT&T led to a highly fragmented and competitive long-distance market with more than 50 long distance and international carriers and 550 service resellers. This competition resulted in dramatic falls in long-distance and international prices and investment in long-distance capacity as traffic volumes increased. The 1996 Telecommunications Act further increased competition but also led to some market consolidation, particularly in the upstream segments of the market (i.e. the long-distance and international carriers). Nowadays, the main long distance telecommunications network capacity is provided by large network operators, including AT&T, Sprint Nextel, Cable & Wireless, Verizon, Level 3, Qwest and PSINet.

The main drivers of this development in network coverage and capacity have been competition and the emergence of new demand for services as a result of the Internet. Apart from the initial public investment in the development of the National Science Foundation Network (NSFNet), a backbone dedicated to the research community, the role of the government has been exclusively one of regulation and promotion of competition among network operators.

Although the ICT sectors of countries in Sub-Saharan Africa are a fraction of the size of that of the U.S. and caution should be exercised in drawing policy conclusions directly from its experience, it is instructive to note that the explosive development of backbone networks in that country has come about entirely through private investment and competition. The government has not invested public funds directly in the development of backbone infrastructure but has limited itself to regulating the market.

4.1.2 Reduce the cost of investment

- *Facilitate access to passive infrastructure.* 60-80% of the cost of constructing fiber optic-cable networks lies in the civil works (Accenture 2006). These costs represent a major fixed and sunk cost that increases the risks faced by investors in networks. By lowering the cost of this investment and reducing the risk associated with it, governments can significantly increase the incentives for private investment. This can be done in a number of different ways:
    - *Provide ready access to alternative network infrastructure at low prices.* Obtaining rights of way can be a lengthy and expensive process so, by providing access to transport (railways and road networks) or energy infrastructure (electricity networks, oil and gas pipelines), governments can facilitate the process of network development.
    - *Include passive backbone infrastructure in the construction of new facilities such as roads.* By including ducting in the design of new roads and then leasing these ducts to operators wishing to lay fiber optic backbone networks, governments can significantly reduce costs. This policy is complementary to that of encouraging

other infrastructure networks to enter the telecommunications market themselves. An example of a similar scheme is given in Box 4.

Box 4: Provision of Passive Infrastructure for Fiber Networks in Spain

Under legislation passed in 2003, the government of Spain required the design and construction of new buildings to include common communications passive infrastructure such as ducting, building risers and access points. Building managers are required to make this infrastructure available to any operator wishing to lay fiber-optic access networks in homes.

This law directly affects the establishment of fiber-to-the-home access infrastructure and the regulations affect the construction of privately developed buildings. However, the same principle could be applied to the development of backbone networks in public infrastructure such as roads and railways.

Source: Ministerio de Ciencia y Tecnología 2003

- *Promote infrastructure-sharing where it does not have an adverse impact on competition.* By sharing backbone network infrastructure, builders of backbone networks can reduce costs and therefore make investment in them more commercially viable, thereby increasing investment in the infrastructure. This is particularly relevant for fiber networks in urban areas where the cost of laying new fibers can be high or in rural areas where the revenues generated by such networks are low. In some cases operators have an incentive to enter into these sharing arrangements. One such example is a recent agreement between MTN and UTL – two competitors in the Uganda mobile market – to jointly develop a fiber link from the Uganda-Rwanda border to Mbarara, a town in South-west Uganda, as described in Box 5.

Box 5: Network Infrastructure-Sharing in Uganda

The Uganda telecommunications market has five mobile operators and several ISPs. MTN and UTL are the two national operators and are also significant mobile operators. Both companies also have operations in Rwanda. They both therefore have an interest in establishing a communications link across the border from Uganda to Rwanda. During 2007, MTN constructed a fiber-optic cable from Kigali in Rwanda to the border with Uganda. However, on the Uganda side, it recently announced a deal with its competitor UTL to jointly develop the fiber on the Uganda side. This is a good example of competing operators forming a cooperative arrangement to reduce the costs of fiber network development outside of the major urban areas.

Policymakers and regulators should exercise a degree of caution in implementing this option for two reasons. First, such infrastructure-sharing arrangements are difficult to enforce if the parties are not willing to do it on a commercial basis. Requirements to share facilities are already included in many operators' licenses but these are rarely implemented or enforced. This is consistent with the experience of other parts of the world where governments have faced similar problems in requiring operators to share infrastructure. In Bahrain, for example, the regulatory framework set up at liberalization required the incumbent operators, Batelco, to share its surplus fiber and duct space with new entrants on regulated terms. However, despite ongoing efforts by the regulator to enforce such arrangements, this policy has had limited success and entrants have opted instead to develop their own wireless-based backbone infrastructure. The regulatory authority is now revisiting the legal and regulatory framework that provides competitors with access to Batelco's infrastructure.

The second reason for caution lies in the concern that facilities-sharing may help sustain collusive agreements between competing operators. This has been a major issue in Europe where the mobile operators wanted to share mobile infrastructure but have faced resistance from the European Commission (European Commission 2004). This was subsequently decided in 2006 in favor of the operators by the European Court of First Instance (European Court of First Instance, 2006). The MTN-UTL fiber arrangement described in Box 3 is a situation in which similar concerns may arise. This is currently the only fiber network connecting Rwanda to Uganda and onwards to Kenya and the future landing stations for the submarine cables. Until competition from other cables develops, this could constitute a bottleneck over which two major operators in each market have joint control. These concerns are less pressing in a situation where there is effective competition and hence collusive agreements are less sustainable. Policymakers may also consider the risk of collusion to be outweighed by the benefits of infrastructure development in rural and otherwise unprofitable areas of the country.

4.1.3 Reduce political and commercial risks

- *Reduce political and regulatory risk through risk guarantees and insurance.* Companies operating in a risky environment are likely to place a premium on scalability and reversibility in their network infrastructure investment decisions. Scalability means that network investments take place in small increments, rather than large one-off expenditures. Scalable investments mean that operators expand their networks as demand develops, hence reducing the risk that networks are overdimensioned. Reversibility reflects the ability of a network to reverse investments and sell or reuse capital equipment if necessary. Some types of network investments are more reversible than others. For example, microwave transmission equipment can be moved and used in another part of the network if necessary. Since the majority of the capital cost of a fiber network lies in the civil works that cannot be moved, once built, investment in such networks is largely irreversible.[25] Wireless backbone infrastructure is more scalable and more reversible than fiber-optic infrastructure. In uncertain political and regulatory environments, operators are likely to favor investment in this type of network technology over fiber-optic networks, *ceteris paribus*. This limits the extent that operators are willing to invest in high-capacity infrastructure that could then be used to consolidate traffic and reduce average costs. These risks can be mitigated through the use of instruments, such as partial risk guarantees and political risk insurance (World Bank 2002).

