Broadband for Africa

DEVELOPING BACKBONE COMMUNICATIONS NETWORKS

Mark D. J. Williams

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THE WORLD BANK

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Foreword

Over the past decade, a large amount of private investment, driven by sector liberalization and competition and major advances in cellular technology, has brought telecommunications services within the reach of the majority of Africa's population. Increasing competition is making services more affordable and putting pressure on operating margins. Operators are responding by expanding their networks beyond towns and cities into rural areas, and tailoring services to the needs of the lower-income tiers of the population. This rapid spread of access to information and communications services is changing the way society and business work in Africa, allowing families to stay in touch with each other, governments to deliver services more effectively, and businesses to operate more efficiently.

Africa's rapid adoption of the mobile phone is quickly closing the digital divide in voice services. But, just as one divide is closing, another one is opening wider. Consumers almost everywhere are demanding more services and larger bandwidth. People everywhere are coming to realize the benefits of having broadband Internet service, which permits instant access to nearly unlimited sources of information globally. The knowledge provided through such easy access to information is creating unprecedented opportunities and having a dramatic impact on the way people live and work. Africa, however, has been largely left behind in the shift to broadband. Increasing the availability and affordability of broadband services is thus high on the agenda for policy makers in Africa, though it will require major efforts from both government and the private sector. Conducive policy environments,

investment in network infrastructure, access to radio spectrum, and availability of affordable international bandwidth will all play key roles in the delivery of low-cost broadband to Africa.

This book looks at one critical element of the broadband network infrastructure: domestic backbones. Backbone networks are the high-capacity, fiber-optic networks that link disparate geographic areas and transport the high volumes of communications traffic associated with broadband services to customers. Africa's focus, thus far, on mobile networks to address an immediate service need has left backbone networks underdeveloped. This has created a major bottleneck in the rollout of high-bandwidth services and in the upgrading of cellular networks to provide value-added services. Overcoming this infrastructure hurdle is an important element in shaping the structure and policy framework of the telecommunications services sector. Without it, broadband will remain expensive and limited to businesses and high-income customers.

This volume takes a comprehensive, analytical view of the policy challenge of backbone networks, starting with the economics and the technology. It develops a set of policy recommendations for governments aiming to raise investment in and access to backbone networks, and lays the foundation for the World Bank's strategy toward backbone communications infrastructure in Africa.

Mohsen A. Khalil
Director, Global Information and Communication Technologies
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Mark D. J. Williams is a senior economist in the Global Information and Communication Technologies Department of the World Bank Group, where he specializes in the economics and regulation of ICT. He has advised governments, regulatory authorities, and private companies around the world on policy and regulation in the telecommunications and postal industries. Recently he has been focusing on the design and implementation of public-private partnerships for ICT infrastructure, particularly backbone networks, in southern and eastern Africa. He regularly publishes articles in journals, speaks at conferences, and contributes to books on ICT in Africa.

Abbreviations

$	All dollar amounts are in U.S. dollars unless otherwise indicated
BTC	Botswana Telecommunications Corporation
CDMA	code division multiple access
DFI	development finance institution
EASSy	Eastern African Submarine Cable System
FCC	Federal Communications Commission (United States)
GSM	Global System for Mobile
ICT	information and communication technology
IP	Internet protocol
IPTV	Internet protocol television
ISP	Internet service provider
kbps	kilobits per second
Mbps	megabits per second
OECD	Organisation for Economic Co-operation and Development
Ofcom	Office of Communications (United Kingdom)
PPP	public-private partnership
SOE	state-owned enterprise
SPV	special purpose vehicle
USF	universal service fund
USO	universal service obligation
UTL	Uganda Telecom
VoIP	voice-over-Internet protocol

Executive Summary

Many countries in Sub-Saharan Africa see information and communication technology (ICT) as a necessary foundation for long-term economic development. While the region has been very successful in increasing access to basic voice communications, there has been no comparable improvement in broadband connectivity. In fact, 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 policy makers across the continent.

This book 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 the reasons for this? What can be done to promote the development of backbone networks and thereby stimulate the take-up of broadband services?

There are two main 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 $366 per month, compared with $6–$44 per month in India. Typical prices for entry-level broadband services in Europe average $40 per month, falling as low as $12 per month in some European countries. Sub-Saharan Africa also has very limited

fixed-line telephone networks, which have been used to provide broadband access in the rest of the world. The average fixed-line penetration rate in the region is currently less than 2 percent. In many countries, the number of fixed lines is declining as people switch to mobile telephones.

Despite these comparatively 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 will increase dramatically as a result of the submarine fiber-optic cables currently under construction. In countries that have issued them, there has been strong commercial interest in licenses for the broadband spectrum, and some of the major regional mobile operators are increasing their strategic focus on data services. Successful development of mass-market broadband connectivity across the region, however, will require investment across the supply chain. One potential bottleneck is the supply of domestic backbone network infrastructure. Government policy related to these networks is therefore a key component of overall broadband policy and is the subject of this book.

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

The market structure of the backbone network infrastructure is another constraint to the development of the broadband market in Sub-Saharan Africa. Backbone networks are 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, so competition in the provision of broadband in the region has not developed as well as it has 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 to only a small portion of the population.

This pattern of network development is the result of a combination of factors. In many countries in Sub-Saharan Africa, 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 backbone 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. The networks have focused on the most profitable geographical areas, primarily major urban areas and intercity routes. Cross-border backbone network connectivity is also developing as regional businesses are established and as network traffic is increasingly composed of Internet-based communication rather than traditional basic voice communications. The majority of the Sub-Saharan African population living outside 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 will probably 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 the type of infrastructure that licensees are allowed to build, and restraints on the services that licensees are allowed to offer. Aside from involving the private sector, the cost of backbone investment for governments in Sub-Saharan Africa can also be reduced by providing access to alternative transport and energy infrastructure. Utility companies, such as electricity transmission operators and railway companies, can become effective

players in the backbone infrastructure market when brought within the formal telecommunications license framework. Finally, government can reduce the risk of investment in backbone infrastructure by offering political risk insurance and partial risk guarantees. Countries in Sub-Saharan Africa and elsewhere that have taken such steps have seen increased private sector investment 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 available backbone capacity.

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 public-private 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) provision of financial incentives to operators to develop networks in underserved areas.

As a whole, this book focuses on backbone networks, which form one part of the broadband supply chain. If backbone network policy is to be effective, then it must be placed in the context of overall broadband policy. Sub-Saharan African countries that are successful in achieving widespread broadband connectivity will have a profound positive effect on their long-term economic development and delivery of public services.

1 Introduction

Access to advanced information and communication technology (ICT) is a key factor in the economic and social development of Sub-Saharan 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 a sustained increase in the incomes of the poor in developing countries (Jensen 2007). Although limited data make the impact of broadband harder to quantify, emerging evidence suggests that access to more advanced ICT services, such as those that require broadband connectivity for delivery, can also have a positive economic and social impact (see, for example, Goyal 2008 and Qiang and Rossotto 2009).

As the understanding of the positive impact of ICT has grown, African governments have begun 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. (Paul Kagame, in Government of Rwanda 2006)

This book does not attempt to evaluate the potential impact of broadband on countries in Sub-Saharan Africa. Rather, 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, particularly one component of the supply side—backbone networks. The network infrastructure required to support broadband connectivity consists of much more than backbone networks, however. 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 here on this specific topic, this book is 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 book 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?
- What can be done to promote the development of backbone networks and thereby stimulate the take-up of broadband services?

This book begins with a brief review of the ICT market and considers the extent of demand for broadband and the 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 book presents a set of policy options that governments in Sub-Saharan Africa might consider in promoting the development of backbone networks in their countries.

2

Backbone Networks in Sub-Saharan Africa

The provision of broadband connectivity to end users involves several elements. A problem in any of these elements will constrain the delivery of affordable broadband services. In Sub-Saharan Africa, the inadequacy of one element, domestic backbone networks, is one of the factors underlying the limited growth of broadband in the region. Current backbone network infrastructure in Sub-Saharan Africa is characterized by widespread, low-capacity networks generally owned and operated by vertically integrated operators focusing on voice services. Incumbent network operators have much less extensive networks than in other regions and, in many cases, do not play a major role as providers of backbone network services. In other regions of the world, by comparison, 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 rollout of broadband services. The underlying causes of this pattern of network and market development in Sub-Saharan Africa are the high cost of network construction and operation, regulatory restrictions, and the historical evolution of networks and the market.

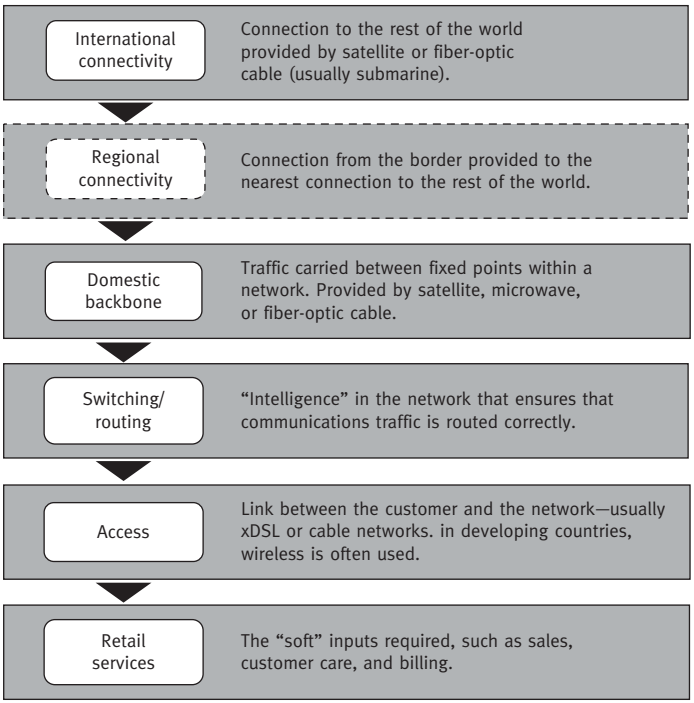
The Role of Backbone Networks

Supplying communications services involves a combination of 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 to other points 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 is 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 2.1.

In practice, there are many variations on the structure of this supply chain. For example, voice services do not rely as heavily

Figure 2.1 Broadband Communications Supply Chain



Source: Author.

on international connectivity as Internet services, and landlocked countries require regional connectivity if they are to access high bandwidth submarine fiber-optic cable networks. Domestic backbone networks lie at the heart of any communications services supply chain and are an integral component in the provision of broadband connectivity.

