CHAPTER 4

Sectoral policies

Making the internet universal, affordable, open, and safe

Access to mobile phones is close to universal, and prices are falling in most countries, thanks to policies based on market competition, private participation, and light-touch regulation. But today's digital economy also requires universal access to the internet—at broadband speeds. First-generation policies for the information and communication technology (ICT) sector, aimed at universal access and affordability, have proved successful for phone service, and supply-side policies should also work well for the internet. But with more than half the world still offline, the benefits of the internet are unevenly distributed. Next-generation policies must also focus on demand-side issues of digital literacy, as well as privacy, cybersecurity, and internet governance, where a global consensus has yet to emerge.

In the last decade, all countries have benefited from the rapid spread of mobile communication networks. But only 15 percent of the world's citizens have access to affordable high-speed internet,[1] and the prices for service vary enormously. This reflects policy failures in some countries, such as regulatory capture, troubled privatizations, inefficient spectrum management, excessive taxation of the sector, or monopoly control of international gateways. To achieve better development outcomes, governments need to address these failures through open consultative policy-making processes involving the industry and users.

Developing countries are following a different route from developed ones. Most member-countries of the Organisation for Economic Co-operation and Development (OECD) benefited from initial state-led investment in their fixed telephone infrastructure, followed by private participation, and added mobile and internet networks later. But developing countries are jumping straight to mobile networks, built by the private sector. This may leave gaps in the backbone infrastructure, especially in rural areas, possibly requiring investment through public-private partnerships (PPPs) for the full benefits of high-speed networks to be enjoyed by all.

While availability, accessibility, and affordability remain concerns, the challenges facing internet stakeholders today are as much about how networks are used (demand) as how they are built (supply). Global interconnectedness introduces new vulnerabilities in areas where coordination mechanisms are weak, still evolving, or based on nongovernment models. Threats to cybersecurity are undermining confidence in the internet and increasing the costs to businesses and governments, resulting in economic losses as well as higher security spending. For privacy and data protection, different countries are taking quite different approaches, making it harder to develop global services. Ensuring safe and secure access will require greater international collaboration based on a multistakeholder model.

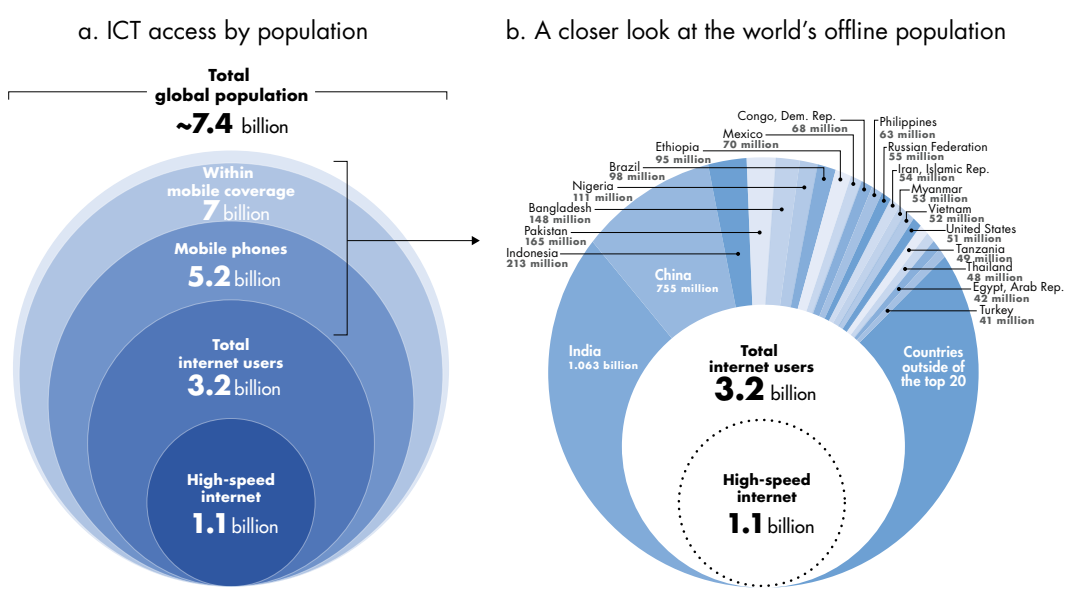
Converting connectivity into digital dividends will work best where an open access internet ecosystem allows content creation and applications development to thrive. ICT clusters tend to form naturally, and governments do not need to intervene to create them. But they can help clusters along and avoid stifling growth unintentionally through high tariffs or restrictions on openness. Most countries have found it useful to develop national ICT sector strategies for broadband, for e-government, and for local content. The process of developing these strategies, through multistakeholder consultations, can be just as useful as the strategies themselves—and ensures that targets are realistic and actionable. Policy challenges are summarized in box 4.1.

Box 4.1 Policy challenges for digital development

Offline, and missing out

Only around 15 percent of the world's population currently has affordable high-speed access to the internet (figure B4.1.1). Use of mobile phones, reaching almost three-quarters of the world's population, provides the main form of internet access in developing countries. But the lives of 2 billion people remain largely untouched by information and communication technologies (ICTs), and half a billion live outside areas with a mobile signal. The world's offline population is mainly in India and China, but more than 100 million people are also offline in North America, mainly in Mexico.

Figure B4.1.1 Global ICT access



Sources: World Bank 2015; Meeker 2015; ITU 2015; http://GSMAintelligence.com; UN Population Division 2014. Data at http://bit.do/WDR2016-FigB4_1_1.

Note: High-speed internet (broadband) includes the total number of fixed-line broadband subscriptions (such as DSL, cable modems, fiber optics), and the total number of 4G/LTE mobile subscriptions, minus a correcting factor to allow for those who have both types of access. 4G = fourth-generation; DSL = digital subscriber line; ICT = information and communication technology; LTE = Long Term Evolution.

Connected, but in the slow lane

Developed and developing countries are following different routes to the information society (figure B4.1.2). In the OECD (Organisation for Economic Co-operation and Development) countries, fixed-line networks came first, and now form the backbone for internet access. But most developing countries jumped straight to mobile networks without investing first in connectivity. The consequence for many users in developing countries is a second-class internet: slow, expensive, and rarely "always on."

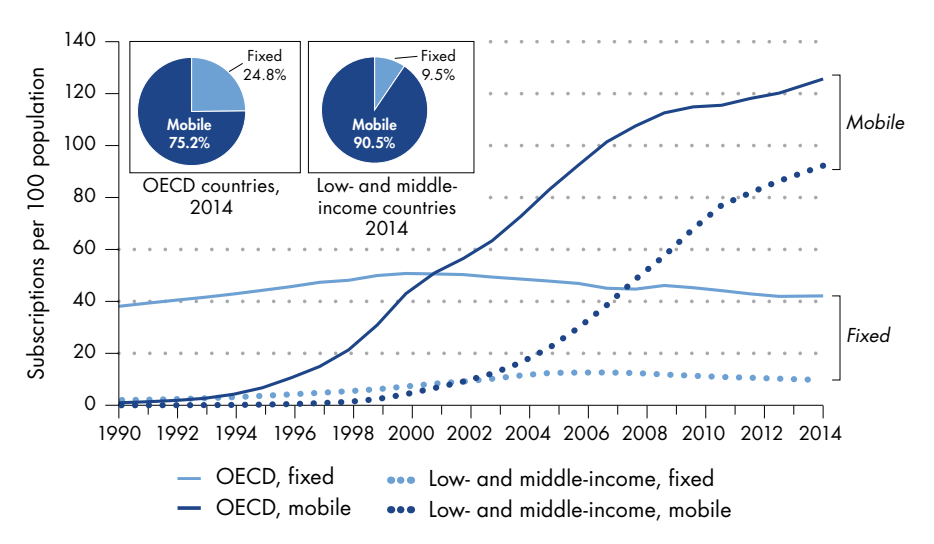
Megabucks for megabytes

ICT prices are falling globally, but large differences remain (map B4.1.1). Although Europe has some of the highest prices in the world for mobile calls and texts, prices are generally cheaper for data. North, South, and Central America have high prices for mobile data, in part due to bundling, but cheaper prices for fixed data. Northern Asia is generally cheaper than southern Asia. In Africa, prices are generally cheaper for mobile than for fixed-line data. Price differences reflect policy failures as much as market failures. Governments need to go further in liberalizing market entry, making available more spectrum, and encouraging investment to achieve more affordable prices.

(Box continues next page)

Box 4.1 Policy challenges for digital development *(continued)*

Figure B4.1.2 Network buildout (subscriptions per 100 population) in OECD and low- and middle-income countries, 1990–2014



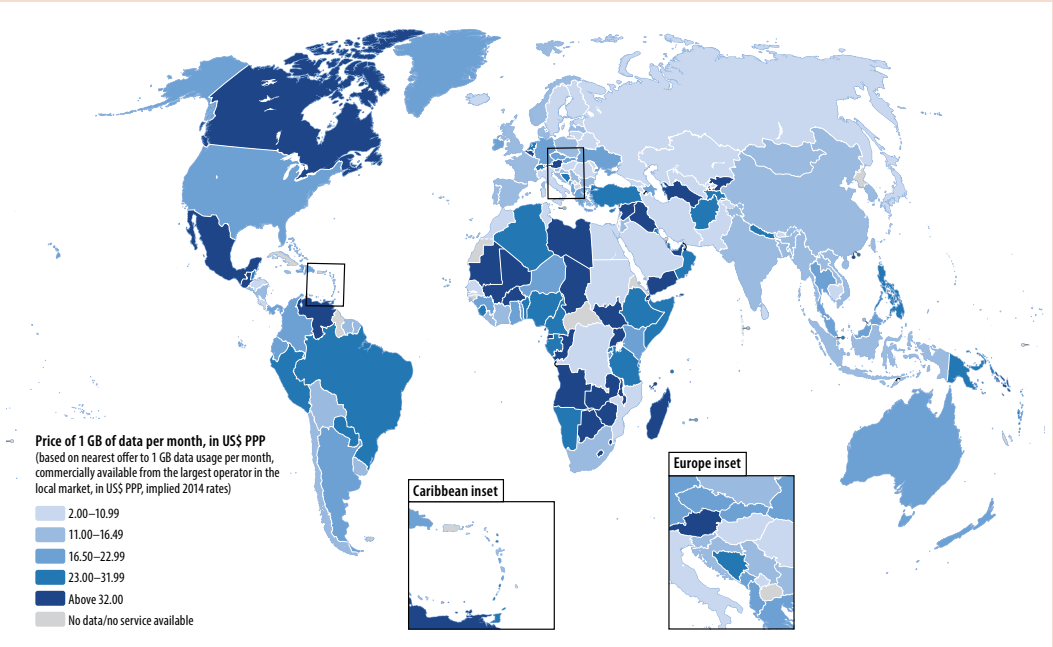
Source: Adapted from ITU World Telecommunication/ICT Indicators database. Data at http://bit.do/WDR2016-FigB4_1_2.