[25] Investments which are irreversible are sometimes referred to as 'sunk' costs.

- *Reduce commercial risk through demand aggregation.* A key part of the risks faced by entrants into any market is the risk that demand will not develop as anticipated or that the cost of obtaining customers turns out to be higher than anticipated. This risk can significantly raise the economic cost of an investment and creates a disincentive for operators to invest in infrastructure, particularly in physical assets that may constitute a sunk cost. One way that governments can reduce this risk is to act as a central purchaser of services on behalf of all public institutions, including those at lower levels of government (e.g. schools, health centers and local government). By doing this, operators effectively deal with a single large customer rather than multiple smaller customers, hence increasing certainty and reducing risks. An example of where this was done on a large scale is South Korea. The most significant role of the government in promoting the roll-out of high-speed backbone infrastructure was by acting as a single purchaser of broadband connectivity on behalf of public institutions, hence reducing operators' risk of investment. A comparable approach was adopted by the government of Ireland with respect to submarine fiber infrastructure. Both cases are described in Box 6.

Box 6: Examples of Infrastructure Development Through Demand Aggregation

South Korea

The government of South Korea provided financing for the development of the country's broadband infrastructure in the form of a pre-payment for the future provision of broadband services to public institutions. Between 1995 and 1997, the government provided US$0.2billion towards the overall $2.2billion cost of building an optical fiber network. The other funds were provided by the private sector, mainly Korea Telecom. The second phase, between 1998 and 2000, focused on the access network and the government contributed $0.3billion to a total investment of $7.3billion. The final phase between 2001 and 2005 involved the upgrading of the entire network and the government contributed US$0.4billion of a total investment cost of US$24billion. In exchange for this up-front payment, operators were required to provide broadband services to public institutions over an extended period. The government's financing can therefore be thought of as prepayment for services that, although only representing a small percentage of the total investment cost, provided the private sector with sufficient incentive to develop the networks and to contribute their own investment resources.

It is also significant to note that this initiative was done in the context of an overall policy of promoting broadband, that included full market liberalization to establish infrastructure competition among operators and demand-side stimulation through initiatives such as ICT literacy training, free broadband access to all schools, 11 e-government projects and supporting the provision of cheap PCs for low-income households. The result of this combined policy has been an explosion of network investment and usage of broadband services. All settlements in the country are now connected by high-speed networks and the cost of broadband services is low.

PPP in Ireland to provide international connectivity

In 1999, Ireland's Industrial Development Authority (IDA) under the Ministry of Public Enterprise entered into an agreement with Global Crossing to build a fiber optic ring that would provide subsidized international connectivity to Ireland's rapidly expanding telecommunications operators, ISPs, and ICTs.

Global Crossing developed, owned and operated the infrastructure. The government purchased the capacity in bulk and resold it to all operators on an open access and uniform subsidized pricing structure. By acting as an "anchor tenant," the government provided a sufficient reduction in the risk to allow the private company to invest. At the same time, by on-selling the capacity at uniform and non-discriminatory rates, this structure supported the development of the downstream market through ensuring that both small and large operators had access to cheap international capacity.

Many companies in the region have difficulty in collecting revenues from public institutions for utility services such as water and electricity. An issue to consider in Sub-Saharan Africa in relation to this policy approach is therefore the extent to which the credit risk associated with the public sector as a customer offsets the commercial advantages of bulk-purchase of backbone services. There are ways of reducing this credit-risk through the use of pre-payment and escrow mechanisms.

4.1.4 Promote effective competition in the downstream market

- *Promote competition among access and service providers.* Operators and service providers wishing to enter the downstream market (i.e. building access networks and offering services to customers) will need either to build their own backbone network or access that of another operator. The terms on which these operators can obtain access to these backbone networks will have a significant impact on the success of their business and will influence whether or not effective competition in the downstream market develops. At the same time, the demand created by these downstream operators will affect the financial viability of the backbone networks since they are the entities that generate traffic and revenues on the networks. By promoting effective competition in the downstream market, governments will help stimulate backbone network development.

  The role of the regulator in this is crucial since it often defines and enforces the terms of access. The decision about whether to regulate directly the terms of access to infrastructure has a major effect on the investment incentives in the market. Under the traditional model of market liberalization followed in Europe in which the incumbent operator was dominant in the market, the priority for the regulator was to provide access to these operators' networks for companies entering the markets since this was seen as being crucial to the development of competition. Subsequently, as competition has emerged, regulators have been required to develop systems for determining which operators should be regulated and how.

  In the European Union, this system is based on the framework of general competition regulation that set out how regulatory authorities determine whether or not competition is functioning effectively and what remedies should be applied where it is not. In most countries in Sub-Saharan Africa, such frameworks do not exist. Regulators will therefore need to develop alternative sets of guidelines to govern how access to the infrastructure of private operators in competitive markets is regulated. This will involve a trade-off between supporting the development of competition in the downstream market and maintaining the incentives to invest in upstream infrastructure. In areas of the country where public support is provided for backbone infrastructure, this trade-off is relatively straightforward since one of the conditions of that public support will be the provision of wholesale services on regulated terms. However, in other areas of the country and in other parts of the infrastructure, the trade-off may be more difficult to determine.

4.2 Stimulate roll-out in underserved areas

The experience of countries in Africa that have gone the furthest in liberalizing network markets shows that, if all the regulatory obstacles are removed, investment and competition will emerge but it will be focused on inter- and intra-urban routes and on commercially attractive cross-border links. A large proportion of the population will not benefit from this competition as they live beyond the range of these networks.

This is consistent with the experience of many countries with advanced ICT markets that have been fully liberalized where competition has focused on a relatively small proportion of the total area of the country. In the rest of the country, the only backbone network available is the one that is provided by the incumbent operator (either currently or formerly owned by the state). In the case of Sub-Saharan Africa, these operators are weak and their backbone networks are often either poor or non-existent.