Communications networks operate by channeling traffic from a geographically dispersed customer base to local switching or routing nodes. From those local nodes, traffic is directed either to other customers (in the case of local voice and data communications) or to 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 network operator to have its own backbone network. 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 information and communication technology (ICT) market is one in which the upstream elements of the market (that is, the higher levels of the supply chain illustrated in figure 2.1) 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 composed 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 provided on a wholesale basis to third-party downstream players. In Sub-Saharan Africa, however, network operators 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 percent of total network costs.[1] For network operators providing broadband connectivity, the cost of backbone networks is much more significant. The average cost of a backbone network (that is, the cost per subscriber) varies enormously depending on its subscribers' geographical location. In urban areas, where subscribers are concentrated, the cost of backbone networks per subscriber is much lower than in smaller towns or rural areas. In practice, the capacity of a backbone network to reduce costs is one of the key determinants of the financial viability of providing broadband services in an area of a country. The absence of a backbone network in a particular area of a country to aggregate traffic and thereby reduce costs means that broadband services are unlikely to be commercially viable there.

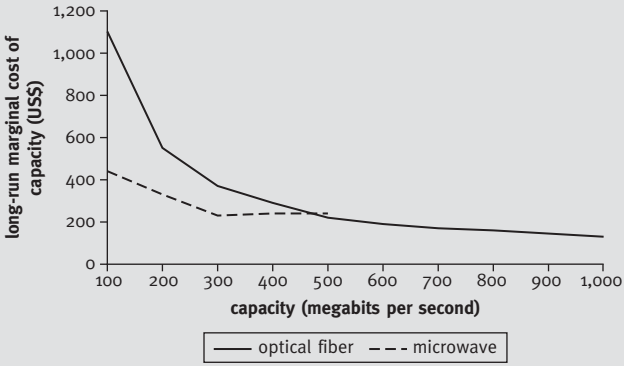
The potential economic impact of backbone networks lies in this reduction of costs through spreading them over higher volumes of traffic. This benefits all broadband providers, particularly smaller downstream players, who can purchase network services rather than having to build their own end-to-end networks. The potential economic impact is illustrated in box 2.1.

This analysis of the impact of backbone networks on costs, illustrated for the case of Nigeria in box 2.1, 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 this against 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 historically has been

Box 2.1 Economic Impact of Backbone Networks

The primary economic impact of backbone networks lies in the greater efficiency of aggregating traffic onto high-capacity networks and the corresponding reduction in average costs. This is a function of the fundamental cost characteristics of backbone networks, as illustrated for a 100-kilometer backbone network link in the first figure.

Average Backbone Network Costs



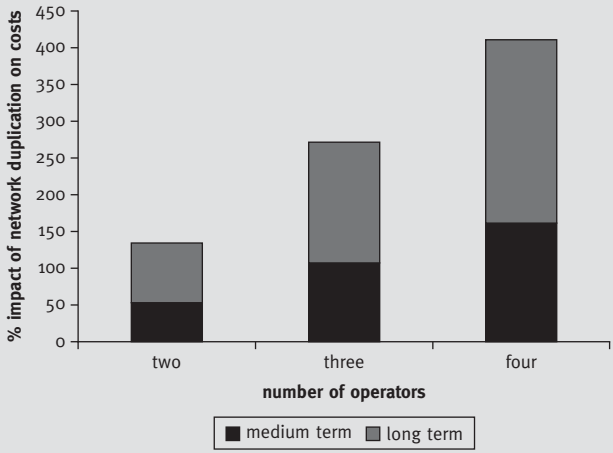
The practical consequences of this cost structure can be seen in the impact of backbone networks on network costs in an actual network. A backbone network was modeled for Nigeria in which the current networks were extended to connect major population centers throughout the country. The economic impact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

The second figure 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

(continued)

Box 2.1 continued

Effect of Traffic Aggregation on Average Costs



for downstream providers to enter the market. In the case of Nigeria, a high-capacity backbone network would result in significant cost savings, equivalent to up to one-third of the current average broadband retail price of around $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.

Source: ICEA 2008.

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 nor regulation effectively controls wholesale prices.

Backbone Network Coverage in Sub-Saharan Africa

Three features of backbone networks in Sub-Saharan Africa stand out: extensive coverage of low-capacity wireless networks, high-capacity fiber networks concentrated in certain specific geographical areas, and limited aggregation of traffic onto these high-capacity networks.

Extensive Low-Capacity Wireless Backbone Network Coverage

Contrary to common assumptions, there is, in fact, extensive backbone infrastructure in Sub-Saharan Africa. There are approximately 508,000 square kilometers of terrestrial backbone infrastructure (microwave and fiber-optic cables) operating in the region,[2] serving around three-quarters of Sub-Saharan Africa's communications users. The remaining one-quarter of the region's communications users utilize satellites for backbone connectivity.[3] These users are typically located in areas of low population density or in areas where network coverage is not contiguous. This average figure hides significant variations among countries. For example, it is estimated that approximately 89 percent of mobile network transmission is provided by satellite in the Democratic Republic of Congo and in Mauritania the level is 48 percent. In smaller countries, such as Mauritius and the Comoros, where population density is higher, satellites do not play a significant role in providing backbone links.

Most of the terrestrial backbone infrastructure in Sub-Saharan Africa is wireless. In fact, only 12 percent 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 mix of wireline and wireless infrastructure varies considerably among various types of network operators. Approximately 99 percent of the backbone network length of mobile operators in Sub-Saharan Africa is made up of microwave technology, while only 1 percent is

fiber. Fixed operators in the region have much more fiber in their networks, with approximately 40 percent of the length of their backbone networks built from fiber technologies.

The capacity of a backbone network is determined by the technology on which it is based and the capacity of the transmission equipment installed on the network. Though there are technical limits on the maximum capacity of wireless networks, in practice, the choice of whether to use wireless or fiber-optic cables in the backbone network 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 optimal solution.[4] 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 network capacity limitations. These wireless networks are not capable of handling the volumes of traffic generated by broadband services, particularly for a large customer base.

The predominance of wireless backbone networks in Sub-Saharan Africa is in contrast to countries in other regions. In Morocco, for example, there are three major fiber backbone network operators: the incumbent Maroc Telecom, Meditel (a major mobile operator), and Maroc Connect (an ISP that was awarded a general telecommunications license). The two entrants obtained 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 1,100 kilometers; and Office National d'Electricité (ONE), the national power company, which has a nationwide infrastructure of aerial fibers of about 4,000 kilometers.

This pattern in Morocco is also the result of market liberalization that has progressively introduced competition within the infrastructure industry, which, in turn, has resulted in rapid growth in broadband

services. In 2005, a company called Marais 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, building, and operation of backbone fiber networks. In Morocco, Marais is reproducing the successful carrier's carrier model by deploying 1,000 kilometers of fiber-optic cable network and signing usage agreements with the other operators.

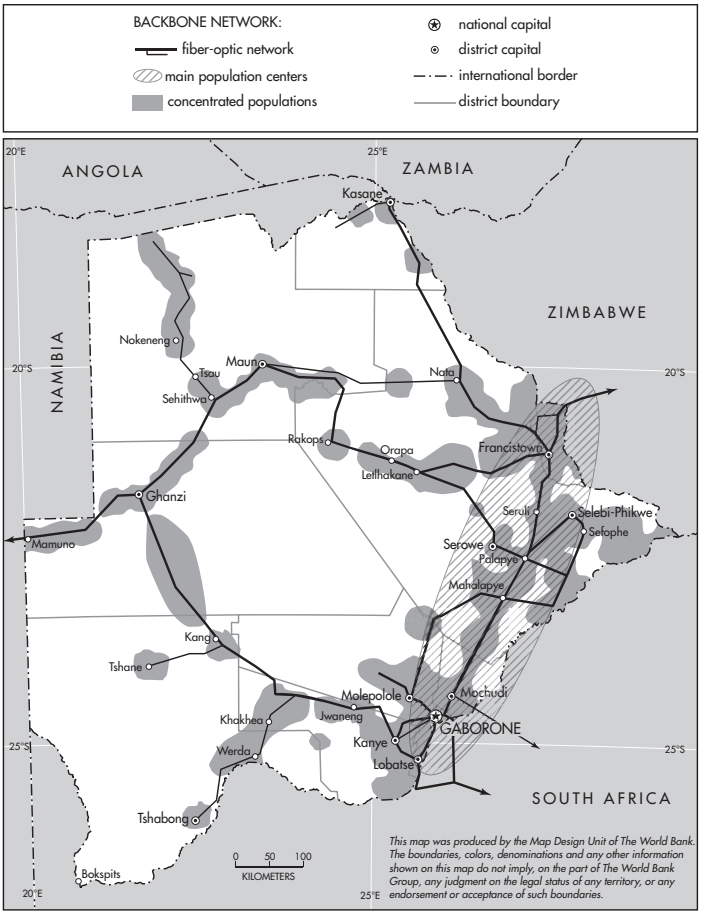
Geographical Concentration of Fiber Networks

While the total coverage of the region's backbone networks is very extensive, the development of fiber-optic backbone networks has occurred predominantly within and between major urban areas and on intercountry 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 percent of the population. This concentration of backbone networks in urban areas is illustrated for Botswana in map 2.1.

This concentration of backbone network development is increased through the effect of infrastructure competition. In countries with fully liberalized backbone markets, entrants have focused backbone network construction in the same areas in which the incumbent operator already has its network. The effect has been to increase the amount of backbone infrastructure available in these areas without benefiting other parts of the country. This is illustrated in map 2.2 for Nigeria, where competing fiber-optic cable networks have concentrated on a limited number of major routes.