Note: OECD = Organisation for Economic Co-operation and Development.

Map B4.1.1 Price of mobile and fixed broadband services

US$, purchasing power parity, 2015

a. Mobile broadband services, price per gigabyte a month



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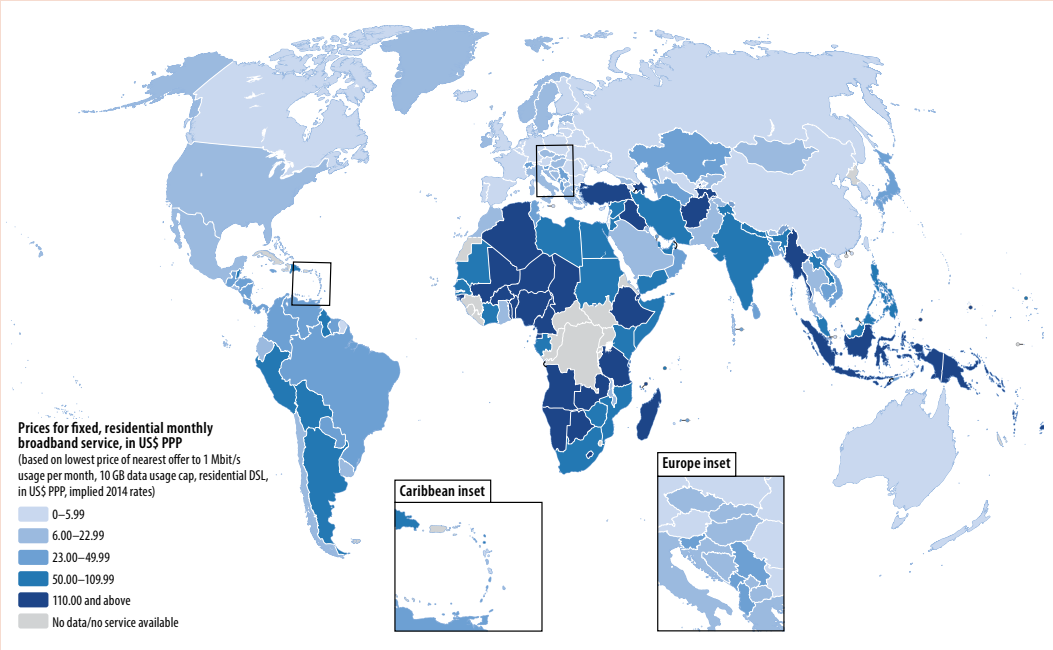
Box 4.1 Policy challenges for digital development *(continued)*

Map B4.1.1 Price of mobile and fixed broadband services *(continued)*

US$, purchasing power parity, 2015

b. Fixed broadband services, residential, price per 1 Mbit/s



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Sources: WDR 2016 team, with additional data from Oxford Internet Institute, Google, http://blogs.oii.ox.ac.uk/roughconsensus/2014/02/could-you-afford-facebook-messenger-in-cameroon-a-global-map-of-mobile-broadband-prices/ and Plot and Scatter. Data and an interactive map of mobile broadband prices, as well as affordability measures, at http://bit.do/WDR2016-MapB4_1_1a and fixed broadband prices at http://bit.do/WDR2016-MapB4_1_1b.

Note: DSL = digital subscriber line; GB = gigabyte; Mbit/s = megabits per second; PPP = purchasing power parity.

Shaping the digital economy

Government policies and regulation of the internet help shape the digital economy. Particularly through their policies for the ICT sector, governments and regulatory agencies create an enabling environment for the private sector to build networks, develop services, and provide content and applications for users. Increasingly, governments seek to cooperate across borders on issues such as cybersecurity, privacy, and cross-border data flows.

Internet-enabling policies have evolved over time, especially those for the ICT sector (chapter 5 looks at complementary policies such as those for skills, regulations, and institutions). In the past, the government's main role was in building the fixed-line telecommunication network and acting as both owner and operator. That role is now pared back to policy maker and regulator, establishing an enabling environment for the private sector to do most of the work. For mobile networks and the internet, governments have been less directly involved, but many of them are seeking a more active role in shaping the digital economy. Broadband internet, in particular, is seen as a general-purpose technology,[2] essential for the competitiveness of nations,[3] and governments have invested more than US$50 billion in broadband networks since 2009 as part of stimulus packages.[4] Most also have national broadband plans.[5]

The internet has transformed telecommunication networks. In the same way that containerization revolutionized physical trade,[6] so the "packetization" of data has commoditized digital trade.[7] Networks have shifted from primarily carrying voice telephony to

Box 4.2 Is the internet a public good?

In considering what policies to apply to the internet, a key question is whether it is a public good. If it is, government intervention would be easier to justify. The internet does not have all the characteristics that economists conventionally associate with a public good—such as being nonexcludable (people can be prevented from using it) or nonrivalrous (a user who hogs bandwidth may impair the quality of service for other users). Even so, the internet provides public access to a vast library of useful information, it uses shared resources such as the spectrum, and it relies on network security; all of which may be considered public goods. Moreover, government intervention in promoting the internet may be justified because it has the characteristics of a general-purpose technology, like electricity.

A more accurate way of expressing the characteristics of the internet is that it is a private good with positive externalities (a club good). While the private sector can and should take the lead in providing internet networks and services, achieving universal and accessible internet is a legitimate public policy goal. The bulk of the investment required to achieve such a goal can come from the private sector, though many countries have invested public money to improve internet access by poor households and those living in remote areas. In a recent global survey, some 83 percent of users said they believe that affordable internet access should be a basic human right.[a] Several governments have followed Finland's lead in defining access to the internet at broadband speeds as a legal right and a goal of universal access policy.[b] High-speed, affordable broadband has been described as a foundation stone of modern society.[c] But it is something that more than five-sixths of the global population still lacks.[d]

a. The Global Survey on Internet Security and Trust (2014), conducted by the Centre for International Governance Innovation and Ipsos, a market research company, polled over 23,000 internet users in 24 countries; see https://www.cigionline.org/internet-survey.
b. World Bank/ITU, ICT Regulation Toolkit at http://www.ictregulationtoolkit.org/en/toolkit/notes/PracticeNote/3270.
c. UN Broadband Commission 2014, 8.
d. ITU 2014.

now providing a wide array of multimedia applications, with internet protocol (IP) as the shared language.[8] Fixed-line networks continue to be important in the developed countries, but in the developing world, especially in Africa, mobile networks are now the main means of delivering services. As the uptake of ICTs grows around the world, the policy focus is shifting from solving supply-side challenges (basic access and affordability) to addressing demand-side dilemmas (how to ensure that networks are open and safe).[9] Policy decisions intended to facilitate the take-up and safe use of ICT products and services will shape the digital economy and wider developmental outcomes.

In broad terms, services in sectors regulated by governments account for just under half of the US$4.2 trillion in revenues generated by the global ICT sector (telecom services, TV services, and internet), with the rest (hardware, software, and computer services) largely unregulated. Services delivered directly over the internet account only for just over 7.5 percent, but they are the fastest growing segment, having more than doubled since 2010 to reach an estimated US$309 billion in 2014.[10] Separate regulations have been traditionally applied to telecom and TV services, with the former focused on carriage (transmission) and the latter on content. Internet regulation has some characteristics of both, but with generally a much lighter touch than either telecom or TV regulation. Indeed, some would argue that internet regulation by government is neither helpful nor necessary, particularly if older models of regulation are applied.[11] But the trend is toward greater government control, not less—even in the United States, where the regulatory body recently proposed to regulate the internet as a common carrier telecommunication service—to preserve the concept of net neutrality, or treating all "bits" of information alike, irrespective of their content or value.[12] As this chapter shows, all governments have been obliged to consider which policies are most appropriate for the internet, and their answers vary widely (box 4.2).

Supply-side policies: Availability, accessibility, and affordability

The supply side of the internet is conditioned by rules on market competition, shaped by the respective roles of the public and private sector, and mediated by the degree to which regulation of the sector

is independent of government and the operators. A useful framework for analyzing supply-side policies is to consider the value chain that stretches from the point where the internet enters a country (the first mile), and passes through that country (middle mile), to reach the end user (last mile). As a general rule, the market works best closest to the end user (last mile). Public-private partnership is more likely to be needed in the first and middle miles, or where customers live in areas that are difficult to serve. In addition to the visible elements of the network, certain hidden elements are vital to ensuring the integrity of the value chain—call them the "invisible mile" (table 4.1). (This framework is used a bit later in this chapter.) The goals of supply-side policies differ between countries, but the general objective is to ensure that the internet is universally available, accessible, and affordable.