The market, by itself, is unlikely to deliver the investment required for the development of backbone networks capable of supporting mass-market basis at affordable prices in areas throughout the country. If such high-capacity backbone networks are be developed in these areas, some form of public financing is likely to be required. The two key issues are therefore,

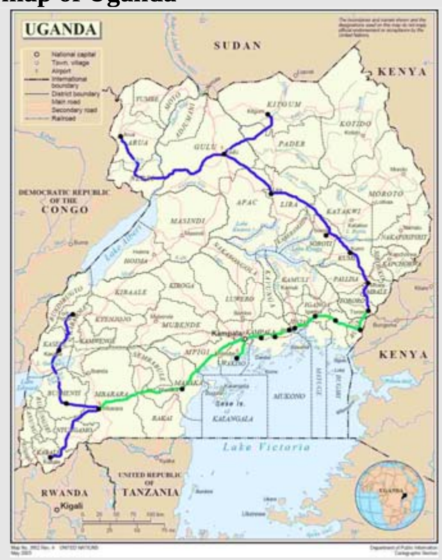
- What level of subsidies will likely be required for the development of a backbone network?
- What are the mechanisms by which the network can be developed and operated?

The amount of public subsidy, either direct or indirect, will vary according to the length of the network, the capacity required and rate at which traffic increases once the network is in place. Box 7 presents an analysis of the public financing requirement for one country – Uganda.

Box 7: Financial Analysis of a Fiber-Optic Backbone Network in Uganda

Uganda is a country of 31 million people in East Africa. It has a fully liberalized telecommunications market with 28 licensed operators and ISPs.[26] Currently most of the backbone network infrastructure is in the southern part of the country where the majority of telecommunications users are concentrated. This is approximately 817 km in length and is shown in green in the map. A backbone network linking up 10 additional towns[27] that are not currently connected to the main fiber networks is shown in blue in Figure 14. These extensions together would have a total length of 2,252 km.

Figure 14: Modeled backbone network map of Uganda



The total cost of constructing and operating such a network (i.e. the extensions to the existing network) would be approximately US$62m.[28] The average cost of capacity on the network is a function of both the length of the network and the volume of capacity being carried. Because traffic volumes are much lower in the periphery of the network and the network length is much longer than in the core, the cost per unit of capacity is approximately 180% higher.

This cost structure also determines the profitability of the network and therefore the subsidy that would be required to make it financially viable. For the network described above in the map, the subsidy lies in the range US$20m to US$26m, representing between 32% and 40% of the total network investment required.[29]

Source: ICEA 2007

Policy towards backbone network roll-out in many countries outside the Sub-Saharan Africa region has focused on the incumbent State-owned operator. However, within the region, the performance of State-Owned Enterprises (SOEs) in the telecommunications sector has historically been poor, particularly in contrast to the success of the private operators (World Bank 2008). The model of state-funding of backbone networks in Sub-Saharan Africa through the SOEs would be likely to face similar challenges. Instead, a partnership with the private-sector is more likely to be successful in ensuring that networks are built and operated. Three different types of such partnership models are identified – competitive subsidies, shared infrastructure/consortia models and incentive-based private-sector models. This is not an exhaustive list and, in practice, there are other models available. However, the three basic models described here are representative of

[26] Source: Uganda Communications Commission website. Accessed 23 June 2008.
[27] Arua, Kitgum, Gulu, Lira, Soroti, Mbale, Kabale, Bushenyi, Kasese and Fort Portal.
[28] Assuming a discount rate of 15%.
[29] A cost of capital of 15% has been assumed for this analysis. This is significantly lower than the rate of return typically earned by operators in the telecommunications industry in Sub-Saharan Africa. If a higher rate of return were needed to attract investment, this would translate into a greater level of subsidy.

the broad scope of policy options. Hybrid models, combing different aspects of the models featured here are also possible.

4.2.1 Competitive subsidy models

Under this approach a license to build and operate a backbone network is awarded. The licensee would also be awarded a contract to build out a network of specifications, defined by the government and that meets its policy objectives. The government would give some resources to this licensee, through in-kind or cash payments. The contract design would also include the terms on which backbone network services are provided. The key aspect of this is the price since this will determine the impact on downstream users of the network. Quality of service and the type of services provided are also key aspects that would be included in contract design. There are a number of variations of this model according to the ownership structure of the network. At one end of the spectrum of options is a network completely owned by a private company that receives a government subsidy to build a network that meets the government's policy objectives. At the other is one in which the public and private sector are joint owners of the backbone network. In all cases, the contract to build and operate the network, together with the associated license can be awarded competitively through a minimum-subsidy auction (Wellenius et. al. 2004).

Advantages

- The government's objective is met while ensuring that the skills, expertise and investment resources of the private sector are leveraged.
- The private operator would have a commercial interest in operating the network as efficiently and effectively as possible since it would sell capacity on a commercial basis.
- The approach is simpler than the consortium approach because there are fewer parties involved. If it is not successful initially, there is also recourse to alternative operators.
- There is some experience of similar approaches being used to promote the roll-out of rural access networks in Sub-Saharan Africa. There is also considerable relevant experience of similar structures in the transport, water and energy sectors that could provide useful benchmarks.

Disadvantages

- Government support to specific operator(s) may adversely affect competition through unduly favoring one operator over the others.
- It can be difficult to obtain accurate information on the performance of licensees and to impose penalties for failure to deliver.
- If the backbone operator has any financial connection to downstream operators (i.e. retail providers), it will have an incentive to discriminate in favor of such operators. This can be dealt with through restricting the backbone network operator to selling on a wholesale basis or through tight regulation.
- It can be politically difficult to justify large public subsidies to private companies in which the government does not maintain an equity stake.

Two examples of where this type of PPP approach has been used are France and Singapore. The models used were different but both are designed around the same principle of partnership between public and private sector to develop fiber communications infrastructure. These examples are described in Box 8.

Box 8: Examples of PPPs for Fiber Optic Networks

Dorsal project in France

Limousin is a rural region in the center of France that suffers from a major rural-urban differential in the availability of broadband services. To address this difference, the government launched the DORSAL project to develop a backbone network capable of delivering equal access to high-speed Internet.

The project is structured as a PPP with a 20-year concession to build and operate a backbone network and to construct a WiMAX access network capable of supporting high-speed value-added services. The cost of the project is 85 million Euros and was shared between the public (45%) and private (55%) sectors. The construction of the fiber backbone network was successfully implemented in mid-2007 and downstream competition has developed. Customers in the DORSAL area now have access to third party service providers offering a wide range of broadband services such as IP-TV, VoIP and high-speed data services in competition with France Telecom.

Source: ICEA 2007

Fiber-optic Access Network PPP in Singapore

The broadband penetration rate in Singapore has risen dramatically from 10.3% of households in 2001 to 45.5% by 2005 (PriceWaterhouseCoopers 2006). However, the access networks currently used are xDSL or cable television technologies that have inherent technological limits on speeds. Looking forward, the government has identified the capacity of the access network infrastructure as a potential future bottleneck in sector development. However, the size of the investment required to upgrade Singapore's access networks and the risks involved have meant that no private operators have been willing to undertake such a project. The government has therefore launched a project to develop a fiber-to-the-home access network infrastructure through a partnership with the private sector.