Map 2.2 shows how competition in Nigeria has concentrated network availability in major urban areas and on interurban routes, resulting in increased availability in these areas but having limited impact outside of them. This effect is further illustrated for four African countries in figure 2.2, which shows two common features of fiber backbone networks in Africa. Though coverage[5] of the incumbent fixed operators' networks is quite limited, at only 23–33 percent of the population, coverage of the competing fixed operators is even more

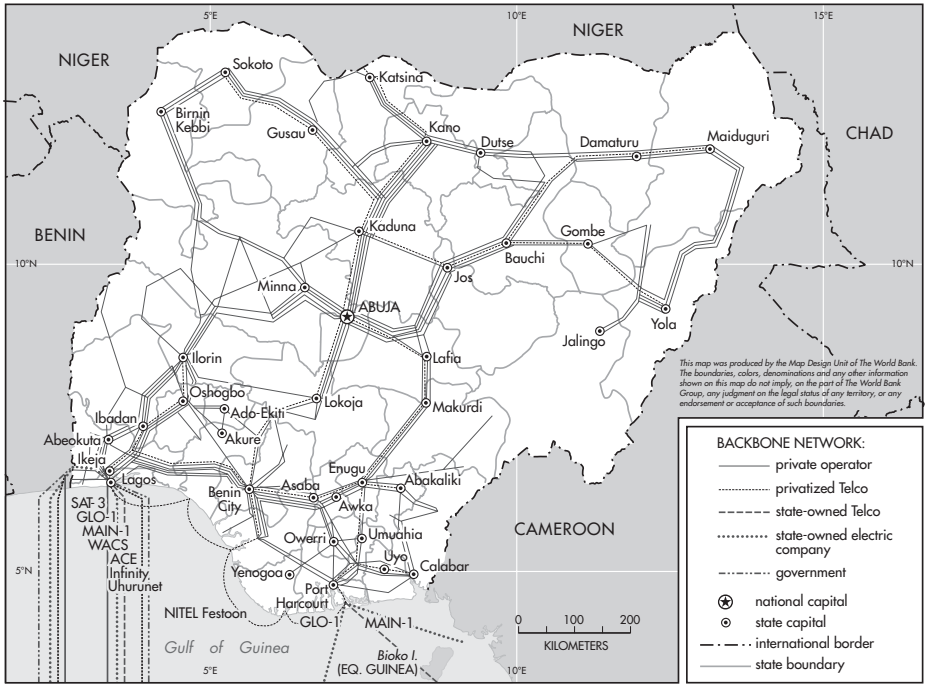
Map 2.1 Backbone Networks in Botswana



Source: Hamilton 2007.
Note: Darkly shaded portions of the map indicate areas where population is concentrated, while dark lines depict backbone networks.

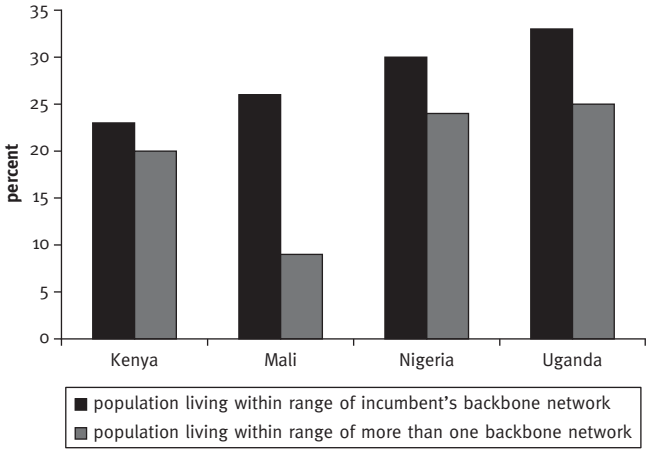
limited. Although not shown in figure 2.2, the population served by the competing operators is usually the same as that served by the incumbent's network.

Map 2.2 Competitive Backbone Network Development in Nigeria



Source: Africa Telecom Transmission Map, 2009, from Hamilton Research Ltd.

Figure 2.2 Population Coverage of Incumbent and Competing Networks



Source: Hamilton 2007.

Another feature of the geographical development of fiber-optic cable networks is that they often connect to borders. In Kenya, for example, the two major fiber networks both extend from Nairobi to the Ugandan border, even though there are few major population centers in this area. The reason this route was built is that it will be able to carry traffic between Uganda and the coastal landing stations of the submarine cables. Where there are no political or regulatory constraints to stop it, a similar process is being seen throughout the region, with networks extending to key border crossing points.

Limited Aggregation of Traffic on High-Capacity Backbone Networks

In the majority of countries in Sub-Saharan Africa, backbone networks are used mainly to provide backbone services for the operator's own retail customers. In Sub-Saharan Africa, these customers are primarily mobile subscribers. 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.

- *Fully liberalized markets.* 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 Nigeria (figure 2.2), and a similar situation is emerging in Kenya. These operators provide long-distance backbone services on a wholesale basis to other operators. However, these countries are the exceptions in Sub-Saharan Africa rather than the rule, and in both countries, some mobile and data operators continue to self-provide their own backbone networks. In several countries in Sub-Saharan Africa, 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, however. In Ghana, for example, the electricity transmission network operator, Volta River Authority, has not been successful in commercializing its fiber-optic communications networks. On the other hand, in Uganda, the electricity transmission network sells capacity to telecommunications operators along certain routes. Though successful examples of wholesale backbone networks show that wholesale markets for backbone capacity are feasible in Sub-Saharan Africa, they continue to face significant constraints.

- *Legal and regulatory requirements.* In some countries, mobile operators are 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.

- *Small operators entering the market.* There are cases of new mobile operators entering the market and purchasing backbone capacity

from either a fixed-line incumbent or an existing mobile operator. An example of this is Kasapa, a small code division multiple access (CDMA) mobile operator in Ghana that purchases backbone network services from Tigo, a major mobile operator in the country.

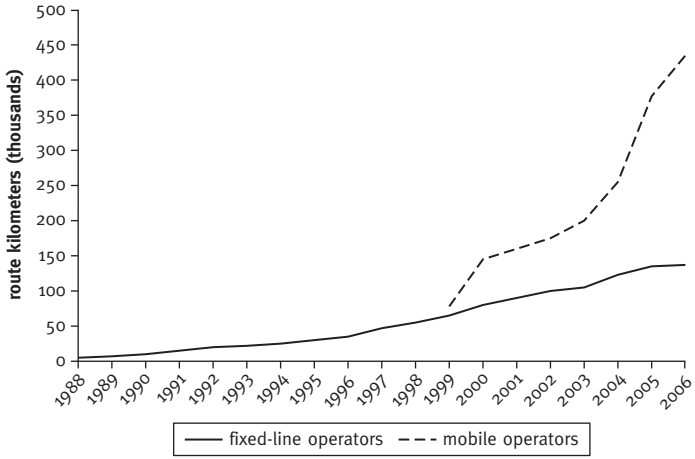
Understanding the Dynamics of Backbone Networks

A combination of economic and regulatory forces have created this pattern of backbone network development in Sub-Saharan Africa characterized by extensive, low-capacity wireless coverage and high-capacity fiber networks concentrated in certain specific geographical areas. These same forces are influencing the way the market structure is developing, being dominated by vertically integrated operators and only limited aggregation of traffic onto high-capacity networks. Understanding why these three features of backbone networks have emerged in Sub-Saharan Africa provides the basis for the policy recommendations outlined in chapter 4.

Extensive Low-Capacity Wireless Backbone Network Coverage

The current predominance of low-capacity backbone network infrastructure in Sub-Saharan Africa reflects the historical development of the communications network infrastructure. This development has been led by mobile operators who have built networks primarily to carry voice traffic. Figure 2.3 shows the expansion of terrestrial backbone networks in Sub-Saharan Africa alongside the rapid recent emergence of mobile backbone networks. Currently, only 32 percent 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 percent of backbone infrastructure is owned by mobile operators. Almost all the satellite-based backbone infrastructure is also operated by mobile operators. This ownership structure is unlike in other regions, where fixed telephone operators

Figure 2.3 Backbone Network Development in Sub-Saharan Africa



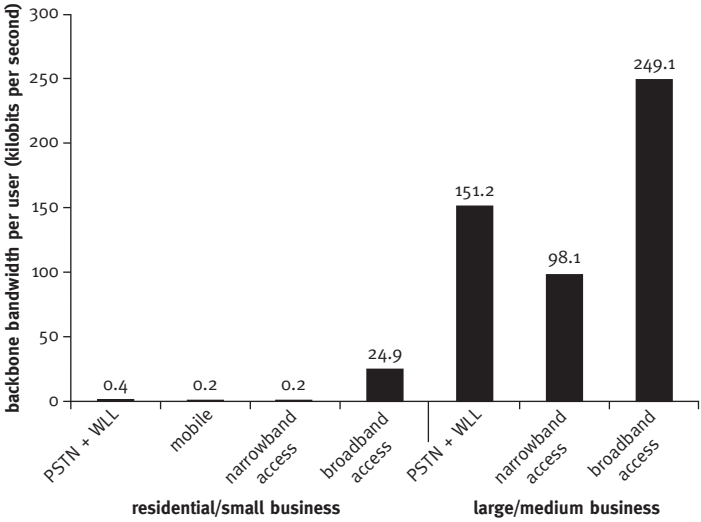
Source: Hamilton 2007.

own the majority of the backbone network infrastructure. Mobile operators in more developed markets often choose not to build their own backbone networks but rather to purchase backbone services from fixed operators.

The voice services provided by mobile operators require much less backbone capacity than broadband data services. This difference in backbone network capacity requirements is illustrated in figure 2.4, which compares 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.

This lower bandwidth requirement, combined with the need to cover Sub-Saharan Africa's large rural population, has driven the focus on wireless backbone networks. The way these two factors interact to determine optimum network technology choice is illustrated in figure 2.5.

Figure 2.4 Backbone Bandwidth Requirements



Source: ICEA 2008; World Bank staff analysis.
Note: PSTN = public switched telephone network; WLL = wireless local loop.

Figure 2.5 Optimum Backbone Technology Choice

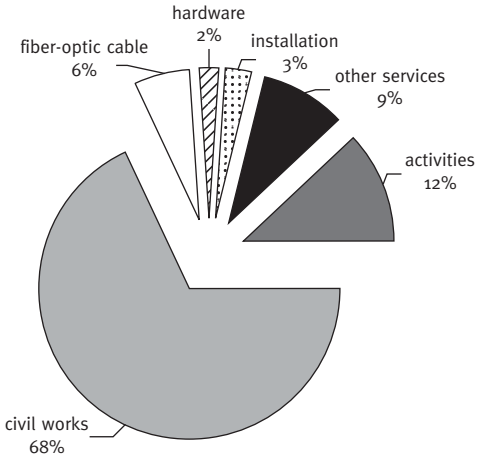
		capacity		
		‹8 Mbps	8–450 Mbps	›450 Mbps
distance	‹100 km	satellite/ microwave	microwave	fiber optic
	›100 km	satellite	microwave/ fiber optic	fiber optic

Source: ICEA 2008.
Note: km = kilometers; Mbps = megabits per second.

Differences in the cost structure of wireless and fiber-optic backbone networks also help to explain why operators have preferred to utilize wireless technologies. In wireless backbone networks, only a small proportion of the total costs are fixed with respect to the capacity of the network, so total costs are primarily driven by the volume of traffic carried. The costs of fiber-optic cable networks, by contrast, are largely fixed. A recent study by the Organisation for Economic Co-operation and Development (OECD) concluded that 68 percent of the costs in the first year of rolling out a fiber network to the premises are in the civil works. These costs are completely unrelated to the volume of traffic that the network will carry (figure 2.6). This is consistent with other studies, which have put the percentage of total costs of fiber networks that are fixed at 60–80 percent (Milad and Ramarao 2006).