Market competition

Today's internet runs on yesterday's legacy networks. In the OECD countries, and some others, the same copper networks built in the 1960s and 1970s to carry voice telephone calls and cable TV (the last mile) have now been upgraded and repurposed to stream movies and social media, carried over IP-based networks. Farther away from the user (the middle mile), the networks are more likely to be newer, and based on fiber, but the wired access networks that connect users were largely built in an era of government-run monopolies. All but a handful of countries had state-owned public telephone and telegraph companies (known as PTTs) when they were building out their networks.[13]

Outside the United States, which followed a different path of private investment, market competition in telecommunications began in the 1980s, with new market entrants arriving in the United Kingdom (1981),[14] the Republic of Korea (1982),[15] and Japan (1985).[16] In the European Union (EU), a coordinated process was set in motion by a Green Paper on telecommunications liberalization in 1987 and a Full Competition Directive in 1996, setting a timetable for full liberalization of the telecommunications sector by January 1, 1998.[17] The EU is now committed to achieving a single digital market by 2020.[18] Globally, some 69 countries[19] made commitments to liberalize telecommunication markets and allow foreign investment in their telecommunication sectors as part of the World Trade Organization (WTO) Basic Telecommunications Agreement in February 1997, when these countries accounted for some 93 percent of global telecommunications revenue.[20]

From these different market opening moves, a policy consensus emerged around three basic ingredients—market competition, private participation, and independent regulation of the ICT sector.[21] In developing countries, the main push toward market growth came in the 1990s with the arrival of digital (second-generation, or 2G) mobile communication services, which allowed for competition, often for the first time. Worldwide, only a handful of countries, including Djibouti, Eritrea, and Ethiopia in the Horn of Africa region, still maintain state-run monopolies in the provision of mobile services and the internet, and they have generally not fared as well as their neighbors. Mobile penetration is only half the level in the countries that have retained monopolies than in Kenya, which has had mobile competition since 2000, or in Sudan, since 2005. The cover photo of this report shows migrants in Djibouti straining to receive cellphone signals from Somalia, where competition in the telecom sector is fierce and prices are much lower (box 4.3).[22] A study of Sub-Saharan Africa showed that telecom revenue averaged 5.6 percent of GDP in liberalized economies, but only 3.5 percent in nonliberalized ones, and was growing twice as fast in liberalized economies.[23]

The recipe of competition, private participation, and independent regulation worked so well for mobile telephony that, as of June 2015, there were more than 7.5 billion subscriptions worldwide—more than the human population.[24] The same recipe should also largely work well for internet services, to extend access to the 4 billion or so people now without affordable service. But there is a wrinkle. For network operators, extending internet access may cannibalize revenues from existing voice and text services, at least in the short term. This is one outcome of market entry by third-party content and service providers that ride "over-the-top" (OTT) of the operator's IP-based networks:

- For telephony, voice over internet protocol services, such as Skype and Viber, substitute paid voice calls with calls made "free of charge" over the internet.[25]
- For text (short message service, or SMS), which had been highly profitable for mobile operators,[26] instant messaging OTT services such as WhatsApp and WeChat provide a more attractive substitute for a fraction of the price.
- For video (such as cable or satellite TV), streaming services like Netflix and YouTube—which together account for almost half the traffic delivered to users in the United States[27]—offer low-priced content and give more freedom to consumers to watch content when and where they like, on multiple devices.

Table 4.1 A policy framework for the supply of internet service

	The first mile (the point at which the internet enters a country)	The middle mile (the national, intercity internet backbone of a country)	The last mile (the connection between users and their nearest internet point of presence)	The invisible mile (other, less visible network components and potential bottlenecks)
Network components	International internet access, including submarine cable landing stations, satellite dishes, domain name registration	National backbone and intercity network, including fiber backbone, microwave, IXPs, local hosting of content	Local access network, including local loop, central office exchanges, wireless masts	Nonvisible network components, including spectrum, border crossings, databases, SIM cards, cybersecurity
Market competition	• Authorization of satellite dishes • Designation of domain name registry and registrars • Licensing of competing international service providers and orbital slots • Authorizations for landing stations, and access (co-location) to international gateway facilities	• Licensing/authorization of nationwide facilities-based operators and service providers • Interconnection arrangements • Infrastructure sharing arrangements • Cross-sectoral participation (such as cable TV and alternative infrastructures) • Licensing mobile virtual network operators	• Licensing/authorization of local facilities-based operators and service providers • Authorization of mobile virtual network operators • Authorization of value-added network service providers, including for mobile money • Unbundling the local loop	• Market mechanisms (such as auctions and resale) for spectrum assignments, especially for 3G and 4G bands • Arrangements for access to essential network facilities, including national numbers, address database
Public-private partnership	• Privatization/ liberalization of international gateway • Development of government data centers • Participation in international cable and satellite consortia • Regulation of legal intercept	• Privatization of the incumbent operator • Industry consultation on a network master plan • Establishment of national and local IXPs • Local hosting of content, including government data center	• Dominantly private operation and ownership, with PPP approach where market fails (as in rural areas) • Stakeholder consultation on a national broadband plan • Universal service obligations (as for emergency services and accessibility for disabled)	• Negotiation of transit and access to virtual landing stations (for landlocked countries) • CSIRTs at national and institutional levels • Open access to short code numbers, as for SMS
Effective regulation	• Open access to international facilities • Open to foreign ownership and investment • Avoiding excessive import and excise taxes • National representation at relevant national and regional bodies, such as ITU, ICANN, and WTO	• Coordinating rights-of-way for linear infrastructures • Safeguards on significant market power • Open access rules for national backbone • Promotion of local content and hosting	• Open access rules for local loop and central office exchanges • Coordination of planning permission for public works among operators and utilities, and authorizations for construction of wireless masts • e-waste recycling guidelines	• Spectrum management, including arrangements for allocation of bands and refarming • SIM card registration arrangements • Data protection and privacy guidelines

Source: WDR 2016 team.

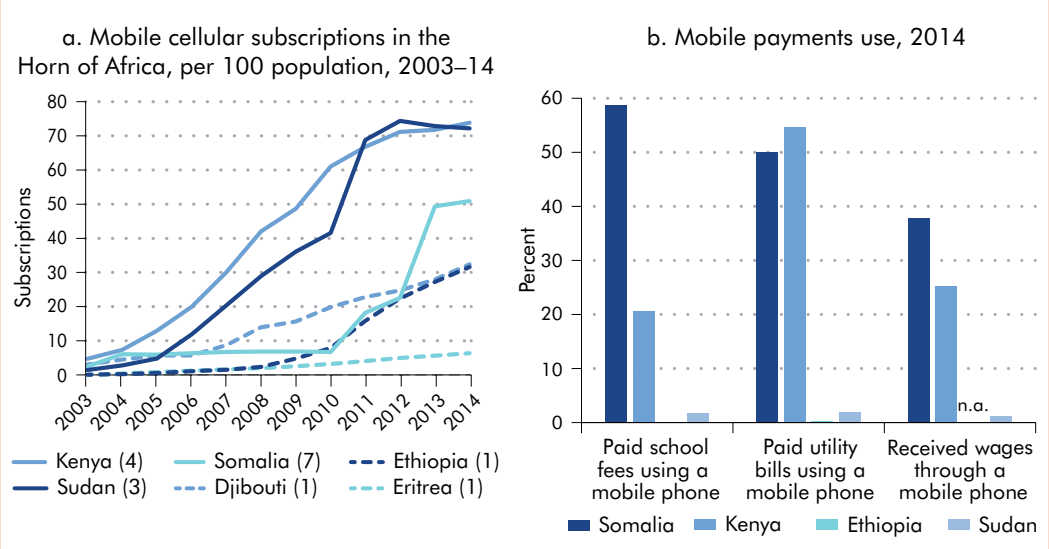
Note: Policy examples are indicative, not exhaustive. Policy actions shaded in *red* are particularly suitable for emerging economies, in *green* for transitioning economies, and in *blue* for transforming economies, but all are good options to pursue at any stage (see chapter 5 for classification of economies). 3G = third-generation; 4G = fourth-generation; CSIRTs = Computer Security Incident Response Teams; ICANN = Internet Corporation for Assigned Names and Numbers; IP = internet protocol; ITU = International Telecommunication Union; IXP = internet exchange point; PPP = public-private partnership; SIM = subscriber identification module; SMS = short message service; WTO = World Trade Organization.

Box 4.3 Fragile states, resilient digital economies

Somalia is emerging from 20 years of civil war, during which time its fixed telecom infrastructure was destroyed. Yet information and communication technologies (ICTs) are one of the bright spots in its economy. With seven mobile operators and multiple internet service providers (ISPs), Somalia has a higher rate of penetration than its monopolistic neighbors, despite the fact that it has the lowest gross domestic product per capita in the East Africa region (figure B4.3.1, panel a).

Telecommunications can play an important role in post-conflict reconstruction.[a] Not only does the sector generate jobs, entrepreneurship opportunities, and foreign currency from incoming phone calls, but using mobile phones to make payments or trade airtime also provides an attractive alternative to the local currency. In Somalia, few citizens have faith in the Somali shilling, and prefer U.S. dollars, but dollars are frequently in short supply. The World Bank's 2014 Findex survey showed that some 38 percent of wage-earning Somalis were paid via a mobile phone, compared with just 25 percent of Kenyans (figure B4.3.1, panel b), despite the popularity of M-Pesa, Safaricom's mobile money service, there.[b] Some 55 percent of Somalis used mobile phones to receive remittances; this has become indispensable recently as other financial channels, such as *Hawalas*, have been blacklisted as part of a crackdown on their suspected links with terror. Furthermore, telecom operators contribute to the national treasury, unlike the banking sector, which contributed nothing in 2014. Somalia has benefited since early 2014 from a fast connection to the global internet, following the completion of the EASSy undersea cable to Mogadishu, in which the International Finance Corporation is a stakeholder. The Shabaab terrorist organization has succeeded in blocking the use of mobile broadband in much of the country, because of traceability, but it still uses social media for recruitment and spreading its message.

Figure B4.3.1 Somalia's rising mobile economy



Sources: Adapted from ITU World Telecommunication/ICT Indicators and World Bank World Development Indicators, and World Bank Findex survey. Data at http://bit.do/WDR2016-FigB4_3_1.

Note: Figures in parentheses in panel a indicate the number of facilities-based mobile operators. n.a. = not available.

a. Kelly and Souter 2014.
b. http://go.worldbank.org/1F2V9ZK8C0.

Although network operators may be losing revenue from traditional voice, text, and video services, they benefit from the demand for data traffic generated by OTT services. But they face a heightened investment challenge to keep up with the service-quality demands of users, especially on mobile networks, where spectrum may be scarce. Cisco estimates that mobile data traffic grew 69 percent in 2014 and will continue to grow at 61 percent a year between 2014 and 2019.[28] Mobile operators in Africa, for instance,

are having to spend on average one-quarter of their annual revenue on capital expenditure as they build out their networks, while in North America, where network buildout took place much earlier, the capital expenditure burden is just 15 percent of revenue.[29] But network operators in developing countries may find it a challenge to persuade users with low incomes to pay for higher data use, which has a lower perceived value than voice calls. Their users may employ OTT services primarily for reducing, rather than increasing, their monthly phone credit use. According to reports from the Global System for Mobile communications Association (GSMA), while average revenue per user in North America has remained steady at above US$65 per month since 2010, it has fallen in Africa from US$14 to below US$10.[30] So, African network operators are caught in a triple bind of rising user expectations (due to higher data usage) requiring higher capital expenditures, but declining user spending (due to OTT services).

For developing countries, the threat of diluting traditional revenue streams is particularly worrying because they are following a trajectory in their network buildout different from the one most developed countries follow. Figure B4.1.2 shows network buildout in developed (OECD) and developing countries (low- and middle-income). Both sets of countries show a similar pattern of mobile networks growing to overtake fixed-line networks in subscriber numbers, since 2001 and 2003, respectively, and fixed-line subscriptions declining thereafter. But the big difference is that OECD countries had already achieved universal fixed-line access (roughly, more than 90 percent household penetration) before 2001.