The government has allocated up to S$1bn (equivalent to approximately US$730 million) for subsidizing the construction of an access network. The network was divided into two "layers" - the passive infrastructure that includes the ducts and fibers on the first layer and the basic IP service on the second layer. Once winners are selected for the two projects, the winning bidders will build and operate the two 'networks' as separate stand-alone entities, at arms-length from their other operations. The terms on which the companies are able to sell wholesale services were set out in the tender documents and compliance will be supervised by the regulatory authority.

This is an example of a PPP in which the government is subsidizing the development of an upstream component of the supply-chain required to provide high-speed services to people's homes. The assets developed under the project will be owned and operated by private companies, on regulated terms, and at arms-length from the rest of their business. Although the project concerns the access networks, in many respects, it is similar to the challenges facing governments in Sub-Saharan Africa trying to develop their backbone networks, particularly in areas outside of the major urban areas.

The two examples given in Box 8 relate to different segments of the network. In Singapore, the PPP is designed to stimulate investment in the access network while, in France, the PPP supported the development of the backbone network as well as a wireless access network. However, in both cases, public funds are being used to support investment in ICT infrastructure in areas of the country or segments of the market that the private sector is not willing to finance on its own. In both cases, the public support is also targeted at an upstream segment of the market that is required to sell wholesale services to third parties. Both models are therefore designed to support infrastructure development by targeting economic bottlenecks while also maintaining the conditions for competition.

4.2.2 Shared infrastructure/consortium models

Private operators form a consortium to build and operate backbone networks in underserved areas. By providing public resources to the consortium, the government can ensure that the network meets public policy objectives (i.e. focusing investment into areas that are not served by private operators, ensuring cost-oriented wholesale prices and ensuring non-discrimination between purchasers of services).

All of this regulatory protection can be written into the consortium structure through the leverage obtained by public support to the operator. However, it is important to note that these policy objectives lie directly counter to the commercial interests of the consortium members since they would benefit from both charging above-cost prices and charging different prices to themselves compared with other customers. Such an arrangement would therefore require continual oversight by the government.

Advantages

- The backbone network would be built and operated by private companies that already operate facilities in the country and therefore have directly relevant experience that is likely to improve the chances of success in operating the network.
- The operators would partially finance the network. This reduces the cost to the government but also ensures that the members have a financial stake in its success.
- The companies that operate the network would also be its primary customers and would therefore have an incentive to ensure that the network is owned and operated efficiently and effectively.

Disadvantages

- A consortium in an otherwise competitive market could allow operators to collude and therefore reduce competition, resulting in higher prices paid by customers for the services and higher profits for the operators.

- Any consortium is unlikely to include all players in the market, particularly as the market develops and new companies enter. Members of the consortium therefore have an incentive to raise prices and discriminate against non-members. Such incentive to discriminate is inherent in the model and would have to be controlled by the government either through role as a financier of the project, or through the regulator.
- Under this model, there is no competitive bidding process so it will be difficult to assess the level of subsidy required for the network. The only option for the government is to undertake a financial analysis and negotiate with consortium members. However, the lack of competitive process may result in the government paying more for the network than would otherwise be the case.

There are few current examples of such consortia/shared infrastructure models being used to develop backbone networks in Sub-Saharan Africa. However this model has been used to develop EASSy, a major submarine cable project in region established by a consortium of operators from the region and partially financed by a group of development finance institutions (DFIs). The involvement of the DFIs in the project has been used to establish an open-access model of governance that will ensure that access to the cable is available to all operators within the region, irrespective of whether they are part of the consortium. This structure is described in more detail in Box 9

Box 9: Example of a Shared Infrastructure-Consortium Model for Backbone Infrastructure Development

The Eastern African Submarine Cable System (EASSy) is a project to build a submarine fiber-optic cable that will stretch from South Africa to Sudan with connections to all of the countries along its route. From the termination points, users will be able to connect to the global submarine communications cable system. The project has been developed by a consortium of over 20 telecommunications operators, mostly from the Eastern and Southern Africa region with the support of five Development Finance Institutions (DFIs).[30]

A key issue for policymakers and the DFIs has been the need to avoid a repetition of the experience of the SAT-3 cable that runs along the West coast of Africa. This is also financed, built and managed by a consortium of operators but each member of the consortium has exclusive control over access to the cable in its own country. As a result, prices for capacity on SAT-3 have remained high and the impact on customers has been limited.

Submarine cables lie, for the most part, far off-shore and are therefore beyond the control of any one regulatory authority. National regulatory authorities do have jurisdiction over cable infrastructure lying within territorial waters and the facilities where the cables land that are usually owned by the incumbent operator. In practice, regulators have found it difficult to exert effective control over the terms of access to landing stations and capacity on the cable.

[30] International Finance Corporation, European Investment Bank, African Development Bank, AFD and KfW

The best long-term solution to this problem is competition among different cables and different landing stations. Where countries have multiple cables landing in their territories and competing with each other, prices have fallen steadily and the capacity available to the market has dramatically increased. However, for those countries that do not have the benefit of infrastructure competition, alternative solutions are needed.

EASSy has been designed to minimize the problems associated with the absence of effective competition and regulation. It is owned by a consortium. One of the members of this consortium is a Special Purpose Vehicle (SPV) that is itself owned by a group of the smaller operators from the region. DFI support for EASSy is provided in the form of loans to this SPV. Under the EASSy cable consortium agreement, the SPV is permitted to sell capacity in any market in the region to licenced operators on an open-access non-discriminatory basis, hence providing competition to other members of the consortium. The agreements that establish the SPV require it to pass through overall cost reductions (which occur as traffic volumes increase) to customers. These mechanisms for competition and pass-through of cost reductions are intended to achieve lower, more affordable prices in the marketplace, hence reducing the need for regulation.

4.2.3 Incentive-Based Private-Sector Models

All countries require operators to pay taxes and levies that typically consist of both general taxes, applicable to all companies in the economy, and sector specific taxes or levies. One common such levy is contribution to Universal Service/Access Funds. These funds are usually calculated as a percentage of revenues and are collected annually from the industry. In most cases, these funds are intended to be used for subsidizing access to services in rural areas. However, in many countries, they are not used effectively and often remain with the government.