This scalability of wireless backbone networks makes them most suitable for the early stages of network development where demand is uncertain and there are significant technical and political risks. Under these circumstances, operators are more likely to invest in

Figure 2.6 Fiber-Optic Cable Network Cost Structure



Source: OECD 2008.

wireless-based backbone networks than in fiber-optic networks, even if from an ex post point of view it would have been cheaper to use fiber.

Geographical Concentration of Fiber Networks

The concentration of fiber-optic networks in urban areas and on inter-urban routes is primarily driven by commercial factors related to both the demand for services and the cost of providing them. Compared to rural areas, urban areas are home to people with higher incomes and contain a greater number of businesses that create demand for ICT services—and thus have more backbone network traffic. Consequently, backbone network 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 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 2.2.

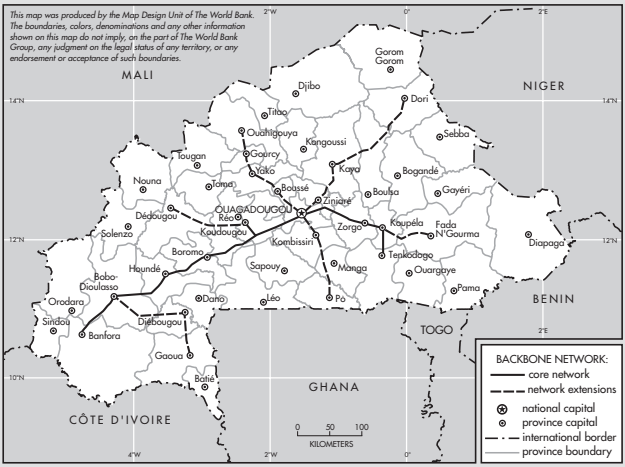
The same factors underlie the extension of fiber networks to connect across borders. First, much of the international communications traffic is intraregional, since personal and business linkages are often maintained within a geographical region. One market response to this has been the development of 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 intraregional traffic that will strengthen operators' incentives to connect their networks across borders.

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

Box 2.2 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 country's current and planned backbone network infrastructure. Extensions to this network to provide services to small, currently unserved towns were then modeled. As shown in the top figure, the modeled network has a basic star topology, with Ouagadougou as a central node. The links shown in green constitute the core network (that is, the existing or planned network links) and those in blue represent 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 shows that 75 percent of total traffic is carried on the core network, although it serves fewer cities and is shorter in total length than the extensions to the network. This has a direct

Burkina Faso Network Map

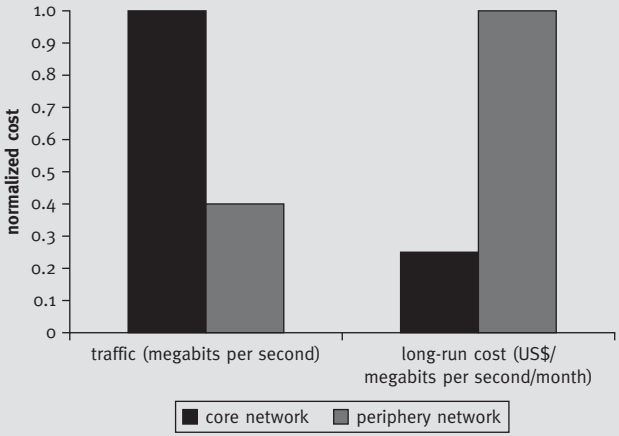


(continued)

Box 2.2 continued

impact on average costs because average cost is primarily determined by the amount of traffic carried by the network. The bottom figure compares traffic and costs of the core versus the periphery of a backbone network. The figure shows that the level of traffic is much higher on the core network than on the periphery and that the costs are much lower on the core network. The traffic and cost figures are closely linked, in fact, 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.

Average Costs in Core versus Periphery



Source: ICEA 2008.

of the region. Until recently, this traffic has been carried via satellite gateways. Each country typically has one or more of these gateways, so cross-border links were not required. However, the development of more submarine fiber-optic cables in the region will change these traffic patterns. Cross-border network connections will be needed

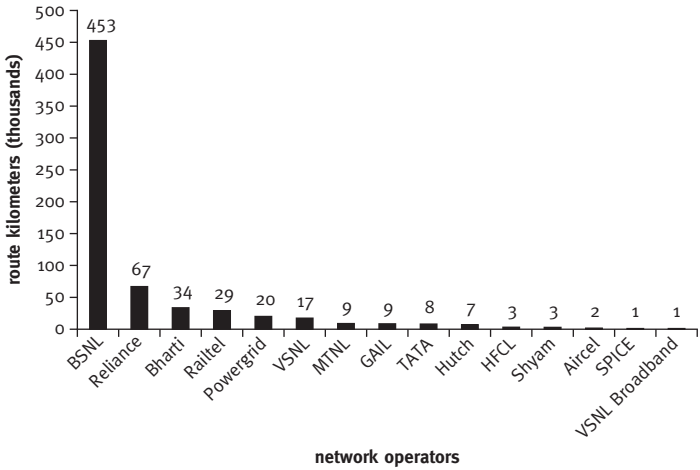
to carry traffic between landlocked countries and the submarine cable landing points. As broadband connectivity in Sub-Saharan Africa increases and the volume of data traffic being carried by the submarine fiber-optic infrastructure goes up, cross-border routes will become more profitable. This pattern of cross-border backbone network development, which is already evident, is likely to develop further.

This geographical concentration of networks in Sub-Saharan African countries is consistent with the experience of countries in other regions. 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 (that is, the market for capacity on backbone networks) carried out in 2004 by the Office of Communications (Ofcom), the regulatory authority concluded that on intra- and interurban routes, the backbone market was highly competitive, particularly for very-high-bandwidth services. In areas where competition among networks exists, the incumbent operator, BT, retained around 75 percent of the market share for low-bandwidth leased-line services (64 kilobits per second [kbps] to 8 megabits per second [Mbps]) but less than 10 percent of the market for very-high-bandwidth services (155 Mbps and above). However, in the 50 percent of the market that lies outside of these areas, BT was the sole supplier of backbone services. According to the report, "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). This pattern of backbone network development is now being seen in European countries that liberalized their markets later than the United Kingdom. The European Commission noted this in its 2007 review of competition in core backbone infrastructure services: "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 development of backbone network infrastructure seen in Sub-Saharan Africa appears to be following the pattern of network development seen in countries with more developed communications

markets. However, one key difference is that state-owned incumbent operators in Sub-Saharan Africa have not been able to fulfill the function of "backbone network of last resort." This is unlikely to change in the foreseeable future since, with few exceptions, publicly owned operators have consistently failed to build and operate backbone networks effectively. This is in contrast to other regions, where publicly owned operators can often be major players in the backbone market. In India, for example, the incumbent operator, which remains state-owned, has a very extensive backbone network and has been required by the government to cover most of the country. It is also required to provide wholesale backbone services (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 2.7.

Figure 2.7 Fiber-Optic Backbone Network Length in India



Source: TRAI 2006.

Bharat Sanchar Nigam Limited (BSNL), the state-owned incumbent operator in India, has undertaken an extensive rollout 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 explain why BSNL's network is so much larger than those of the other operators. Though some of the many other companies operating fiber-optic backbone networks in India, such as Reliance, are quite large, these operators have focused on the major urban and interurban routes and therefore the total length of their networks is substantially less than that of BSNL.

Limited Aggregation of Traffic on High-Capacity Backbone Networks

A key feature of the development of backbone networks in Sub-Saharan Africa has been the failure of markets to aggregate traffic onto high-capacity networks. As there are strong fixed costs associated with backbone networks, shifting traffic toward high-capacity networks would reduce average costs and create a more efficient network structure. It is thus reasonable to expect that such a shift would occur through market forces, as has been the case throughout the developed countries and in many emerging markets, where high-capacity upstream networks have emerged to carry traffic. Several factors, however, are constraining this process.

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

In many Sub-Saharan African countries, mobile operators are allowed to build their own backbone networks for the provision of services to their own retail customers but have been prevented from selling backbone services to other operators on a wholesale basis, effectively constraining the development of a market in backbone

network services. The restriction also limits opportunities for taking advantage of economies of scale in network infrastructure and reduces incentives to invest in high-capacity backbone networks. As a result, mobile operators have built their own networks that operate parallel to 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 1998. This framework allowed entry of mobile network operators under authorization of the telecommunications ministry, 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. Because these regulatory restrictions in Burkina Faso reduced the incentives for operators to invest in backbone networks, network investment has focused on lower-capacity wireless networks.[6]

One way of encouraging investment in backbone networks is to issue "carrier" (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 several companies that have built networks and provide services on a purely wholesale basis to other operators.[7] The potential opportunity for these types of operators is shown in Kenya, where KDN has developed 1,900 kilometers of fiber network infrastructure, and in Nigeria, where there are more than 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, and other areas. Such contracts are 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 customers. This is such an important issue that purchasing operators are reluctant to depend on contractual arrangements 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 a surprise price increase of 200 percent (Boosting Economic Growth in Ghana 2006).

Another type of regulatory structure constraining the development of backbone networks in Sub-Saharan Africa is one in which operators are required to use the backbone network of the incumbent operator. In Botswana, for example, prior to the revision of the sector legislation, mobile operators were required to purchase backbone services from the incumbent, Botswana Telecommunications Corporation (BTC), if it was able to supply them.[8] While this arrangement has the effect of aggregating traffic onto a single backbone network, thus increasing the potential to achieve economies of scale, the fact that it creates such a structure through regulatory rule rather than the operation of market forces means operators that otherwise might 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 it delivered, which caused problems for downstream users (Ovum 2005).

Stage of market development. The second reason for the lack of aggregation of traffic onto backbone networks in Sub-Saharan Africa lies in the stage of market development in most countries. Operators face a tradeoff when deciding whether to allow competing operators to use their backbone networks. On 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 tradeoff is that direct competitors in growing markets typically cannot reach agreement on the use of each others' backbone networks, a difficulty that 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, the ISP Infocom reports that it was unable to negotiate an interconnection agreement with MTN and Uganda Telecom (UTL), the two biggest network operators, on the use of their backbone networks. Although Infocom does not offer mobile voice services, the use of voice-over-Internet protocol (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 had to find an alternative solution to obtaining backbone network services. Ultimately, it reached agreement to purchase capacity on the electricity transmission network's optical fiber, which operates as a wholesale backbone operator in certain areas of the country. This case illustrates a key aspect of the operation of these markets. Where operators compete in the downstream (retail) market, they are less likely to trade backbone network services than where there are backbone networks that specifically target the wholesale market.