In developing countries, the decline in fixed-line access occurred before it had reached even one-quarter of the universal service level, and is now well below that. This is significant because wireless networks (using spectrum) are not fully substitutable for fixed networks (using copper or fiber), either in usage (which rarely offers flat-rate pricing, without data limits) or in performance (where speeds are generally lower). So, despite procompetitive policies that have encouraged infrastructure competition and allowed for the development of OTT services, many developing countries are stuck with a second-class internet that may fail to deliver the expected benefits, especially for business users.

Indeed, most developing countries are unlikely ever to attract, or generate, sufficient investment to extend a nationwide backbone (the middle mile) or create fixed-line networks in rural areas without some kind of public-private partnership. Some developing countries, such as the Democratic Republic of Congo or South Sudan, may never get a fixed-line access network, even in urban areas. An optimistic assessment is that developing countries are leapfrogging a whole stage of network development, but more realistically they may be missing an essential stage. Available evidence suggests that access to the internet from big-screen devices (PCs), with always-on flat-rate access, provides a bigger boost to economic activities than access from small-screen devices (mobile phones), which generally have use-based pricing.[31] As long as mobile operators dominate the provision of voice and internet services in developing countries, companies whose business models are based on long-term investment in fixed assets, without revenues from mobile services, will find it difficult to survive. That is why some degree of government intervention, through public-private investment, may be necessary in smaller developing countries to build up resilient international connectivity, and an open access backbone network, in order to retrofit the missing stages of network development.

Public-private partnership

After market competition, the next essential ingredient in the ICT policy recipe is private investment. Private companies have driven network investment throughout the world, especially in mobile networks. The biggest network operator of them all, China Mobile, which had over 800 million subscriptions at the end of 2014, is still majority state-owned.[32] But it is the partial exception, and its public shareholding is listed on the stock exchanges of Hong Kong SAR, China and New York. Network operators dominate the ICT sector in revenues and customer connections. But stock markets appear to prize internet companies that sell content and OTT services more highly than telecom operators that build networks. Alibaba, a Chinese e-commerce company that went public in September 2014, is valued at more than US$200 billion—a level similar to China Mobile, although it has only one-tenth the network operator's revenue.[33] Low market valuations for network operators, and the cannibalization of their voice and text revenues, make it harder for them to invest in network capacity, particularly in fiber backbone networks or fourth-generation (4G) mobile networks. Private investment in telecommunication networks in 2013 had fallen by almost one-third since its peak in 2008, suggesting that operators are finding it harder to justify capital expenditure at a time when future revenues are uncertain.[34]

One response is to revive public investment in the internet backbone. In the United States, the internet

benefited from public funding from the 1960s until 1993, when the government began "privatizing" the internet by transitioning the role of the National Science Foundation to the private sector, including responsibility for registering domain names and managing network access points.[35] This process is due to be completed in September 2016, when the Department of Commerce is expected to transfer its oversight role for the Internet Corporation for Assigned Names and Numbers (ICANN) to the global multistakeholder community.[36] In other countries, too, the government took an early role in building out the national backbone infrastructure for the internet, as in the Republic of Korea (box 4.4). This role continues, for instance, in National Research and Education Networks (NRENs), where many governments subsidize the higher edu-

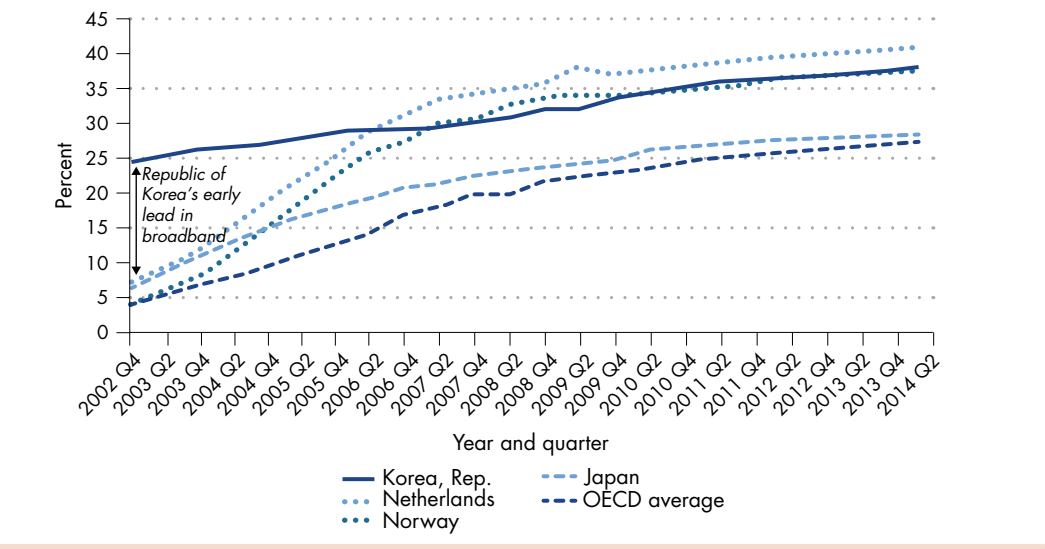
Box 4.4 How public-private partnership helped build the internet backbone in the Republic of Korea

Until other developed countries caught up around mid-2006, the Republic of Korea's fixed broadband penetration was well ahead of its competitors (figure B4.4.1 and table B4.4.1). In fiber-based ultrafast broadband, it is still ahead of the game. It has the highest percentage of fiber among fixed broadband connections (66 percent) of any country except Japan. Korea also leads in the "internet of things" and sensor technology (see spotlight 6).

One secret to Korea's success was a public-private partnership (PPP) that combined government funding and policy direction with private infrastructure investment and management. The Korea Information Infrastructure program, which ran from 1995 to 2005, and the Broadband Convergence Network that followed it from 2005 to 2014 saw government investment of just under US$1 billion in each phase. Private investment dominated in the initial phase, as the backbone network was established and larger cities were served. During this phase, government money was used mainly to purchase bandwidth for government's own needs. Since 2005, government spending has been proportionately greater, as network investment reached out to rural areas, where there was less incentive for the private sector to take the lead. The government of Korea has followed up with a program to upgrade network performance, through the Ultra Broadband Convergence Network, with around one-third of total investment coming from the government.

Figure B4.4.1 Broadband in the Republic of Korea and other selected economies

Broadband per 100 inhabitants, 2002 Q4 through 2014 Q2



Source: OECD Broadband Portal, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm. Data at http://bit.do/WDR2016-FigB4_4_1.

Note: The gap between the Republic of Korea and the two nearest countries of the Netherlands and Japan in 2002–04 indicates Korea's early lead in broadband. OECD = Organisation for Economic Co-operation and Development.

(Box continues next page)

Box 4.4 How public-private partnership helped build the internet backbone in the Republic of Korea *(continued)*

Table B4.4.1 Broadband investment program, Republic of Korea

US$ million and percent of total

Investment	Information infrastructure, 1995–2005	Broadband convergence network, 2005–14	Total, 1995–2014
Government	806 (2.4%)	981 (38.0%)	1,787 (5.1%)
Private	31,721 (97.5%)	1,599 (62.0%)	33,320 (94.9%)
Total (US$ million)	32,527	2,580	35,107

Sources: Kim, Kelly, and Raja 2010; World Bank and Korean Development Institute 2015.

cation community, such as Internet2 in the United States, SURFNet in the Netherlands, and KENET in Kenya.[37] Governments can also aggregate demand to negotiate lower bandwidth rates for universities and government departments, for example.

Effective regulation

After market competition and private participation, the third key policy ingredient is independent regulation: establishing ICT regulatory agencies that are independent of leading operators and of government departments. The International Telecommunication Union (ITU) records that some 159 of its 194 member-states (82 percent) had separate ICT regulatory agencies by the end of 2013, a doubling since 1998.[38] Effective regulation creates a level playing field for operators and helps promote market entry. Governance structures and mandates for regulators differ, but most have responsibility for spectrum management and for issuing and overseeing licenses for network operators. Most regulators are run on a cost-recovery basis, and some generate a significant surplus from license fees and spectrum auctions.[39]

Telecom sector regulation should work primarily in favor of the consumer—addressing market failure, fostering effective competition, protecting consumer interests, and increasing access to technology and services.[40] In particular, the regulator should seek to ensure that the benefits from technological change, greater efficiency and reduced costs, are passed on to consumers rather than appropriated in higher profits for private firms or extortionate taxes to governments. But even in the best of circumstances, regulatory agencies may lack sufficient high-caliber staff, or they may be captured by commercial or governmental interests. In the many countries where governments still hold a stake in the incumbent operator, true regulatory independence is rare. The worst case is where commercial and governmental interests coincide, in what is sometimes called "crony capitalism." In Tunisia during the Ben Ali regime, three telecom companies with ownership related directly to the Ben Ali family generated revenues of US$86.8 million, or 8.8 percent of total turnover from the sector in 2010, but they accounted for some 42.7 percent of total gross profit generated by the sector.[41] High demand for scarce spectrum also creates incentives for corruption. In India, the sale of 2G cellular licenses in 2007–08 was rigged to create an artificial scarcity that favored some companies over others, ending up in a scandal and a jailed minister.[42] Regulators bear a responsibility to protect consumers against such vested interests. They must also work closely with competition authorities to ensure that consolidation in the number of operators does not reduce true competition in the sector.

Where markets fail

By almost every measure, the policy recipe for promoting the supply side of the ICT industry, based on market competition, private investment, and independent regulation, has been tremendously effective in extending coverage, at least for mobile communications. The estimated 7.5 billion mobile

subscriptions in use worldwide generate revenues of US$1.13 trillion a year, as of May 2015.[43] And some 95 percent of the world's inhabitants live within range of a mobile signal,[44] with two-thirds of them served by a 3G signal with theoretical access to the internet if they have a suitably equipped device.[45] Even in Africa, the region where mobile coverage is lowest, at just 88 percent in 2012, more-efficient markets could close all but 4.4 percent of the remaining gap, without needing a cross-subsidy.[46]

But that is not the whole story. Markets fail where the private sector underinvests—for instance, because the private return may be less than the social return. This appears to be happening in the ICT sector in at least three areas.