The government could give operators an incentive to develop backbone networks in commercially unattractive areas by offering to reduce these levies in exchange for the operators meeting specific targets. This can be done on a competitive basis – i.e. a limited number of companies are awarded the levy-reduction and they have to compete for it – or it could be available to all. Such “pay-or-play” schemes are not common in the telecommunications sector but have recently been receiving increasing amount of attention.

Advantages

- Private companies own and operate the network(s), which increases the likelihood that they will be efficiently and effectively managed.
- Government is able to specify the type of network that it requires and the terms on which services are sold.
- No cash changes hands between the operator(s) and the government because it would involve a reduction in taxes, rather than a transfer of funds.
- As operators are required to pay taxes on an ongoing basis, government retains the option to penalize failure to meet the contractual obligations by removing the tax-break.

Disadvantages

- Any network built under such a scheme would be privately owned by operators competing in the market. There would therefore be a significant incentive to discriminate against competing operators. Since the government's objective is to ensure the backbone network is built as a common facility, available to all, it would require strong monitoring of the way in which it is operated.

Box 10 summarizes the experience of two countries that have used incentive-based mechanisms to achieve similar objectives.

Box 10: Examples of Incentive-Based Mechanisms for Developing Backbone Networks

Backbone Networks in Sweden

Since 1999 when it launched its first broadband policy, the Swedish government has provided subsidies for broadband roll-out through several different programs including tax incentives for operators building networks in rural areas, and grants to municipalities to build out fiber networks. It is estimated that the total value of these subsidies is $820m but a government-appointed committee recently recommended that the government should spend an additional US$500m on grants to municipalities and operators for investment in high-speed networks.

These direct financial incentives for infrastructure development were part of an overall package of policy measures used to promote broadband that included promotion of competition, demand-side stimulation and the use of state-owned businesses to develop fiber-optic infrastructure.

Source: ITIF 2008

Pay-or-play mechanisms in Brazil

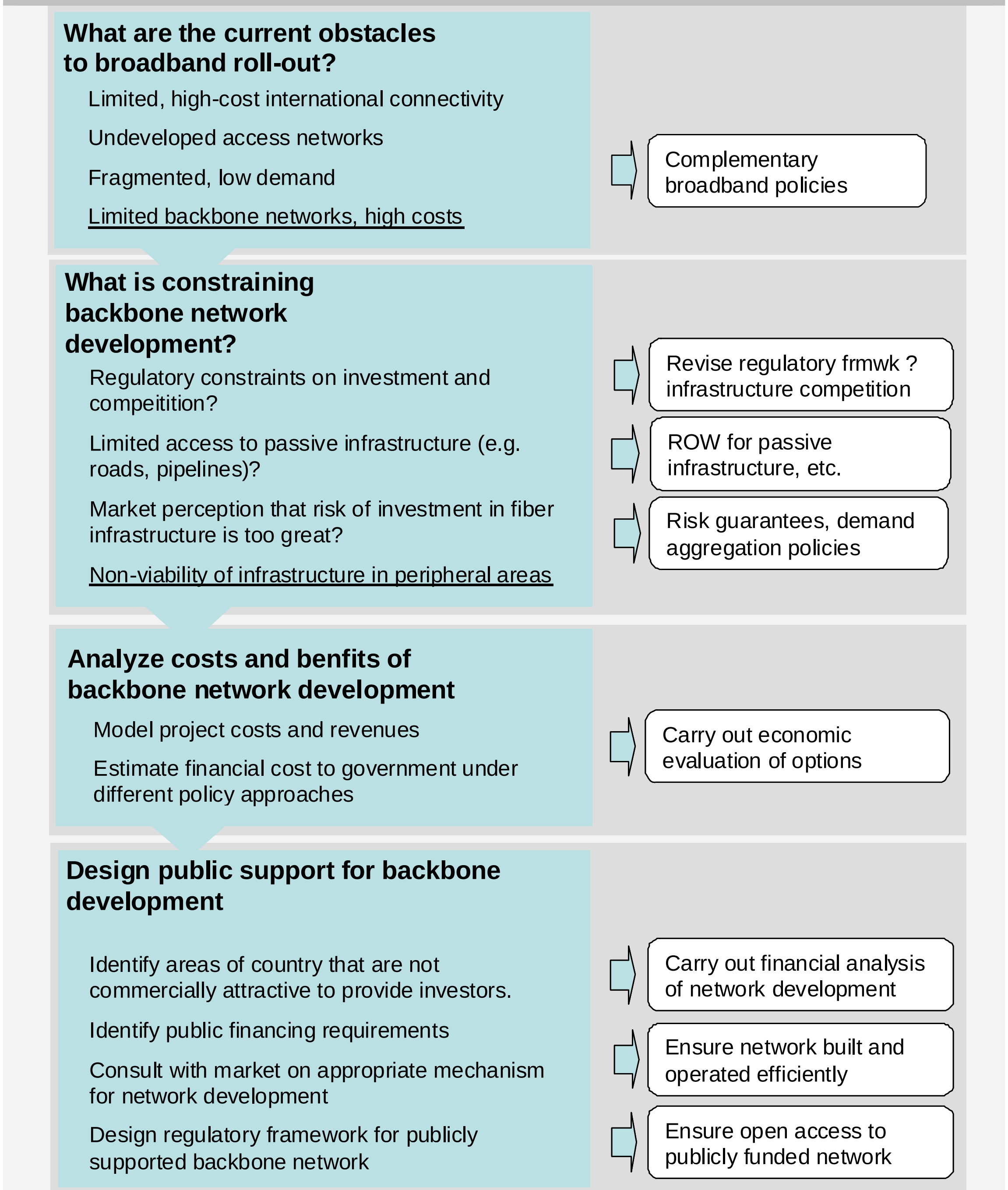
Under a joint initiative taken by four government ministries and the national telecommunications regulator in May 2008, five fixed-line operators in Brazil have undertaken to build out broadband backhaul networks connecting 3,439 municipalities in which broadband services are not currently available. In exchange for this commitment, the operators are to be relieved of their existing obligation to install 8,000 dial-up equipped telecenters. This arrangement is an example of where operators are provided with a reduction in their USO obligations in exchange for investing in broadband and backbone investments. Such mechanisms are sometimes referred to as pay-or-play mechanisms.