Exceptions to this scenario are also instructive. For example, in Ghana, the mobile operator Tigo provided backbone services to another operator, Kasapa. This was justified by Tigo on the basis of different target markets (Kasapa was targeting low-end, price-sensitive customers) and different network technologies (Kasapa has a CDMA network, while Tigo has a Global System for Mobile [GSM] network). In discussions with World Bank staff, Tigo indicated that it believed the additional revenues generated by selling spare backbone capacity wholesale to Kasapa outweighed any loss in competitive advantage.

Network economics. The current predominance of wireless backbone networks in the region has implications for the way in which

the backbone market is developing. Wireless backbone networks are scalable, meaning that operators develop them incrementally to meet internal capacity requirements. Operators are therefore less likely to have excess backbone network capacity than might have been the case if they had invested in fiber networks.[9] This has implications for the market in backbone services because the marginal cost of capacity on a network in which there is a 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 spare 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 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. An operator with a wireless backbone network thus has less of an incentive to enter into this market than an operator with a fiber-optic cable network.

Notes

1. Figures are based on discussions with network operators.

2. Data presented in this section refer to 47 Sub-Saharan African countries—all countries in the region except South Africa. South Africa was excluded from the analysis because its backbone network infrastructure is highly developed and is unrepresentative of the pattern of infrastructure for the region as a whole.

3. The metrics used to measure the extent of backbone networks is typically length (kilometers) and capacity (megabits per second, or Mbps). Microwave and fiber networks can be measured this way, but measuring the length of satellite links is not a relevant statistic.

4. Cost structure is discussed in more detail later in this chapter.

5. The population covered by backbone networks is defined for this analysis as the people living within a 10-kilometer radius of the network.

6. This framework has been subsequently reviewed by the government of Burkina Faso, however.

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

8. 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 voice-over-Internet protocol (VoIP) services to customers. These constraints have been removed in the new framework.

9. It is worth noting that this is changing. The commercial success of mobile operators in Africa, the increase in traffic arising from a growing customer base, and the shift in strategy from an exclusive focus on voice to one that includes broadband mean that network operators are now considering investment in fiber-optic networks that once would have been considered too risky.

3

Backbone Policies for Sub-Saharan Africa

Two themes emerge from the analysis of backbone networks in Sub-Saharan Africa presented in this book. First, though the majority of countries in the region have introduced some degree of infrastructure competition in the telecommunications sector, only a few have liberalized their markets to an extent likely to create effective competition among backbone network operators. This is constraining investment in high-capacity networks and preventing markets from achieving economies of scale. It also has had a knock-on effect in the downstream market, limiting the development of Internet service providers (ISP) and the data services market as a whole. And second, where fiber backbone network development has taken place, it has been concentrated in urban areas and on interurban routes, leaving smaller towns and rural areas dependent on low-capacity wireless backbone networks.

Policy toward backbone network development in Sub-Saharan Africa must address both of these themes if it is to be successful. Successful policy will include two complementary elements:

- *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 rollout in underserved areas,* especially in rural areas and small towns.

Within each of these elements, there are a number of policies that governments could adopt. These are summarized in table 3.1 and explained in more detail in the sections that follow.

Table 3.1 Summary of Policy Options

Create an enabling environment for infrastructure competition	Stimulate rollout in underserved areas
Remove regulatory obstacles to investment and competition ■ Remove limits on the number of network licenses ■ Encourage entry of alternative infrastructure providers ■ Remove constraints on the backbone services market ■ Improve the regulation of backbone networks	Implement incentive-based private sector models ■ Provide operators with incentives to cooperate in the development of backbone infrastructure in currently underserved areas of the country where infrastructure competition is not commercially viable
Reduce the cost of investment ■ Facilitate access to passive infrastructure ■ Promote infrastructure sharing	Establish competitive subsidy models ■ Provide operators with incentives to build networks in currently underserved areas through reductions in taxation or universal service fund (USF) contributions
Reduce political and commercial risks ■ Provide risk guarantees and political risk insurance ■ Aggregate demand	Create shared infrastructure/ consortium models ■ Provide operator(s) with a subsidy to build and operate a network in currently underserved areas of the country; provide services in these areas on a nondiscriminatory basis
Promote competition in the downstream market ■ Implement regulation that will effectively promote such competition	

Source: Author.

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 competition. By effectively promoting private investment into backbone networks, governments are likely to achieve policy objectives for urban areas and on interurban routes. Simultaneously, they would reduce the overall financial burden on the public sector of ensuring widespread and affordable broadband availability. Encouraging investment in and effective competition among backbone networks would also allow market forces to aggregate traffic onto higher-capacity networks, thus reducing costs and stimulating downstream investment and competition among ISPs and other data users.

This policy of promoting infrastructure competition to support the development of backbone networks is consistent with the experience of developed countries. For example, in a 2006 report, the Organisation for Economic Co-operation and Development (OECD) observed that "opening markets to facilities competition and the rapid development of technology [has] 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 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 [percent] in India. For example, a 256 [kilobits per second] xDSL connection with 400 [m]egabytes of data transfer included, is available from Bharat Sanchar Nigam Limited (BSNL) for less than [$]6 per month."

Multiple policy initiatives are needed to effectively create this enabling environment for infrastructure competition. They can be divided into four groups: removing regulatory obstacles, reducing the cost of

investment, removing political and commercial risks, and promoting effective competition in the downstream market.

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 a formal or informal limit on the number of licenses issued (World Bank 2008). There is little economic justification for such a limit, however, since many types of networks do not require scarce resources. This is particularly true for fiber-optic cable networks that do not use radio spectrum. 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 a substantial amount of financial resources in fiber-optic cable 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 infrastructure companies have already laid fiber-optic cables as part of their internal communications systems, and many of these cables have substantial unused 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 Sub-Saharan African countries, such as Uganda and Zambia, but not in others, such as Ghana. Whether infrastructure companies are successful in becoming commercial backbone network operators appears to depend on differences in the institutional environment (that is, whether the company is given sufficient political incentives and the regulatory freedom) and in managerial capacity, rather than on the technical characteristics of the networks.

Remove constraints on the backbone services market. Many countries in Sub-Saharan Africa impose constraints on the activities of

both backbone network operators and the users of those networks. 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 backbone services from and sell services to 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 in Sub-Saharan Africa has been difficulty in enforcing contracts and service-level agreements. While the ability to enforce legal contracts in commercial courts in most African countries is unlikely to improve significantly over the short term, the regulatory authority could improve the situation through several measures:

- Establishing clear regulations on interconnection at the backbone level
- Amending licenses to increase the enforceability of such rules, if necessary
- Setting out effective quality controls and clear dispute resolution procedures
- Collecting accurate quality of service information to facilitate market functionality and dispute resolution.

Regional approaches to regulating backbone network infrastructure may also be a way to improve the quality of regulation in Sub-Saharan Africa, particularly as regional businesses and networks emerge. Governments might, for example, reach a regional agreement on principles of open-access regulation or on the way in which a specific type of multicountry network is regulated. One example of this type of approach is the telecommunications-related commitments that countries make when joining the World Trade Organization. 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 a regional regulation agreement, governments may be able to provide additional assurance that investors will not face excessive political risk originating at the national level. However, regional approaches to the governance of the telecommunications sector have proven very difficult to implement in practice. Even in the European Union, where there has been a strong move toward harmonization of sector regulation in the context of general economic and institutional integration, telecommunications sector regulation remains the responsibility of national regulatory authorities, albeit within an overall regulatory framework defined at the European level.

Because regional approaches to regulatory capacity building and technical assistance in dealing with backbone networks are likely to be easier to achieve than complete regional regulatory harmonization, they may be a more effective way of improving the quality of regulation. Examples of the former approach include developing regional benchmarking data on prices and quality of service for backbone network services, standardizing reference interconnection offers (RIOs), and standardizing license terms and conditions. Existing regional associations of regulatory authorities in Sub-Saharan Africa provide a potential basis for such regional approaches to regulating backbone networks.

The best national example of the positive 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 3.1.

Although the information and communication technology (ICT) sectors of Sub-Saharan African countries are a fraction of the size of those in the United States (and thus caution should be exercised in drawing policy conclusions directly from the experience of the latter), it is instructive to note that the extremely rapid development of backbone networks in the United States has come about entirely

Box 3.1 Backbone Network Development in the United States

Though telecommunications in the United States was initially a competitive market, the passage of the 1934 Communications Act provided the biggest operator, AT&T, with a monopoly in the provision of telecommunications services. This monopoly ended for the long-distance segment of the market in 1969 when the Federal Communications Commission (FCC) gave a license to Microwave Communications, Inc. (MCI) to provide long-distance wireless network services to private clients. MCI's approval was immediately followed by license applications from other companies wishing to provide long-distance communications services. This policy of limited market liberalization was extended in 1977 with the overturning of the FCC decision, restricting the services that these long-distance operators could offer. These steps were the first stages of a series of regulatory reforms that led to the development of a competitive long-distance telecommunications market. This market later produced the extensive, high-capacity backbone networks that we see today.

Competition was further boosted with the breakup of AT&T in 1984 (following an antitrust lawsuit initiated 10 years earlier), and the passage of the 1996 Telecommunications Act. Subsequently, there has been consolidation throughout the market, including the backbone network segment. The backbone market in the United States is currently dominated by a handful of large network operators such as AT&T, Sprint, and Nextel, which operate very-high-capacity long-distance networks that cover large parts of the country.

The main drivers of this development in backbone 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 primarily been one of regulation and promotion of competition among network operators.

Source: Author, adapted from Lee and Prime 2009.

through private investment and competition. The government has not invested public funds directly in the development of backbone infrastructure, instead limiting itself to regulating the market.

Reduce the Cost of Investment

Facilitate access to alternative infrastructure. Fiber-optic cable networks are usually built along existing infrastructure networks such as roads, railways, pipelines, or electricity transmission lines. As discussed in chapter 2, most of the cost of constructing fiber-optic cable networks along these alternative infrastructure networks lies in the civil works. These costs represent a major fixed and sunk investment, increasing the risks faced by the networks operators. By lowering the cost of access to these infrastructure networks and reducing the risk associated with it, governments can significantly increase incentives for private investment into backbone networks.

Such incentives can be achieved in three ways: first, by making rights-of-way readily available to network developers at low cost. Obtaining these rights-of-way is often very difficult because of the lack of a clear legal framework and the multiple jurisdictions involved. By simplifying the legal process and limiting the fees that can be charged by local authorities for granting rights-of-way, governments can significantly reduce the cost of backbone network development.