- *Remote areas.* Although only less than 5 percent of the global population remains unserved with cellular mobile coverage, that still represents almost half a billion people worldwide. Even where it is technically viable to serve these people, there may be little commercial incentive to do so. The costs of reaching them are high in relation to the commercial return, as they live mainly in rural locations with low population density, or in geographically remote areas (box 4.5). But the social costs of remaining unserved are high and growing, so universal service policies may be required.
- *Unattractive markets.* Competitive market entry may not take place even in markets that are nominally open to competition, especially in fragile or conflict-afflicted states, or in small island developing states.[47] A lack of scale and the failure to use competitive tendering for infrastructure investment, for instance, may also result in prices that are unaffordable for users.
- *Uneconomic services.* More worrying, even if basic services can be delivered, delivering more advanced networks suitable for carrying data services, such as high-speed internet, may not be economic. On mobile broadband networks, this requires third- (3G) or preferably fourth-generation (Long Term Evolution, LTE) networks, which need higher levels of investment and generally a denser network of base stations and masts.[48] Some developing countries have yet to launch mobile broadband. Even where services are launched, coverage can be low, reaching just 1 percent of the rural population in Zambia or 11 percent in Namibia, for example.[49]

To extend affordable access, governments have tried price controls, regulated prices, public facilities (such as telecenters), and mandated public pay phones. Public telecom operators use geographical averaging of tariffs to offer the same price to users in both urban and rural areas. Historically, they have also used profits from lucrative international and long-distance services to cross-subsidize loss-making local services. But with privatization and the shift to more competitive markets and IP-based networks, this became unsustainable.[50]

An alternative, followed by more than 70 countries, is a Universal Service Fund (USF) to channel payments by operators to fund infrastructure in rural areas or to provide access to libraries, schools, and hospitals. Some USFs have performed well, notably those that use competitive mechanisms to distribute funds, such as least-cost subsidies in Pakistan or reverse auctions in rural Chile.[51] But USFs generate funds that often remain unspent or go for unintended purposes. Unspent USFs amounted to more than US$11 billion in 2012, and in Côte d'Ivoire and Paraguay more than 0.6 percent of GDP. In several countries, USFs continue to fund basic fixed-line telephony long after user demand had shifted to mobile and broadband internet.[52]

By far the most successful measure to extend access is to license competing mobile service providers and internet service providers. Governments often include specific network rollout obligations in the license conditions of mobile operators, and these are frequently exceeded thanks to strong demand, at least for basic mobile telephony. But for advanced mobile networks, suitable for carrying data services such as high-speed internet, rollout into areas of sparse population density has been slower. For voice services, provision of coverage to rural areas by private investors could sometimes be justified by the volume of incoming calls. But for data services, although the direction of traffic might be similarly asymmetric, only the ability of the local population to pay for service justifies investment in network upgrading, as there is no payment for incoming traffic.

Given the increasing importance of broadband for modern life, better provision in rural areas could help revitalize the local economy in secondary towns and rural areas.[53] Here are some possible solutions for rural broadband:[54]

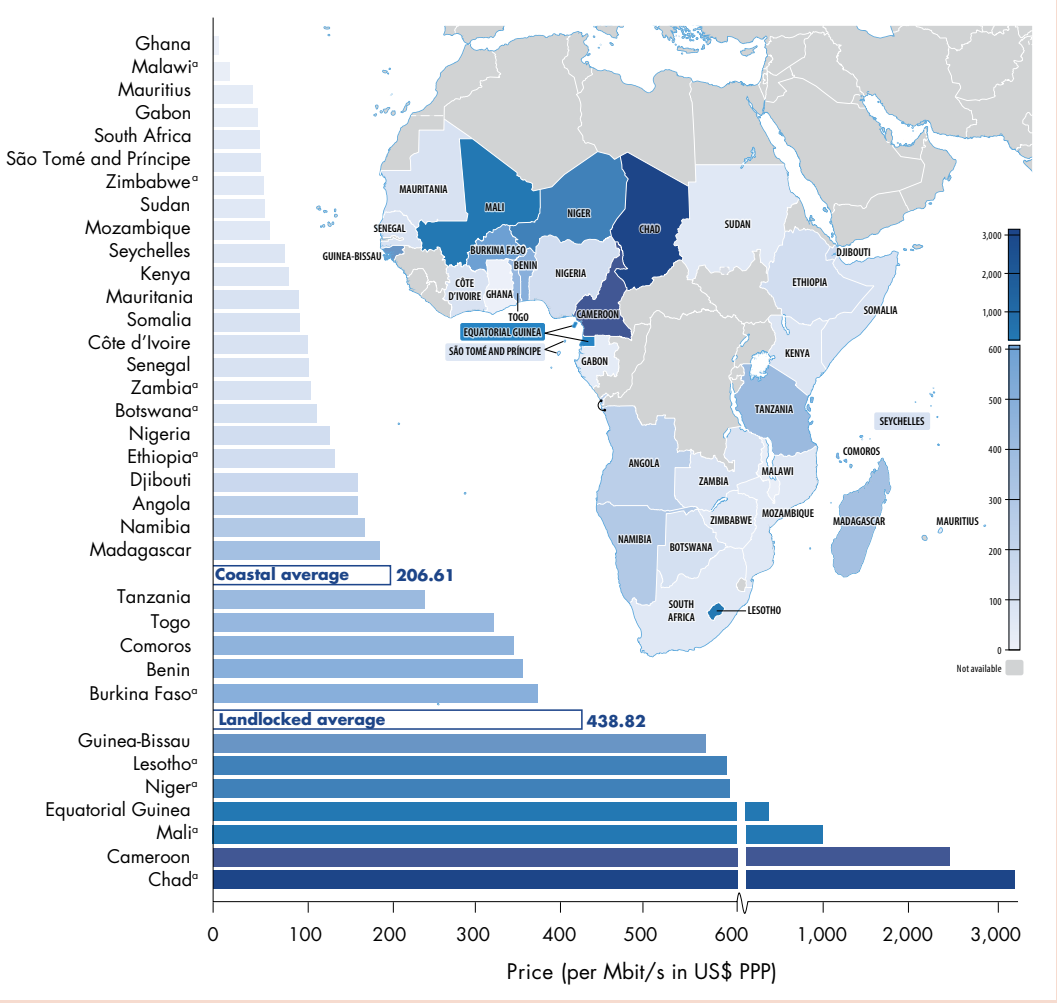
- *USFs can be repurposed to focus on broadband.* In the United States, since a 2011 decision by the regulatory body, the Federal Communications Commission (FCC), universal service subsidies have been channeled to the Connect America Fund, to the tune of around US$4.5 billion a year.[55] A similar initiative in Europe, using regional development funds, is the Connecting Europe Facility.[56] Already,

Box 4.5 The last (1,000) mile(s)

The "last mile" problem is a term commonly used in communications and transport economics to describe the relatively high cost of building the infrastructure to link to end users: the access network. Technological change, particularly the development of cellular mobile communications and data compression techniques, has greatly reduced infrastructure investment costs and is helping to solve the last mile problem, at least in urban areas. But a different problem, perhaps better described as the "last 1,000 miles," plagues remote rural communities. Specifically, what is the best way to bring the internet to areas "landlocked," far from the cable landing stations on the coast, or "sealocked," small islands with small populations that cannot justify an investment in undersea cable?

Where undersea fiber-optic cable is available, it will generally trump all other solutions in speed, performance, and cost. But for low-density, dispersed populations or remote islands, satellite offers a quick and easy alternative.

Map B4.5.1 The effect of geography on internet prices, Africa



IBRD 42012

Source: WDR 2016 team. Data at http://bit.do/WDR2016-MapB4_5_1.

Note: Price per Mbit/s in US$ PPP a month in 2014 Q4/2015 Q1 for fixed, residential broadband service. Mbit/s = megabits per second; PPP = purchasing power parity.

a. Indicates landlocked country; the gradient indicates greater cost.

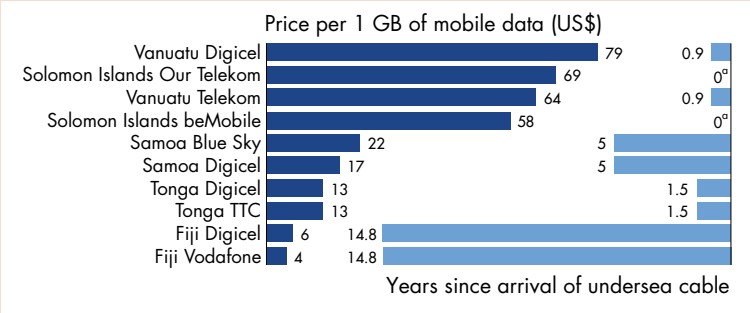
(Box continues next page)

Box 4.5 The last (1,000) mile(s) *(continued)*

Usage costs have come down, with the entry of new players, such as Avanti Communications[a] and O3B.[b] The Cook Islands, with fewer than 14,000 people spread over 15 inhabited islands across 2.2 million square kilometers of ocean, recently opted for a satellite network from O3B.[c] But satellite has the disadvantage of being more expensive than fiber-optic cable per unit of data, and, with older generations of satellite, suffers from higher latency (delay), which makes them unsuitable for real-time uses like video gaming. Even the Cook Islands are now considering an undersea cable.

Although satellite offers distributional advantages, it makes it hard to aggregate demand and therefore to negotiate lower bandwidth costs. South Sudan, for instance, has an estimated 3,000 very small aperture terminals (VSATs) serving its population of just over 10 million, who pay expensive retail rather than wholesale rates for the limited capacity provided. Geography matters. Landlocked countries generally pay higher prices for bandwidth than coastal countries. In Africa, for instance, being landlocked adds an average of US$232 to the monthly price for fixed broadband access (map B4.5.1). But history matters, too. In the Pacific, countries first reached by cable, such as Fiji, tend to have lower internet prices than those reached more recently (figure B4.5.1). Once served with fiber, small island states may find that they use only a tiny amount of the capacity available; Tonga, for instance, barely uses 10 percent. Moving to flat-rate pricing ("all you can eat") for bandwidth may be the best way to recoup the initial investment.[d]

Figure B4.5.1 The effect of history on internet prices, Pacific



Source: See http://www.theprif.org/index.php/news/53-media-releases/169-prif-ict-study. Data at http://bit.do/WDR2016-FigB4_5_1.

Note: Price, per gigabyte (GB) of data in US$ a month in 2014, for prepaid mobile broadband.

a. Cable to Solomon Islands under consideration.

a. http://www.avantiplc.com/.
b. http://www.o3bnetworks.com/.
c. http://www.islandsbusiness.com/2014/4/business-intelligence/cooks-opt-for-satellite-telecom-network/.
d. PRIF 2015.

from 2007 to 2014, some €14.7 billion (US$16.5 billion) had been committed to broadband networks under PPP funding, using EU structural funds, in more than 100 different projects in the European Union.[57] But few developing countries have this level of resources to commit.