Source: Intelecon 2008

4.3 Implementing backbone policy

The analysis and menu of policy options presented in this report indicate that achieving the objective of widespread broadband service availability is likely to be a complex challenge, involving a number of interrelated decisions. This process begins with an understanding of the dynamics underlying the current backbone network infrastructure. A benchmarking of the current state of network development against other countries provides an assessment of how the broadband market is performing relative to other countries. This is followed by an analysis of the constraints on network development that may lie in the availability of alternative infrastructure (e.g. international connectivity) or they in the details of the regulatory framework. Once a clear diagnosis of the situation is available, it is possible to develop a menu of policy options designed to address the problems. However, before options are selected, a clear understanding of the costs and the benefits of each one is required. This is discussed in more detail in Section 4.4. The final stage in the process is to select the appropriate set of policies that will address the problems identified. The backbone policy development process is summarized in the policy 'roadmap' shown in Box 11.

Box 11: Roadmap for Backbone Network Policy



4.4 Assessing the costs and the benefits of support to the development of backbone networks

A key step in implementing the backbone policy framework will be an assessment of its costs and benefits. It is challenging to estimate the value of the benefits for two reasons. The first reason relates to defining the benefits of backbone networks. As one element of the broadband supply chain, backbone networks, on their own, do not deliver the final product to customers (i.e. broadband connectivity). If backbone policy is not placed within the overall context of broadband policy, it is therefore unlikely to be effective in increasing connectivity to end users. However, by doing so, it is difficult to attribute causality directly to the backbone policy since the benefits could be equally ascribed to policy actions taken on international connectivity or access networks. The second reason relates to the uncertainty surrounding future broadband development in Sub-Saharan Africa. Since the economic benefits arise from lower prices and greater consumption of broadband connectivity, any attempt to estimate the benefits of backbone policy will require a forecast of broadband take-up following policy implementation.

Notwithstanding these challenges, it may be possible to undertake a basic analysis of the costs and benefits of an overall policy designed to boost broadband connectivity. The starting point of this analysis would be an assumption that the government would undertake a comprehensive approach, aimed at all of the major potential bottlenecks in the broadband market. The potential benefits of this type of broadband policy lie in the additional consumer surplus that would be generated by meeting increased demand for broadband connectivity and the long-term boost to economic growth that might accrue from increased broadband connectivity. There are few robust estimates of the parameters required for such calculations so there would be a considerable margin of error surrounding any such estimate of the benefits. Estimating the costs of broadband policy initiatives, however, is likely to be more straightforward since these are based on defined actions by the government to which cost estimates can be attached.

In practice, decisions on public expenditure are rarely based only on cost-benefit analysis (Irwin 2003) and political priorities often have an impact on the allocation of public resources. In such circumstances or where an accurate estimate of the benefits of public support to broadband connectivity is not available, an analysis of the costs of the different policy options would still be useful since it would allow policy-makers to make decisions on the basis of information on the relative costs of each potential course of action. Table 2 below summarizes some of the basic principles for calculation of the cost of the backbone policy initiatives outlined in this report.

Table 2: Principles for estimating the cost of backbone policy options

Policy option	Approach to cost calculation
Licensing and regulatory reforms	The cost of issuing additional licenses is very low. In practice, the net cost to government is likely to be negative since operators usually pay fees for such licenses. If a revision of the licensing framework is required, this may entail significant expenditure of professional advisory services. If changes to the licenses of existing operators (e.g. removal of an exclusivity clause in an operator's license) may also involve additional expense as a result of legal action.
Improving the quality of regulation of backbone networks	Increasing the capacity of regulatory authorities to regulate backbone networks effectively is likely to incur expenditure in training and in the preparation of the regulations themselves.
Reducing the cost of investment	Providing access for operators to alternative infrastructure involves little costs other than drawing up standard terms and conditions for such access. Since infrastructure providers usually charge a fee for this type of access, the net cost to government is likely to be zero or negative. Building network access facilities into new infrastructure developments such as ducting and access points in new road developments may involve some costs. However, relevant measure of cost is the incremental costs incurred in such developments. This is likely to be significantly lower than the cost of laying fiber after the other infrastructure has been built. The cost of political risk insurance and partial risk guarantees is well defined and can be relatively easily estimated. The cost of demand aggregation by the public sector may be more difficult to define. The correct measure of cost is not the cost of paying for the services themselves but the incremental cost of paying for these as a single contract rather than through many different institutions.
Public support to backbone networks in underserved areas	All of the options for stimulating network roll-out in underserved areas outlined in Section 4.2 will require some form of public investment. In the case of a minimum-subsidy mechanism, this will be a cash expenditure of public resources. In the case of an incentive-based scheme, the subsidy would be in the form of foregone revenues from levies. The level of investment required by the government is the net cost (i.e. the subsidy required). This will be determined by the technical specifications of the network, the likely commercial revenues that the operator will generate and the level of prices set for network services. The only way of estimating the net cost to the government of such policies in advance is to model the costs and revenues associated with the operation of the network. However, under some mechanisms, the actual net cost to government would be determined as a result of a competitive bidding process.

4.5 Institutional implications of backbone policy recommendations

An important issue to consider in designing the appropriate policy framework for promoting backbone networks is the implications for the institutions that govern the sector, typically the Ministry of Communications and the regulatory authority. The policy options outlined in this report vary in the size of the burden that they place on these institutions and on the extent that their success depends on them being able to perform their functions. For example, issuing new licenses typically does not require institutional capacity beyond that which already exists in most countries. However, designing complex consortium structures with regulated terms of access places a much larger burden on a government or regulatory authority. Given the limited capacity of many regulatory institutions in Sub-Saharan Africa, the dependence of the success of the policy options on the regulatory authority is an important factor to take into account in designing the overall backbone policy framework.

The challenges faced by regulators in implementing these policies can be divided into three categories. The first relates to the technical difficulty associated with implementation of the policy. For example, defining standard quality of service criteria for backbone services in order to improve the functioning of the market is less technically demanding, than developing complex consortia-based investment projects. The second type of challenge is an institutional one relating to the capacity of public institutions to make and enforce decisions relating to the sector. This capacity is determined by a number of factors such as the legal framework that defines the institution's powers, the financial resources of the institution and the access to skilled staff to work there. The third type of challenge relates to the political economy of the ICT sector. Some policy decisions may act directly counter to the interests of one or more party in the market or the government. For example, in countries where backbone services are reserved as a monopoly for the incumbent operator, by liberalizing the wholesale market, the profits of the incumbent operators may be adversely affected in the short-run. Implementing such a decision may therefore meet significant institutional resistance. Other policy options are likely to face less opposition and would therefore be easier to implement. Table 3 below provides a brief summary of the implications for government institutions of each of the policies outlined above. It also provides an assessment of the extent of the technical and institutional challenges likely to arise.