Second, governments can provide direct access to existing infrastructure which it owns through state-owned enterprises. For example, the railway company could partner with one or more operators to build a fiber-optic cable network along the railway lines. This approach has been used very successfully around the world to develop extensive backbone networks at relatively low cost.

Finally, governments can specifically provide for backbone network development in the design and construction of other types of infrastructure. For example, by pre-installing ducting when new roads are built and then leasing these ducts to operators wishing to lay fiber-optic backbone networks, governments can significantly reduce costs.

An example of a comparable scheme from Spain in which telecommunications passive infrastructure is required to be installed in new buildings is described in box 3.2.

Promote infrastructure sharing where it does not have an adverse impact on competition. By sharing backbone network infrastructure, builders of backbone networks can significantly reduce costs and make investment in them more commercially viable. This is particularly relevant for fiber networks in urban areas where the cost of laying new fibers is high or in rural areas where the revenues generated by such networks are low. In some cases, operators have a commercial incentive to enter into these sharing arrangements. For example, in Nigeria, where there has been extensive fiber-optic cable network rollout, operators have entered into a variety of network-sharing agreements aimed at reducing costs and improving quality of supply.

Box 3.2 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 passive communications 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 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. If developers of these networks were required to install passive telecommunications infrastructure and then provide it to backbone operators on an open-access basis, it would significantly reduce backbone network development costs.

Source: Ministerio de Ciencia y Tecnología 2003.

Despite the advantages of infrastructure sharing, governments should exercise a degree of caution in pushing it, for two reasons. The first is that such arrangements are difficult to enforce if the parties are not willing to undertake enforcement on a commercial basis. Though requirements to share facilities are already included in many operators' licenses, they are rarely implemented or enforced if the operators are not willing to enter into the arrangements anyway.

Governments of countries in other regions have faced similar problems. In Bahrain, for example, the regulatory framework set up at liberalization required the incumbent operator, Batelco, to share its surplus fiber and duct space with new entrants on regulated terms. 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 in Bahrain is now revisiting the legal and regulatory framework that provides competitors with access to Batelco's infrastructure. It has also introduced more detailed rules on network sharing (box 3.3).

A 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 mobile operators seeking to share mobile infrastructure faced resistance from the European Commission (European Commission 2004). The European Court of First Instance (2006), however, subsequently ruled in favor of the operators. In most countries of Sub-Saharan Africa with their increasingly competitive telecommunications markets, competition-related issues may be of less immediate concern, particularly when balanced against the need for new infrastructure investment. Policy makers may consider that the risk of collusion is outweighed by the benefits of infrastructure development in rural and otherwise unprofitable areas.

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

Box 3.3 Network Sharing in Bahrain

Article 3(c) 13 of the Telecommunications Law of The Kingdom of Bahrain[a] gives the regulatory authority the right to require operators to share infrastructure. The details of this requirement are given in guidelines issued in 2008.

Telecommunications operators in Bahrain are "required to adopt joint infrastructure installation methods when more than one provider wishes to lay telecommunications infrastructure at the same location and within a timeframe not exceeding one year" (Section 1.11 [a]). The operators are required to share the costs of such joint network construction on a pro rata basis.

The article goes further in encouraging infrastructure sharing through the following provisions:

- If operators are unable to reach a commercial agreement on a joint project, they are required to go to the regulatory body for "mediation and/or a binding decision."
- Operators are not permitted to undertake fiber network development in a particular area if a fiber network has been constructed in the same area within the past 12 months.
- Operators are required to install at least 20 percent reserve area in their ducts for future use by other operators.
- Operators are prevented from using spare ducts for themselves or blocking other operators from obtaining access to them.

Source: Government of Bahrain 2008.

a. Legislative Decree No. 48 of 2002 Promulgating the Telecommunications Law.

investments take place in small increments, rather than large one-off expenditures. Scalable investments allow operators to expand their networks as demand develops, hence reducing the risk that networks are overdimensioned. Reversibility reflects the ability of a network operator to reverse investments and sell or reuse capital equipment if necessary.

Some types of network investments are more reversible than others. Microwave and satellite transmission equipment, for example, 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 civil works, such as construction of trenches and installation of ducts, that cannot be moved once built, investment in such networks is largely irreversible (sometimes referred to as "sunk costs"). In uncertain political and regulatory environments, operators are likely to favor more flexible investment in wireless network technology over fiber-optic networks, *ceteris paribus*. The risk of investment in fiber-optic cable networks could be mitigated, however, through the use of financial instruments such as partial risk guarantees and political risk insurance (World Bank 2002).

Reduce commercial risk through demand aggregation. Two key risks faced by entrants into any market are the risk that demand does not develop as anticipated and that the cost of obtaining customers turns out to be higher than anticipated. These risks can significantly raise the economic cost of an investment and create a disincentive for operators to invest in infrastructure, particularly in physical assets that may constitute a sunk cost. One way that governments can reduce these risks is to act as a central purchaser of services on behalf of all public institutions at all levels (including, for example, schools, health centers, and local government). By doing this, operators effectively deal with a single large customer rather than multiple smaller customers, hence reducing commercial risks. Such a strategy was undertaken on a large scale in the Republic of Korea, where the government promoted the rollout of high-speed backbone infrastructure 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 3.4.

Because many companies in Sub-Saharan Africa have difficulty in collecting revenues from public institutions for utility services such as water and electricity, an issue to consider in relation to commercial risk is therefore the extent to which the credit risk associated with the public sector as a customer offsets the commercial advantages of

Box 3.4 Examples of Infrastructure Development through Demand Aggregation

Republic of Korea

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

It is significant that the Korean initiative was done in the context of an overall policy 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 support for the provision of inexpensive personal computers for low-income households. The result of this combined policy has been an explosion of network investment and usage of broadband services. All cities, towns, and villages are now connected by high-speed networks and the cost of broadband services is low.

(continued)

Box 3.4 continued

Ireland

In 1999, Ireland's Industrial Development Authority, under the Ministry of Public Enterprise, entered into a public-private partnership (PPP) with Global Crossing under which the latter would build a fiber-optic ring that would provide subsidized international connectivity to Ireland's rapidly expanding telecommunications operators, ISPs, and ICT firms.

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 uniformly subsidized pricing structure. By acting as an "anchor tenant," the government provided risk reduction sufficient enough to allow the private company to invest. At the same time, by on-selling the capacity at uniform and nondiscriminatory rates, this structure supported the development of the downstream market through ensuring that both small and large operators had access to inexpensive international capacity.

Source: Author.

bulk purchase of backbone services. Use of prepayment and escrow mechanisms can reduce this credit risk.

Promote Effective Competition in the Downstream Market

Promote competition among access and service providers. Network operators and service providers wishing to enter the downstream market (that is, building access networks and offering services to customers) must either build their own backbone network or access the network of another operator. The terms under which operators

can obtain access to the backbone networks of other operators will have a significant impact on the success of their business and will influence whether 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 is crucial, since the regulator often defines and enforces the terms of access. The decision about whether to directly regulate the terms of access to infrastructure has a major effect on the investment incentives. Under the traditional model of liberalization followed in Europe, in which the incumbent operator dominated 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 tradeoff between supporting the development of competition in the downstream market and maintaining the incentives to invest in upstream infrastructure. In areas of a country where public support is provided for backbone infrastructure, this tradeoff is relatively straightforward, since one of the conditions of public support will be the provision of wholesale services on regulated terms. In other areas of the country and in other parts of the infrastructure, the tradeoff may be more difficult to determine.

Stimulate Rollout in Underserved Areas

The experience of countries in Sub-Saharan 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 they will be focused on inter- and intraurban routes and on commercially attractive cross-border links. A large proportion of the population will not benefit from this competition, though, as they live beyond the range of these networks.

The experience of Sub-Saharan African countries in this regard is consistent with the experience of many countries with advanced ICT markets that have been fully liberalized and 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 provided by the incumbent operator (either currently or formerly owned by the state). In the case of Sub-Saharan Africa, incumbent operators are generally weak and their backbone networks are often either poor or nonexistent.

Market forces, on their own, are unlikely to deliver universal backbone network coverage. If high-capacity backbone networks are to be developed in less commercially attractive 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 the rate at which traffic increases once the network is in place. Box 3.5 presents an analysis of the public financing requirements for Uganda.

Policy toward backbone network rollout in many countries outside the Sub-Saharan Africa region has focused on the incumbent

Box 3.5 Financial Analysis of a Fiber-Optic Backbone Network in Uganda

Uganda, a country of 31 million people in East Africa, has a fully liberalized telecommunications market with 28 licensed operators and ISPs. Currently, most of the backbone network infrastructure is in the southern part of the country, where the

Modeled Backbone Network Map of Uganda

(continued)

Box 3.5 continued

majority of telecommunications users are concentrated. This backbone network is approximately 817 kilometers in length and is shown as a solid line in the map. A backbone network that would link 10 additional towns[a] that are not currently connected to the main fiber networks is shown as a dashed line. Together, these extensions would have a total length of 2,252 kilometers.

Assuming a discount rate of 15 percent, the total cost of the extensions to the existing network would be approximately $62 million. 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 volume would be much lower and the network length longer in the periphery of the network than in the core, the cost per unit of capacity would be approximately 180 percent 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 in the map, the required government subsidy lies in the range of $20 million–$26 million, representing 32–40 percent of the total network investment required.[b]

Source: ICEA 2008.

a. Arua, Kitgum, Gulu, Lira, Soroti, Mbale, Kabale, Bushenyi, Kasese, and Fort Portal.

b. The 15 percent cost of capital used for this analysis 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, a higher level of subsidy would be required.

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 private operators (World Bank 2008). Attempting to develop high-capacity backbone networks through state-owned enterprises

is, thus, unlikely to be successful. Partnerships with the private sector are more likely to succeed. Three types of such a partnership model are described below—competitive subsidies, shared infrastructure/consortium 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 the broad scope of policy options. Hybrid models that combine different aspects of the models featured here are also possible.

Competitive Subsidy Models

Under this approach, a license to build and operate a backbone network is awarded by the government to a private sector entity. The licensee would also be awarded a contract to build out a network defined by the government and that meets the government's policy objectives. The government would provide some resources, in the form of in-kind or cash payments, to this licensee. The contract design would include the terms on which backbone network services are provided. One key aspect of these terms would be the price of service, since this determines the impact on downstream users of the network. Quality of service and the type of services provided would be other important aspects of 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 end is a network in which the public and private sectors 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, Foster, and Malmberg-Calvo 2004).

Advantages

- The government's objective of extending the backbone network is met while ensuring that the skills, expertise, and investment resources of the private sector are leveraged.

- The private operator has 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, recourse to alternative operators is also possible.