- *Infrastructure sharing and mutualization*[58] *can also reduce costs for operators.* Infrastructure sharing refers to the operators sharing one another's network infrastructure, or at least some elements of it, such as wireless masts or cable ducts. They may also share infrastructure from other sectors, such as electricity or transport. Mutualization is slightly different, with a wholesale operator created to sell only to other operators and not directly to users. Increasingly, specialist wireless mast companies, like Indus or Reliance Infratel, two Indian companies, are emerging for wireless infrastructure, while cable backbone companies include Botswana's BoFiNet and the Burundi Backbone System. Sharing assets can improve management efficiency, though it may also lead to disputes.

- *Technological solutions are emerging that promise a fresh approach to rural broadband.* From drones to balloons to nanosats, there is no shortage of inventive solutions to providing wide area coverage. But these new technologies will need to leverage the physical and market infrastructure that the cellular mobile industry has built in order to become commercially viable and achieve scale. And efforts to bring new technology will have to be complemented by more efficient use of spectrum, such as spread spectrum and digital dividend spectrum, which releases for cellular commercial use the highly valuable spectrum (for instance, in the 700 MHz band previously used for terrestrial TV broadcasts), and in the "white spaces" between digital channels. These spectrum bands have wider coverage and are therefore ideal for rural areas.

Managing spectrum and other scarce resources

Managing scarce resources—such as numbers, rights-of-way, and especially spectrum—presents regulatory challenges. Policy makers are turning to market mechanisms, such as auctions, to deliver the best outcomes, and this can result in lower prices and higher growth, as in Guatemala (see box 4.6). More flexible approaches to spectrum sharing between services, use of spectrum-hopping technologies, and refarming of spectrum will also help. But demand for bandwidth, and thus also for spectrum, continues to grow rapidly, especially as video entertainment shifts from television sets to mobile devices. By 2020, around 2 GHz of total spectrum will be needed in major markets for cellular services.[59] Today, most developing countries have only around 500 MHz allocated, and some have less than 300 MHz.[60] Spectrum availability and allocation is one of the factors determining the future wealth of nations, and governments will have a vital role in maximizing the benefits from this resource.

The internet brings new challenges for allocating scarce resources, including domain names and the transition to longer (IPv6) addresses. While spectrum and numbers are regulated primarily by the public sector—internationally by the ITU and nationally by government ministries or regulators—domain names and IP addresses are controlled almost entirely by the Internet Corporation for Assigned Names and Numbers (ICANN), a California not-for-profit corporation, and the entities to which it subcontracts. The management of top-level domain names, such as .org and .com, IP addresses, and even country code domains, such as .za (South Africa), generally is not the provenance of government regulation. Their regulation is a complex matter, involving contract rights with private parties and not administrative fiat. But the natural shortage of attractive, or easy to remember, domain names creates opportunities for profiteering.

ICT prices are falling . . .

The trend toward declining prices in the ICT sector has been a long-term and predictable driver of growth. For hardware, it is encapsulated in the prediction made by Gordon Moore, the cofounder of Intel, in a 1965 paper that the number of transistors in an integrated circuit would double about every two years, with consequent improvement in price and performance.[61] For memory storage, this means that, in 2014, a typical price to store a gigabyte of data was just 3 U.S. cents, whereas 20 years earlier it was more than US$500.[62] Similar rates of progress are observable in the unit price of computer processing power and in the availability and price of bandwidth[63] (figure 4.1). Manufacturers have, to some extent, compensated for this by building greater functionality into devices for the same price. But as they have started to chase mass markets, device prices have also started to fall—since 2011 for smartphones, and earlier for older technologies such as laptops and televisions. Smartphones, with more computing power than NASA had at the time of the moonshots, can now be purchased for less than US$40 (although the typical cost is much higher), and it is forecast that, by 2020, 80 percent of adults around the world will own one.[64]

Predictable, rapid price declines create an interesting dynamic: it is possible to foresee, with reasonable accuracy, at what point services and devices will flip from narrow to mass markets, as the price of ownership and use falls. But there is a tendency to overestimate the effect of a technology in the short term and to underestimate its effects in the long.[65] This may in part explain why the initial impact of the internet caused a catastrophic swing in the markets, starting around 1997 and peaking in March 2000, since known as the dot-com bubble. The aspirations of many of the startups of the time—like Broadcast.com, an internet radio company, or Pets.com, an e-commerce supplier—simply could not be met by the slow-speed dial-up internet access available, and their business models were often unrealistic. The value of stock markets worldwide fell by some US$5 trillion in the 18 months that followed.[66] But that period of creative destruction also saw the birth of many of the giants that dominate the internet today, including Google and Tencent (both founded in 1998) and Alibaba (in 1999).

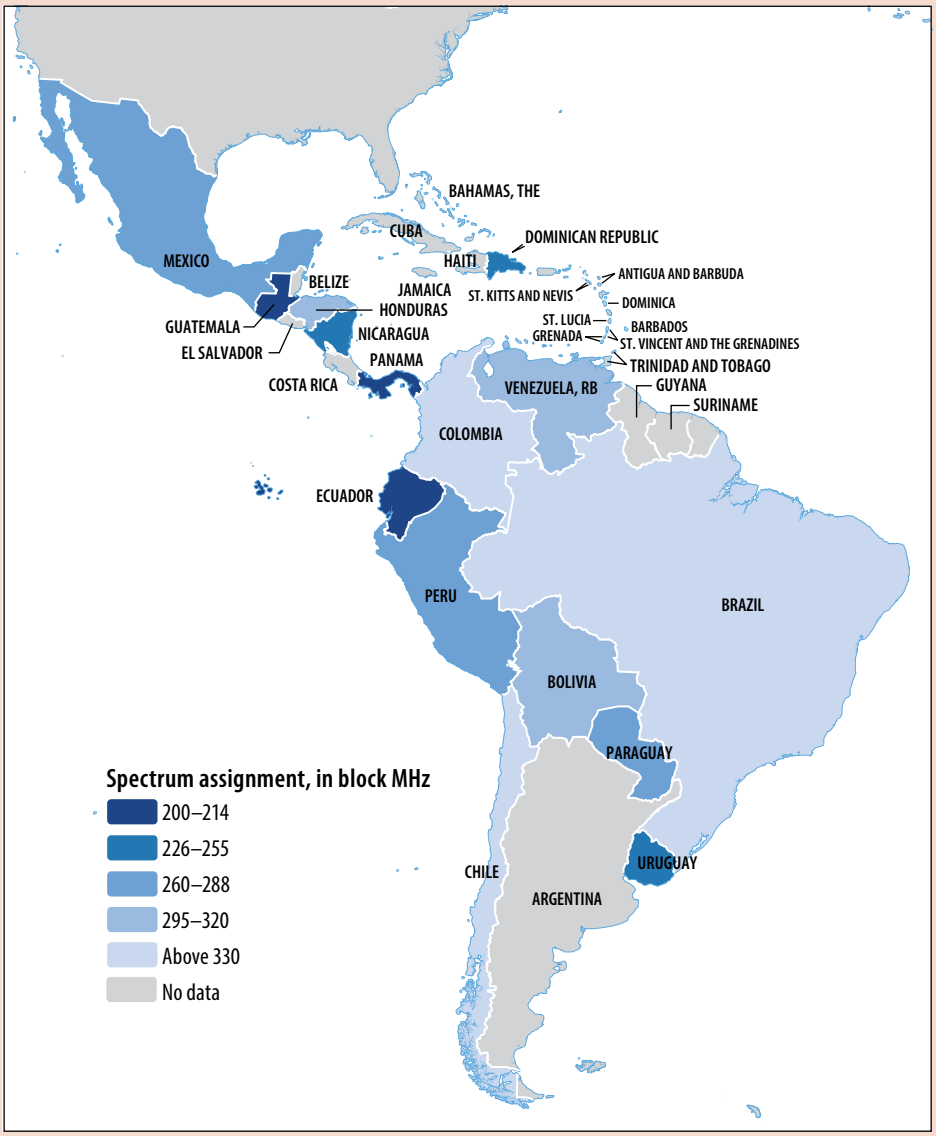
Perhaps the most sustained example of how falling prices drive market expansion comes with

Box 4.6 Guatemala: An early pioneer of spectrum auctions

In most countries, the management of the civil radio frequency spectrum was carried out on a "first come, first served" basis, with incumbent operators taking the lead. As countries separated the functions of operator and regulator, starting in the 1980s, spectrum management moved toward newly created regulatory agencies. But growing demand for using the airwaves for providing mobile communication services meant that supply soon exceeded demand.

Guatemala was one of the first countries to respond to the changing dynamics of the marketplace, and in its 1996

Map B4.6.1 Spectrum assignment in Latin America, in MHz blocks



Source: Adapted from GSMA (unpublished spectrum database). Data at http://bit.do/WDR2016-MapB4_6_1.

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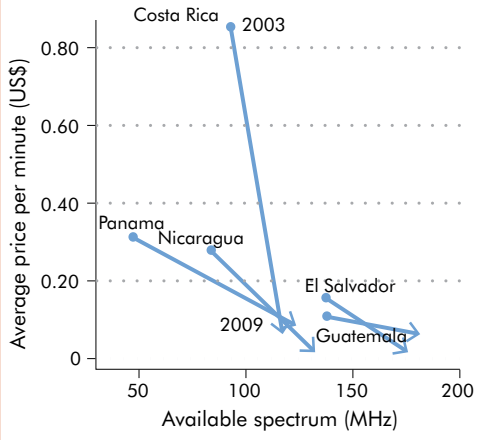
(Box continues next page)

Box 4.6 Guatemala: An early pioneer of spectrum auctions *(continued)*

Figure B4.6.1 How greater spectrum availability led to lower prices in Latin America, 2003–09



Source: Adapted from Marino García 2015b. Data at http://bit.do/WDR2016-FigB4_6_1.

Note: The start of each arrow is a 2003 data point, and the end of each arrow is a 2009 data point.