Table 3: Institutional implications of policy options	
Policy option	**Institutional implications**
Remove limits on the number of network licenses.	Governments and regulators are familiar with the process of issuing licenses and examples of license templates are available from other countries. Increasing the number of players in the market will increase competition and may face opposition from existing licensees. However, many countries have proved that it is possible to do.
Encourage the entry of alternative infrastructure providers.	Licensing alternative infrastructure networks as telecommunications operators is not technically challenging. In many cases, the companies have an incentive to enter the market since it is a means of generating additional profit.
Remove constraints on the backbone services market.	Removing regulatory constraints on the backbone services market is not technically difficult but might face opposition from any operators that currently have a monopoly (usually a state-owned incumbent).
Improve the regulation of backbone networks.	Issuing and enforcing standard interconnection guidelines can be technically challenging, particularly for regulators with little previous experience of it. Such regulation may not run directly against the interests of any particular market player but regulators may face institutional constraints on their ability to enforce such regulations.
Facilitate access to passive infrastructure.	The technical requirements of ensuring access for operators to passive infrastructure are not challenging. However, it may be difficult to implement because governance of these types of infrastructure usually lie outside the telecommunications sector and therefore outside of the scope of authority of the regulator.
Promote infrastructure-sharing where it does not have an adverse impact on competition.	Many countries have included infrastructure-sharing requirements in their legal and regulatory frameworks. However, enforcement of them, particularly in situations where it is not in the direct commercial interest of the parties, may be difficult.
Reduce political and regulatory risk through risk guarantees and insurance.	Political risk insurance and partial risk guarantees are common in developing countries but are rarely used in the telecommunications sector. Developing them may therefore be both technically and institutionally challenging.
Reduce commercial risk through	Although simple in principle, this option can be difficult to implement because it affects budget

demand aggregation.	allocations for public institutions and coordination across institutions can be difficult. This raises political economy challenges that may make implementation difficult in practice.
Ensure competition among access and service providers.	The majority of countries in the region have liberalized their telecommunication and ICT services markets. However, further liberalization may face political opposition from existing market players.
Competitive subsidy models	This category of models involves issuing a license and a long-term contract to build and operate a backbone network, selling services at pre-determined prices. The process for designing the license and selecting a bidder would be similar to the process that is undertaken for other license awards. However, the regulator would have an important role in ensuring that the network was built to the contract specifications and that the services were provided at the appropriate quality and price. Since this would be a new operator for the market and the network would provide ready access to backbone services for other players, it would be unlikely to face significant institutional opposition.
Shared-infrastructure/ Consortium models	This type of model would involve a negotiated arrangement among a group of operators and, in some cases, the government. Such arrangements have proved challenging to establish because of competing interest of the members of the consortium. There are relatively few examples of such arrangements to draw on from other countries and regions that would add to the technical challenges of setting up such structures. Since the members of the consortium are also the primary customers, the role of the regulator in supervising the performance of the network is reduced. However, the regulator would have an essential role in ensuring that non-members have non-discriminatory access to services.
Incentive-based private sector models	The challenges faced by governments and regulators in implementing Incentive-based models are similar to those of competitive subsidy models in that the government specifies the required outputs and then monitors the operators' performance in delivering these outputs. In some respects, the administrative process is simpler because direct payments are replaced by incentive schemes. Under this model, operators developing backbone networks under the scheme would be required to offer non-discriminatory access to their competitors. Ensuring that this takes place would involve a significant role for the regulator authority.

5 Conclusion: Beyond the backbone

As the pace of broadband development accelerates globally and economies adapt to better and more widespread connectivity, the importance of broadband connectivity is growing. The widening gap between the countries of Sub-Saharan Africa and other parts of the developing world is therefore squarely on the policy agenda of many countries in the region.

In the majority of countries of Sub-Saharan Africa, the incumbent operator is not sufficiently strong to be an effective backbone network of last resort. The model of market liberalization and regulation of access to the incumbent, that has been successful in Europe, North America, and increasingly in Asia and Latin America, is therefore not directly relevant in the region. The challenge facing policymakers in Sub-Saharan Africa is not one of ensuring that entrants have access to a dominant operator's infrastructure. Rather, it is ensuring that entrants have access to existing infrastructure developed by private operators and that networks are built in areas where commercial operators are not currently willing to invest. Both of these objectives have to be achieved without creating disincentives to the private sector to invest their own resources in network infrastructure.

Some countries in the region have already begun investing public resources in backbone infrastructure in the belief that this will ease one of the bottlenecks in the network infrastructure that is holding back service development. This is being done both directly by governments and also through state-owned incumbent operators. Often, these networks are being developed in direct competition with the private companies that have already invested in infrastructure there. This approach is unlikely to be the most effective way of spending scarce public resources and may have only a limited impact on the availability of broadband services. A market-based approach to backbone policy is more likely to be successful. Such an approach harnesses the investment resources of the private sector through effectively liberalizing the infrastructure segments of the market while focusing public investment in areas of the country not immediately commercially attractive to the private sector. This principle of market-based solutions to backbone policy also underlies the concept of channeling these public resources through partnerships with the private-sector.

Implementing this approach will require innovation by governments and regulators in the region. There are few clear, off-the-shelf examples from other parts of the world that can be directly transposed into the African context. However, this dearth of ready-made examples from other parts of the world can be considered an opportunity, rather than a problem. It provides policy-makers with an opportunity to design tailor-made policy solutions, aimed at meeting their specific challenges.

More effective backbone infrastructure would benefit all players in the market. There is, therefore, a common interest in ensuring that appropriate policies are adopted. At the same time, the power of incumbent operators to block sector reforms that might threaten their commercial interests is usually limited. This situation provides an ideal opportunity for governments to match the innovation of the African telecommunications market with policy innovation to meet the challenges emerging in the sector in Sub-Saharan Africa.

However, policy for backbone networks must be set in the context of the overall sector objective which is to provide low-cost broadband services on a mass-market basis.

Policy-makers therefore also need to look beyond the backbone and consider the other challenges facing the sector in ensuring that these services are delivered. Although these challenges are many, three stand out as priorities for the development of the sector.

High-speed international connectivity is currently a major constraint on the delivery of broadband services in Sub-Saharan Africa. Most of the region is dependent on satellites for international connectivity. Even where countries are connected to international submarine cables (i.e. the SAT-3 cable on the West coast of Africa), the impact has been very limited because access to these cables has been controlled by individual operators that have been able to set high prices. Access to high bandwidth international capacity at low prices is a necessary (but not sufficient) condition for the development of mass-market broadband. The global experience of international connectivity shows clearly that international infrastructure competition results in lower prices and higher bandwidth. In order to support the development of such competition in Africa, the licensing and regulatory frameworks, including rights to land submarine cables, may need to be reformed to ensure that monopoly control over bottleneck facilities does not emerge. However, this facilities competition may take some time to develop. In the short-run regulators will have a key role to play in guaranteeing access to bottleneck facilities such as landing stations. This is both technically and institutionally challenging. However many regulatory authorities around the world have been successful in doing this and there is considerable international experience available to support the regulators in Africa.