- There is some experience of similar approaches being used to promote the rollout of rural access networks in Sub-Saharan Africa. Examples of similar structures in the transport, water, and energy sectors also provide useful benchmarks.

Disadvantages

- Government support to one specific operator may adversely affect competition through unduly favoring one operator over others.

- It can be difficult to obtain accurate information on the performance of licensees and to impose penalties for failure to deliver.

- Existing financial connections between the backbone operator and downstream operators (that is, retail providers) will create an incentive for the backbone operator 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. Though the models used were different, both were designed around the same principle of partnership between the public and private sectors to develop fiber communications infrastructure. The two cases are described in box 3.6.

Box 3.6 Competitive Subsidy Models in France and Singapore

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 high-speed Internet access to all residents.

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, €85 million, was shared between the public (45 percent) and private (55 percent) sectors. The construction of the fiber-optic backbone network was successfully implemented in mid-2007; subsequently, 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 Internet protocol television (IPTV), voice-over-Internet protocol, and high-speed data services in competition with France Telecom.

Fiber-Optic Access Network PPP in Singapore

The broadband penetration rate in Singapore has risen dramatically in recent years, from 10.3 percent of households in 2001 to 45.5 percent in 2005 (PricewaterhouseCoopers 2006). However, the access networks currently used—xDSL or cable television technologies—have inherent speed limitations. Looking forward, the government has identified the capacity of the access network infrastructure as a potential future bottleneck in fiber-optic network sector development. However, the size of the investment required to upgrade Singapore's access networks and the risks involved mean that no private operators

(continued)

Box 3.6 continued

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 PPP.

The government has allocated up to S$1 billion (approximately $730 million) to subsidize 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 Internet protocol (IP) service on the second layer. The contracts to build and operate these two network layers were awarded through a tender process. They will manage them as separate, stand-alone entities operating at arm's length from their other operations. The terms on which the companies will be 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. 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 agglomerations.

Source: Author and ICEA 2008.

The two examples given in box 3.6 relate to different segments of the communications network infrastructure. 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. But in both cases, public funds were used to support investment in ICT infrastructure in areas of the country or segments of the market that the private sector was not willing to finance. In both cases, the public support was also targeted at

an upstream segment of the market that was 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.

Shared Infrastructure/Consortium Models

Under a shared infrastructure/consortium model, 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 such as focusing investment on areas not served by private operators, ensuring cost-oriented wholesale prices, and ensuring nondiscrimination between purchasers of services.

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 not only reduces the cost to the government but also ensures that the members have a financial stake in its success.

- Because the companies that operate the network would also be its primary customers, they would 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, resulting in higher prices for customers 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 nonmembers. Such an incentive to discriminate is inherent in the model and would have to be controlled by the government either through its role as a financier of the project or through the regulator.

- Because there is no competitive bidding process under this model, 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, lack of a competitive process may result in the government paying more for the network than would otherwise be the case.

The Eastern African Submarine Cable System (EASSy), a major submarine cable project, is one of the few examples of a shared infrastructure/consortium model being used to develop backbone networks in Sub-Saharan Africa. It is based on 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. Although EASSy is a submarine fiber-optic cable, the regulatory principles that underlie its design can be equally applied to the domestic backbone networks that are the subject of this book. The structure is described in more detail in box 3.7.

Incentive-Based Private Sector Models

All countries require operators to pay taxes and levies that typically consist of both general taxes (those 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, but in practice, they are often not used effectively. Countries also often impose obligations on licensees to cover unprofitable parts of the country or provide services that may not be commercially viable. Such obligations are generally referred to as universal service obligations (USOs).

Box 3.7 EASSy as a Shared Infrastructure/Consortium Model

EASSy is a submarine fiber-optic cable that stretches from South Africa to Sudan with connections to countries along the 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 more than 20 telecommunications operators, mostly from eastern and southern Africa with the support of five development finance institutions (DFIs), the International Finance Corporation, the European Investment Bank, the African Development Bank, Agence France de Développement, and the German government-owned development bank KfW (Kreditanstalt für Weideraufblau).

A key issue for policy makers 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. Though the SAT-3 was also financed and built, and is managed, by a consortium of operators, 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.

EASSy has been designed to minimize the problems associated with the absence of effective competition and regulation. One of the members of the consortium that owns the cable 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 to licensed operators on an open-access nondiscriminatory basis in any market in the region, 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 prices in the marketplace, hence reducing the need for regulation.

Source: Author.

The government could provide operators with an incentive to develop backbone networks in commercially unattractive areas by offering to reduce these levies or relax USOs in exchange for the operators meeting specific targets. The incentive could be done on a competitive basis—by making companies compete for a reduction—or it could be available to all companies. Though such "pay-or-play" schemes are not common in the telecommunications sector, they have recently received an increasing amount of attention.

Advantages

- Private companies own and operate the network(s), increasing 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.
- Because operators are required to pay taxes on an ongoing basis, the government retains the option to penalize failure to meet the contractual obligations by removing the tax break.

Disadvantage

- Any network built under such a model is privately owned by operators competing in the market, creating a significant incentive to discriminate against competing operators. Since the government's objective is to ensure that the backbone network is built as a common facility, available to all, the model requires strong monitoring of the way it is operated.

Box 3.8 summarizes the experiences of two countries, Sweden and Brazil, that have used incentive-based mechanisms to achieve similar objectives.

Box 3.8 Incentive-Based Private Sector Models in Sweden and Brazil

Backbone Networks in Sweden

Since 1999, when it launched its first broadband policy, the Swedish government has provided subsidies for broadband rollout through several programs, including tax incentives for operators building networks in rural areas and grants to municipalities to build fiber networks. The total value of these subsidies is an estimated $820 million. A government-appointed committee recently recommended, though, that the government should distribute an additional $500 million in 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.

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 are building out backbone 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 operators being provided a reduction in their USO in exchange for investing in broadband and backbone investments. Such mechanisms are sometimes referred to as "pay or play."

Source: Intelecon Research and Consultancy 2008 and Atkinson, Correa, and Hedlund 2008.

Implement Backbone Policy

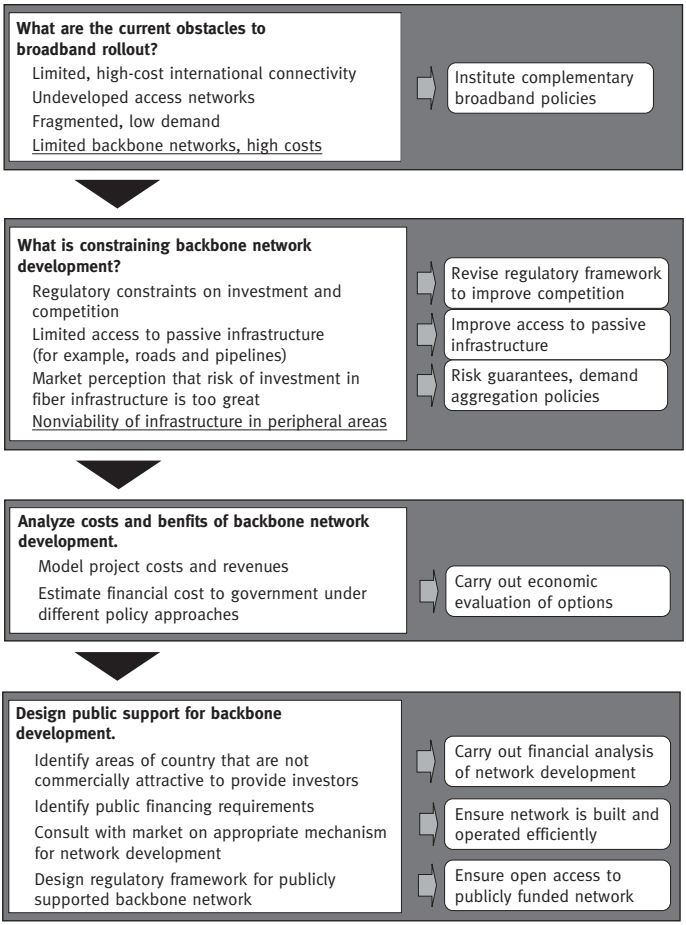
Achieving widespread availability and use of broadband in Sub-Saharan Africa is likely to be a complex challenge, involving a number of interrelated decisions. The extension of high-capacity backbone networks is a key part of this and is likely to require targeted policies. The process of designing these policies 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 backbone network development that may lie in the availability of alternative infrastructure (for example, international connectivity) or 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 the following section. 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 "road map" shown in figure 3.1.

Assess the Costs and Benefits of Support to the Development of Backbone Networks

A key step in implementing the backbone policy framework in Sub-Saharan Africa is an assessment of costs and benefits. Estimating the value of the benefits is challenging 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 (that is, broadband connectivity) to customers. If backbone policy is not placed within the overall context of broadband policy, it is unlikely to be effective in increasing connectivity to end users. However, by doing so, it is difficult to attribute

Figure 3.1 Road Map for Backbone Network Policy



Source: Author.

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 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 is 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 undertakes a comprehensive approach, aimed at all the major potential bottlenecks in the broadband market. 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 a greater 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, as it would allow policy makers to make decisions on the basis of information on the relative costs of each potential course of action. Table 3.2 summarizes some of the basic principles for calculating the cost of the backbone policy initiatives outlined in this report.

Determine the Institutional Implications of Backbone Network Policy Recommendations

An important issue to consider in designing the appropriate policy framework for promoting backbone networks is the implications for

Table 3.2 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. ■ Changes to the licenses of existing operators (for example, 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 cost 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, the relevant measure of cost is the incremental costs incurred in such developments. This is 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 them as a single contract rather than through many different institutions.

(continued)

Table 3.2 continued

Policy option	Approach to cost calculation
Public support to backbone networks in underserved areas	■ All of the options outlined in the section on stimulating rollout in underserved areas 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 will be in the form of foregone revenues from levies. The level of investment required by the government is the net cost (that is, the subsidy required). This will be determined by the technical specifications of the network, the commercial revenues the operator is likely to generate, and the level of prices set for network services. ■ The only way to estimate 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.

Source: Author.

the institutions that govern the sector, typically the ministry of communications and the regulatory authority. The policy options outlined in this chapter vary both in the burden they place on these institutions and on the extent that their success depends on their 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 backbone network 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 is an institutional challenge related 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 availability of skilled staff in the institution. The third challenge relates to the political economy of the ICT sector. Some policy decisions may act directly counter to the interests of one or more parties in the market or the government. For example, in countries where backbone services are monopolized by an incumbent operator, liberalizing the wholesale market may adversely affect the profits of the incumbent, particularly in the short term. Liberalization may therefore meet significant institutional resistance, thus making other policy options easier to implement. Table 3.3 provides a summary of the institutional and technical implications of each of the policies outlined above.