General Telecommunications Law, recognized the economic value of the spectrum.[a] The law gave operators the right to request that any unallocated portions of spectrum be offered for sale, through auctions, and once awarded, it gave operators the right to use, lease, and resell the spectrum, creating a tradable market. Guatemala benefited from a faster reduction in prices for mobile services than the rest of the region (see figure B4.6.1). Other countries adopted similar policies, following Guatemala's early lead,[b] and indeed have now overtaken Guatemala in the spectrum allocated to mobile communications (see map B4.6.1).

a. Ibarguen 2003.
b. IDRC 2010.

mobile phone services. When the dot-com bubble burst in March 2000, there were fewer than 700 million mobile phone subscriptions (SIM cards)—but now, there are more than 7 billion, with over three-quarters in developing countries. That success story has come about, in part, because of the falling price of ownership and usage of mobile phones, particularly in South Asia, where it has been labelled the "budget telecom model,"[67] based on prepaid billing, very low entry costs, and extensive use of discounts. Six of the ten cheapest countries to use a mobile phone are in South Asia, where the cost of ownership is typically below US$5 a month (figure 4.2). Seven of the top ten most expensive countries are in Western Europe. On affordability, measured by the monthly price of a basket of services as a percentage of income, developed countries still do better, as might be expected, though the gap is narrowing.

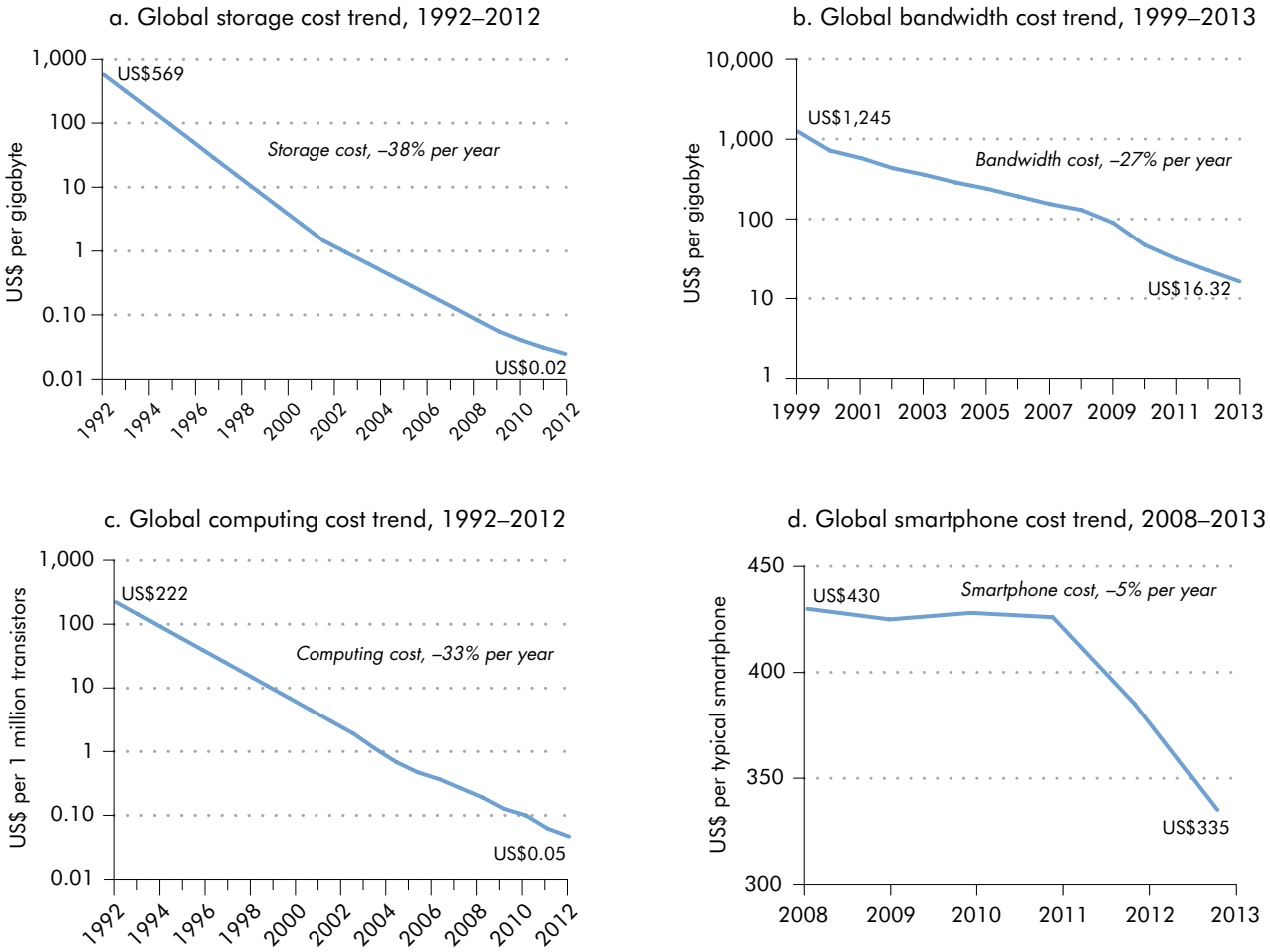
. . . but ICT prices still vary widely

Why do prices for ICT services vary so widely, by a factor of more than 40 for mobile cellular prices? Economies of scale seem to matter, with both India and China having prices below US$5 a month, while small island states, such as Vanuatu or the Marshall Islands, are generally more expensive than the global average, although there are many exceptions. But geography and population density appear to matter less than might be expected, with mountainous Bhutan and Nepal among the cheapest countries for mobile service, and the flat and densely populated Netherlands one of the more expensive. The practice of geographical averaging of pricing, applying the same price throughout a country, is still the norm—suggesting that, once basic coverage is established, rural areas are not necessarily more expensive to serve than urban ones. Mobile prices appear to be demand-driven rather than cost-based, with some of the cheapest prices in countries where the ability to pay is lowest.

Instead, to understand differences in ICT prices, it is necessary to look at policy and regulatory explanations. For mobile cellular services in Western Europe, larger operators found it profitable to set high rates for terminating each other's calls, and especially those from fixed-line operators. Higher prices for off-net calls locked in users, while high roaming charges drove profits. Regulatory interventions, to oblige operators to reduce termination and roaming rates, were only partially effective because operators simply absorbed lower interconnection payments by raising prices for outgoing calls in a "waterbed" effect.[68] In Canada and the United States, the unusual system of "both parties pay" pricing, where users pay both to receive and make calls with their mobile phones, should in theory obviate the problem of high mobile termination rates, in that "sender keeps all" is used (there are no payments between operators), which means there are no interconnection payments.[69]

But in practice, both appear among the most expensive countries for mobile calls, based on the

Figure 4.1 Prices are falling for computer processing, storage, bandwidth, and smartphones



Source: Deloitte Shift Index 2013; see http://www2.deloitte.com/us/en/pages/center-for-the-edge/topics/deloitte-shift-index-series.html. Data at http://bit.do/WDR2016-Fig4_1.

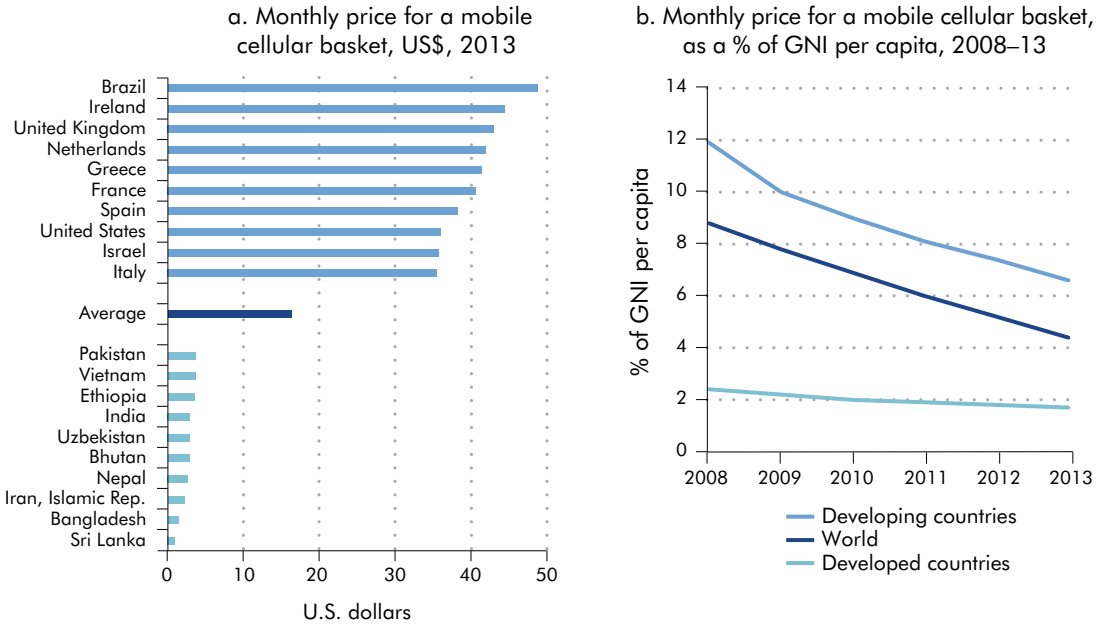
OECD low-user basket. Excessive bundling of different services, notably in North, South, and Central America, keeps prices for individual services high, and "locked" SIM (subscriber identification module) cards limit consumers' ability to choose among operators. Again, it is hard to escape the conclusion that operators are using demand-based, rather than cost-based, pricing, as operators in these countries have largely saturated markets. One more positive development is the dropping of mobile roaming charges in East Africa in October 2014, which led, for instance, to a 950-percent increase in traffic from Rwanda to Kenya compared with the previous month.[70]

Price differences between countries are even more evident for the internet. The range between countries for fixed-line broadband is almost 200-fold between Vietnam ($2.93 a month, for an entry-level price with a minimum speed of 256 kbit/s and monthly use of 1 gigabyte, GB) and the Central African Republic (US$584.97). For mobile broadband too, the range is more than 100-fold between Pakistan (US$1.48 for a GB of data a month, downloaded to a mobile handset) and São Tomé and Príncipe (US$169.38).[71] In contrast to mobile voice services, European countries, particularly in Scandinavia and Eastern Europe, are generally among the cheapest in the world, thanks to vibrant competition (see map B4.1.1). Mobile broadband in Europe does not suffer from the termination rates that keep prices high for voice calls and SMS.

What policy and regulatory options are available?

What can regulators do to address the shortfalls in availability and the wide price differences for internet

Figure 4.2 If you want to make a mobile phone call, go to Sri Lanka



Source: ITU 2014. Data at http://bit.do/WDR2016-Fig4_2.