Downstream competition among the ISPs and other types of data services companies that provide broadband connectivity to customers is a key factor in the success of the broadband market. This is a potentially competitive segment of the market and competition has rapidly emerged in countries where markets have been effectively liberalized. However, for this competition to be sustained, these companies will require access to radio-spectrum and, in many cases, access to some of the larger operators' infrastructure (e.g. towers). Without such measures, this downstream segment of the market may become dominated by large network operators which would have adverse consequences for customers. Regulators have a key role to play in ensuring that effective competition develops in this segment of the market and this role is likely to become more important as the broadband market develops.

Demand stimulation has been a key component of the policy framework in many of the countries that have been successful in developing broadband connectivity. The different ways of doing this include supporting the use of computers in schools, providing training, increasing the use of broadband in public institutions. Recent worldwide initiatives to reduce the cost of computers in developing countries may make such a policy much more financially feasible for resource-constrained governments in the region. This type of initiative has a positive feedback effect on the provision of broadband connectivity as well, since increased usage of computers results in increased demand for broadband connectivity and therefore more investment into the broadband segment of the market.

The broadband market is a complex one with multiple interrelated market segments. Policy towards the sector is similarly complex. This report has focused specifically on backbone networks, as they are a key part of the sector and one that presents particular challenges for policy-makers in the region. However, at the same time that policy-makers are focusing on these networks, it is also critical that they are looking beyond them towards the rest of the market and the development of the sector.

As backbone network infrastructure in Sub-Saharan Africa develops and broadband connectivity expands, there will be a significant increase in economic opportunities and the channels for delivery of public services. With faster and more effective communications links between the institutions of government and with the rest of the world, policy-makers will the opportunity to improve the efficiency of service delivery and the transparency of public decisions. This process has already started with the establishment of e-government systems and the incorporation of mobile phone connectivity into government processes. Ready availability of broadband connectivity will increase the opportunities for these types of innovation and deepen their transformational impact.

References

Accenture. 2006. *Cost Optimization for Transmission and Backhaul Technologies.*

Balancing Act. 2007. Balancing Act News Update; Issue no 374

CNNIC (China Internet Network Information Center). 2008. *Statistical Survey Report on the Internet Development in China*

European Commission. 2004. "Commission Decision of 16 July 2003 relating to a proceeding under Article 81 of the EC Treaty and Article 53 of the EEA Agreement (Case COMP/38.369: T-Mobile Deutschland/O2 Germany: Network Sharing Rahmenvertrag)." Official Journal 2004, L 75/32

European Commission. 2005. *Information Society Benchmarking Report.*

European Commission. 2007. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Market Reviews Under the EU Regulatory Framework (2nd Report)*

European Court of First Instance. 2006. "Case T-328/03, O2 (Germany) & Co OHG vs. European Commission"

Global Insight. 2006. *Sub-Saharan Africa: Celtel Launches "One Network" in East Africa*

Global Insight. 2007. *The Shifting Geography of Broadband in Sub-Saharan Africa*

Government of Rwanda. 2006. *An Integrated ICT-Led Socio-Economic Development Plan for Rwanda 2006-2010. The NICI-2010 Plan.*

Goyal, Aparajita. 2008 "Information Technology and Rural Markets: Theory and Evidence from a Unique Intervention in Central India" University of Maryland Working Paper

Hamilton, Paul. 2007. *Analysis of the Extent of Development of Transmission Backbone Networks in Sub-Saharan Africa.* Study commissioned by World Bank.

ICEA. 2008. *Strategies for the promotion of backbone communications networks in Sub-Saharan Africa;* Study commissioned by World Bank.

Intelecon Research and Consultancy Ltd. 2008. *http://www.inteleconresearch.com /regnews/recent.html* (Accessed 23 June 2008)

Irwin, Timothy. 2003. *Public Money for Private Infrastructure: Deciding When to Offer Guarantees, Output-based Subsidies, and Other Fiscal Support.* World Bank Working Paper No. 10

ITIF (The Information Technology and Innovation Foundation). 2008. *Explaining International Broadband Leadership*

ITU (International Telecommunication Union). 2007a. *Telecommunications/ICT Markets and Trends 2007.* Geneva: ITU

—————. 2007b. *World Information Society Report 2007 Beyond WSIS*. Geneva: ITU

—————. 2008. *African Telecommunications/ICT Indicators 2008: At a Crossroads. Geneva: ITU*

Jensen, Robert. 2007 "The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector". *The Quarterly Journal of Economics; Vol. CXXII August 2007 Issue 3*

Ministerio de Ciencia y Tecnología. 2003. *"9688 REAL DECRETO 401/2003, de 4 de abril, por el que se aprueba el Reglamento regulador de las infraestructuras comunes de telecomunicaciones para el acceso a los servicios de telecomunicación en el interior de los edificios y de la actividad de instalación de equipos y sistemas de telecomunicaciones."*

OECD (Organization of Economic Cooperation and Development). 2006. *Internet Traffic Exchange: Market Developments and Measurement of Growth.*

OFCOM (Office of Communications). 2004. Review of the retail leased lines, symmetric broadband origination and wholesale trunk segments markets.

Ovum. 2005. *Recommendations on further liberalization of the telecommunications industry of Botswana; A final report to the Botswana Telecommunications Authority*.

PricewaterhouseCoopers. 2006. *Global Entertainment and media Outlook 2006-2010*

Roller, Lars-Hendrik, Waverman, Leonard. 2001. Telecommunications Infrastructure and Economic Development: A simultaneous Approach." *The American Economic Review, Vol. 91, No. 4. (Sep., 2001), pp. 909-923*

Telegeography. 2008. *Global Internet Geography.*

TRAI (Telecom Regulatory Authority of India). 2006. Study Paper on Analysis of Internet and Broadband Tariffs in India 28/11/06

Wellenius, Björn, Foster, Vivien, Malmberg-calvo, Christina. 2004. Private provision of rural infrastructure services: competing for subsidies. *World Bank Policy Research Working Paper No. 3365*

World Bank. 2002. *The World Bank Guarantees: Leveraging Private Finance for Emerging Markets.*

World Bank. 2008. *Africa Infrastructure Country Diagnostic for Sub-Saharan Africa, 2008*