Table 3.3 Institutional and Technical Implications of Policy Options

Policy option	Institutional and technical implications
Remove limits on the number of network licenses	Governments and regulators are familiar with the process of issuing licenses, as license templates are available from other countries. Because increasing the number of players in the market will increase competition, it may face opposition from existing licensees. Many countries have proved that it is possible to do, however.
Encourage the entry of alternative infrastructure providers	Licensing alternative infrastructure networks as telecommunications operators is not technically challenging. In many cases, 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 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 in this area. Though such regulation may not run directly against the interests of any particular market player, regulators may face institutional constraints on their ability to enforce such regulations.
Facilitate access to passive infrastructure	While the technical requirements of ensuring access for operators to passive infrastructure are not challenging, the policy may be difficult to implement because governance of these types of infrastructure usually lies 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 such requirements, 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 demand aggregation	Although simple in principle, this option can be difficult to implement because it affects budget 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 Sub-Saharan Africa have liberalized their telecommunications and ICT services markets to some extent. Further liberalization may face political opposition from existing market players.
Competitive subsidy model	This category of models involves issuing a license and a long-term contract to build and operate a backbone network and selling services at predetermined prices. The process for designing the license and selecting a bidder is similar to the process undertaken for other license awards. However, the regulator has an important role in ensuring that the network is built to the contract specifications and that services are provided at the appropriate quality and price. Since the regulator is a new operator for the market and the network would provide ready access to backbone services for other players, it is unlikely to face significant institutional opposition.

(continued)

Table 3.3 continued

Policy option	Institutional and technical implications
Shared infrastructure/ consortium model	This type of model involves a negotiated arrangement among a group of operators and, in some cases, the government. Such arrangements have proved challenging to establish because of the competing interests of the members of the consortium. There are relatively few examples of such arrangements from other countries and regions to draw on, however, adding 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 has an essential role in ensuring that nonmembers have nondiscriminatory access to services.
Incentive-based private sector model	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 are required to offer nondiscriminatory access to their competitors. Ensuring that this takes place involves a significant role for the regulatory authority.

Source: Author.

4

Conclusion: Beyond the Backbone

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

In the majority of countries of Sub-Saharan Africa, the incumbent broadband network operator is not sufficiently strong to be an effective backbone network of last resort. The model of market liberalization and regulation that has been successful in Europe and North America, and increasingly in Asia and Latin America, is therefore not directly relevant in the region. The challenge facing policy makers 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 in which commercial operators are not currently willing to invest. Both of these objectives must be achieved without creating disincentives to the private sector to invest their own resources in network infrastructure.

Some countries in Sub-Saharan Africa have already begun investing public resources in backbone infrastructure with 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 by state-owned incumbent operators. Often,

these networks are being developed in direct competition with the private companies that have already invested in infrastructure in the country in question. 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 both governments and regulators in Sub-Saharan Africa. There are few clear, off-the-shelf examples from other parts of the world that can be directly transposed into the African context. However, the dearth of ready examples from other parts of the world can be considered an opportunity, rather than a problem, as policy makers have an opportunity to design tailor-made policy solutions aimed at meeting their specific challenges.

More effective backbone infrastructure would benefit all players in the broadband 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 in Sub-Saharan Africa. This situation provides an ideal opportunity for governments to match the innovation of the African telecommunications market with policy innovation to meet the emerging challenges of the broadband sector in Sub-Saharan Africa.

However, policy for backbone networks must be set in the context of the overall broadband sector objective—providing 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 numerous, 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 (for example, the SAT-3 cable on the west coast of Africa), the impact has been very limited because access to these cables is 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 Sub-Saharan Africa, 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, but regulatory authorities in other regions have been successful in improving such access, so 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 (for example, towers). Without such measures, this downstream segment of the market may become dominated by large network operators, with 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. Methods for doing this include supporting the use of computers in schools, providing training, and increasing the use of broadband in public institutions. Recent worldwide initiatives to reduce the cost of computers in developing countries may make demand stimulation much more financially feasible for resource-constrained governments in Sub-Saharan Africa. Demand stimulation also has a positive feedback effect on the provision of broadband connectivity, 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 complex, with multiple interrelated market segments. Policy toward the sector is similarly complex. This book focuses specifically on backbone networks, as they are a key part of the sector and a part that presents particular challenges for policy makers in Sub-Saharan Africa. At the same time policy makers are focusing on these networks, however, it is critical that they also consider the development of other segments of the market, and the sector as a whole.

As backbone network infrastructure in Sub-Saharan Africa develops and broadband connectivity expands, there will be a significant increase in the economic opportunities and channels for delivery of public services. With faster and more effective communications links between government institutions and the rest of the world, policy makers will have the opportunity to improve the efficiency of service delivery and the transparency of public decisions. This process began 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 innovations and deepen their transformational impact.

References and Other Resources

Atkinson, Robert D., Daniel K. Correa, and Julie A. Hedlund. 2008. *Explaining International Broadband Leadership*. Washington, DC: The Information Technology & Innovation Foundation. http://www.itif.org/files/2008BBExecutiveSummary.pdf.

Balancing Act. 2007. "Just as the Power of the Incumbent Fades, the Vertical Integrators Are on the March Again." Balancing Act News Update, Issue 374.

CNNIC (China Internet Network Information Center). 2008. "Statistical Survey Report on the Internet Development in China." CNNIC, Beijing. http://www.cnnic.net.cn/uploadfiles/pdf/2008/2/29/104126.pdf.

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 of the European Union*, L 75/32. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:075:0032:0058:EN:PDF.

———. 2005. "Information Society Benchmarking Report." European Commission, Brussels. http://www.epractice.eu/files/media/media_504.pdf.

———. 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): Consolidating the Internal Market for Electronic Communications." European Commission, Brussels.

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

Boosting Economic Growth in Ghana by Improving Domestic and International Communications Connectivity. 2006. Workshop held at La Palm Royal Beach Hotel in Accra, Ghana, May 10.

Global Insight. 2006. "Sub-Saharan Africa: Celtel Launches 'One Network' in East Africa." http://www.ihsglobalinsight.com.

———. 2007. "The Shifting Geography of Broadband in Sub-Saharan Africa." http://www.ihsglobalinsight.com.

Government of Bahrain. 2008. "Guidelines for Telecommunications Infrastructure Deployment." http://www.tra.org.bh/en/pdf/ReportonConsultation-GuidelinesforTelecomInfraDeployment-FINAL.pdf.

Government of Rwanda. 2006. "An Integrated ICT-Led Socio-Economic Development Plan for Rwanda 2006–2010: The NICI-2010 Plan." http://www.rita.gov.rw/IMG/pdf/NICIfinal.pdf.

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

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

ICEA. 2008. "Strategies for the Promotion of Backbone Communications Networks in Sub-Saharan Africa." Study commissioned by the World Bank, Washington, DC.

Intelecon Research and Consultancy Ltd. 2008. "Intelecon Regulatory News." http://www.inteleconresearch.com/regnews/recent.html (accessed June 23, 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 10, World Bank, Washington, DC.

ITU (International Telecommunication Union). 2007a. "Telecommunications/ICT Markets and Trends in Africa, 2007." ITU, Geneva. http://www.itu.int/ITU-D/ict/statistics/material/af_report07.pdf.

———. 2007b. *World Information Society Report 2007: Beyond WSIS*. Geneva: ITU. http://www.itu.int/osg/spu/publications/worldinformationsociety/2007/report.html.

———. 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* 122 (3): 879–924.

Lee, Karen, and Jamison Prime. 2009. "US Telecommunications Law." In *Telecommunications Law and Regulation*, ed. Ian Walden. Oxford: Oxford University Press.

Milad, Hanna, and Balaji Ramarao. 2006. "Cost Optimization for Transmission and Backhaul Technologies." Accenture. http://www.accenture.com/NR/rdonlyres/0000aae5/nwhotfppdswdgywuynxzagosezkmkgtr/acs_cost_opt_pov.pdf.

Ministerio de Ciencia y Tecnología (Spain). 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 (Organisation for Economic Co-operation and Development). 2006. "Internet Traffic Exchange: Market Developments and Measurement of Growth." OECD, Paris.

———. 2008. "Public Rights of Way for Fibre Deployment to the Home." OECD, Paris. http://www.oecd.org/dataoecd/49/9/40390753.pdf.

Ofcom (Office of Communications, United Kingdom). 2004. "Review of the Retail Leased Lines, Symmetric Broadband Origination and Wholesale Trunk Segments Markets." http://www.ofcom.org.uk/consult/condocs/llmr/statement/.

Ovum. 2005. "Recommendations on Further Liberalization of the Telecommunications Industry of Botswana: A Final Report to the Botswana Telecommunications Authority." Ovum, London.

PricewaterhouseCoopers. 2006. *Global Entertainment and Media Outlook: 2006–2010.* New York: PricewaterhouseCoopers.

Qiang, Christine Zhen-Wei, and Carlo M. Rossotto, with Kaoru Kimura. 2009. "Economic Impacts of Broadband." In *Information and Communications for Development 2009: Extending Reach and Increasing Impact*, 35–50. Washington, DC: World Bank.

Roller, Lars-Hendrik, and Leonard Waverman. 2001. "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach." *The American Economic Review* 91 (4): 909–23.

TeleGeography. 2008. "Global Internet Geography." Washington, DC.

TRAI (Telecom Regulatory Authority of India). 2006. "Study Paper on Analysis of Internet and Broadband Tariffs in India." TRAI, New Delhi.

Wellenius, Björn, Vivien Foster, and Christina Malmberg-Calvo. 2004. "Private Provision of Rural Infrastructure Services: Competing for Subsidies." World Bank Policy Research Working Paper 3365, World Bank, Washington, DC.

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

———. 2008. "Africa Infrastructure Country Diagnostic for Sub-Saharan Africa." World Bank, Washington, DC.

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Since 2000, Sub-Saharan Africa's embrace of cellular technology has brought telephone services within the reach of a majority of the population. Private investment and competition have expanded telecommunications service into rural areas and made it more affordable. Not so for the Internet. Consumers understand the benefits of accessibility to nearly unlimited sources of global information and are demanding better network coverage, affordable prices, and larger bandwidth. Governments are also realizing that broadband can have a positive impact on economic growth and assist in the delivery of public services. Increasing access to broadband is therefore becoming a high priority for policy makers across the region.

Broadband for Africa focuses on one part of the broadband policy jigsaw puzzle—backbone networks. These are the high-capacity communications networks that form the heart of the Internet. This book 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 Africa and the reasons for this? What can be done to promote the development of backbone networks?

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