Note: The basket of services used is based on the OECD low-user basket, which includes 30 outgoing calls a month (on and off-net, peak and off-peak), plus 100 SMS messages. Prices were sampled in the fourth quarter of 2013. Panel a is based on 167 economies, and panel b on a simple unweighted average for 140 countries with a complete data set. GNI = gross national income; OECD = Organisation for Economic Co-operation and Development; SMS = short message service.

prices worldwide? Table 4.1 offers some suggestions, based on applying the principles of market competition, public-private partnership, and independent regulation to the different phases of the internet supply value chain. The first step is benchmarking, to gather up-to-date price data to allow for comparisons, both within the country (between operators and over time) and between countries, using appropriate comparators. Price comparisons are tricky and generally require using a predefined basket of services and methodology, such as those used by the OECD[72] or ITU.[73] Operators often resist price comparisons, so it is essential to give the ICT regulatory agency a legal mandate for collecting, and publishing, relevant pricing and quality of service data (box 4.7).

Armed with data, the next step is to work out in which part of the value chain for the supply of internet the market may be failing. Table 4.1 suggests several distinct submarkets:

The first mile. This refers to the point at which the internet enters a country.

- *International connectivity*. The connection between a country and the global internet can be measured in bits per second per internet user. The global range is very wide—between 6.4 Mbit/s in Luxembourg to just 146 bit/s in the Central African Republic.[74] Governments can encourage a higher availability of international bandwidth, for instance, by liberalizing the market for satellite dishes, including very small aperture terminals, and allowing open access to submarine cables, satellite consortia, and landing stations. Government procurement can also lead in bringing down prices by aggregating demand among different services—all the universities in a region, for example—to negotiate better prices for bandwidth with international providers.
- *The international gateway* is the point at which a country connects to the global internet, and this can often become a bottleneck. Although the Arab Republic of Egypt liberalized its market for internet service providers in 1996, the incumbent, Telecom Egypt through its subsidiary TE Data, still has a legal monopoly over the international gateway and cable landing station, in Alexandria, at least until June 2016. Competitors pay as much for interconnection in Alexandria and backhaul to Cairo as they pay for international connectivity, resulting in some of the highest prices for internet in the region.[75] In such cases, regulating wholesale prices for connectivity,

Box 4.7 How better ICT data can lead to cheaper services

Better data on how information and communication technologies (ICTs) are used in developing countries can spur policy changes that benefit the poor and increase their digital access. In some parts of the world, one of the best ways to spur policy reform is to shame governments into action by comparing them to countries with better records. When a report from Research ICT Africa revealed that prepaid mobile prices were higher in South Africa than in 34 other African countries, pressure from the Parliament obliged the regulator to cut mobile termination rates, resulting in a wave of price cuts by mobile operators.[a] But such examples are rare, and there is an alarming lack of accurate and timely data on ICT use in the developing world. This makes it hard to understand the mechanisms by which greater information access among the poor drives economic opportunity. It also leaves important policy questions unanswered, such as whether new "free" internet services (or "zero-rated" services like "Facebook zero") drive the take-up of broadband or whether they deny access to the "free and open" internet.

In general, supply-side indicators (such as subscriptions, or domain name registrations) are better reported than demand-side use and applications data. The International Telecommunication Union has collected such data from its membership since the 19th century. But gaps in its database are increasing, as operators in more competitive environments have become more wary of releasing commercially sensitive data. National Statistical Offices could collect data on ICT use, but in developing countries they often lack the resources to carry out household surveys or do not have the know-how to collect policy-relevant data. A few donor agencies provide support, such as the funding of Research ICT Africa's household surveys by Canada's International Development Research Centre (IDRC)[b] or the funding of LIRNEasia's research on mobile phone usage at the base of the pyramid by the United Kingdom's Department for International Development (DFID).[c] The latter helped to persuade the government of Sri Lanka to forgo new mobile taxation policy.[d] But more should be done. Key areas for future action include:

- At the national level, ensuring that service licenses require operators to report data to regulators, and encouraging National Statistical Offices to include questions in their household surveys regarding ICT access and use
- At the global level, reigniting global coordination bodies, such as the Partnership for Measuring ICT for Development,[e] to compile, coordinate, and improve ICT data gathering
- Exploring the use of new data sources such as "big data," crowdsourced data, and social media to complement ICT access and usage statistics
- Creating mechanisms for telecommunications companies to share data, such as anonymized call records, for public research, policy, and planning purposes.

a. http://www.researchictafrica.net/docs/Fair_Mobile_Prices%20Q2-v04.pdf and http://www.researchictafrica.net/home_archive_reader.php?aid=118.
b. http://www.researchictafrica.net/home_archive_reader.php?aid=128.
c. http://lirneasia.net/projects/2010-12-research-program/teleusebop4/.
d. http://lirneasia.net/2007/10/lirneasias-policy-influence-on-mobile-tax -issue-in-sri-lanka/.
e. http://lirneasia.net/2007/10/lirneasias-policy-influence-on-mobile-tax -issue-in-sri-lanka/.

Contributed by Laurent Elder.

or structurally separating the supply of wholesale from retail services, could help.

The middle mile. This refers to the national, intercity internet backbone of a country.

- *The national backbone network.* The internet backbone network in a country provides backhaul from cable stations or satellite stations to major cities and towns. Ideally, it should include fiber-optic cables, but microwave and even copper links can also be used. The simplest step a government can take is to liberalize the market for building and operating backbone networks, and to encourage open access to the incumbent's network at the wholesale level. The risk is that the most popular routes—say, between the two main cities—are "superserved," while the rest of the country is underserved. So, many governments favor public-private partnerships to "direct" private investment, as in the Republic of Korea (see box 4.4). Governments can also help by making rights-of-way available to investors—and by requiring that all major infrastructure programs (such as roads, railways, pipelines, and energy

distribution) include provision for an optical fiber link,[76] and follow the principle of "dig once, dig smart," by obliging contractors to anticipate future demand for fiber when digging trenches.[77]

- *The internet exchange point (IXP).* The IXP is where IP-based traffic is exchanged within a country. As of May 2015, there were some 446 IXPs around the world, but 87 countries still lacked a single one.[78] Average traffic handled by each exchange ranges from some 4.47 terabits a second on the Amsterdam Internet Exchange, founded in 1997, to just 21 kbit/s on the BurundiX IXP, founded in 2014. Setting up an IXP is one of the most cost-effective steps a country can take to enhance local connectivity. Research by the Internet Society shows that the Kenya IXP (KIXP), operating since November 2001 despite being initially declared illegal by the regulator, saves local internet service providers (ISPs) some US$1.5 million a year in reduced costs for international connectivity. And it reduces latency from 200–600 milliseconds to 2–10 milliseconds, on average, by exchanging traffic locally.[79]
- *Local hosting of content.* Promoting local hosting of content and creating a local cache for frequently used content from elsewhere can also enhance the efficiency of the network and reduce latency, increasing usage as users experienced shorter waiting times for websites to load. In Rwanda, 14 of the top 20 sites with Rwandese content were commercial sites, and all were hosted outside the country so that a typical website could save around US$100 a year and enjoyed a more reliable service. But this imposed additional costs of US$13,500 a year for local ISPs that had to bring the content back in over expensive international links—costs which are then passed on to users. Promoting local hosting, already required for government sites in Rwanda, could avoid this, and help improve service quality.[80]

The last mile. This refers to the connection between the user and their nearest internet point of presence (POP).

- *The local access network.* The most costly part of the network, and the hardest to duplicate, is the local access network, which connects the user to the nearest internet POP. In the early days, this was typically achieved through dial-up, using a modem, over ordinary copper telephone lines. Starting in the late 1990s, a technology called digital subscriber line (DSL) allowed that same telephone network to be used for always-on broadband connections, while cable modems offered the same facility for cable TV networks. In developing countries, where copper-based local access networks serve only a few areas, wireless-based access networks offer the most popular alternatives. Just over half the world's inhabitants live within coverage of advanced, third- (3G) or fourth-generation (4G) networks, but even second-generation (2G) networks can be adapted for slow-speed internet use.
- *Government policies to encourage the spread of fixed-line broadband networks* include permitting competing facilities, especially for intermodal competition (between cable, DSL, and wireless), and local loop unbundling (LLU), or mandating the incumbent to make local access lines available to competitors at wholesale prices. The widespread enforcement of LLU in Europe since 2000, following EU directives,[81] is one reason its average broadband prices are among the lowest in the world. LLU is most effective once a minimum level of penetration has been achieved; below that, it can act as a deterrent for investment.[82] LLU also offers a foothold for new entrants that can quickly offer nationwide service and then later develop their own infrastructure, as has been the case for free.fr, a new entrant in France.

The invisible mile. This refers to the other, less visible network components and potential bottlenecks.

- *Efficient spectrum management.* Critical at all stages of the internet supply chain but especially in the local access network, efficient management of the civil radio frequency spectrum includes increasing the amount of spectrum available, ensuring competitive access, encouraging sharing of essential facilities such as radio masts, and liberalizing the market for spectrum resale and leasing to allow the creation of mobile virtual network operators. In this sense, spectrum resale in the wireless world is the equivalent of LLU in the fixed-line world. Policy makers can also help by making more unlicensed spectrum available, especially for innovative uses such as cognitive radio (which hops between frequency bands to avoid interference), and by opening up underused government spectrum for commercial applications.
- *Over-the-top services.* Policies to encourage a wide range and diversity of OTT services can provide a wider choice to consumers at lower cost. Policies to encourage OTT growth include removing regulatory barriers to providing voice over IP and

mandating that operators provide access to essential facilities such as billing and app stores. Of course, OTT services introduce many regulatory issues of their own, not least the concept of "net neutrality." A recent consultation on net neutrality[83] by the Federal Communications Commission, the U.S. regulatory agency, attracted a record number of comments, around 4 million.[84] Ultimately, with support for net neutrality from the U.S. president, the FCC ruled in February 2015 in favor of regulating broadband internet as a public utility, although legal challenges could continue for years.[85]

- *Mobile money.* For developing countries, one of the most significant OTT services is mobile money, which is also fraught with regulatory challenges (see spotlight 2, "Digital finance").

Demand-side policies: Open and safe internet use

The internet is at once unique, complex, and one of the most used global communications media. It has different layers of infrastructure and applications, and different stakeholders are involved in its operation, use, and governance. What features affect the stability and security of the global internet to engender trust and therefore encourage use of the internet? What is the best way to balance stakeholder interests in these areas? This section addresses the creation of an enabling environment of "trust" for the internet to achieve its full potential.

Censorship and content filtering threaten the internet's utility as an engine of growth

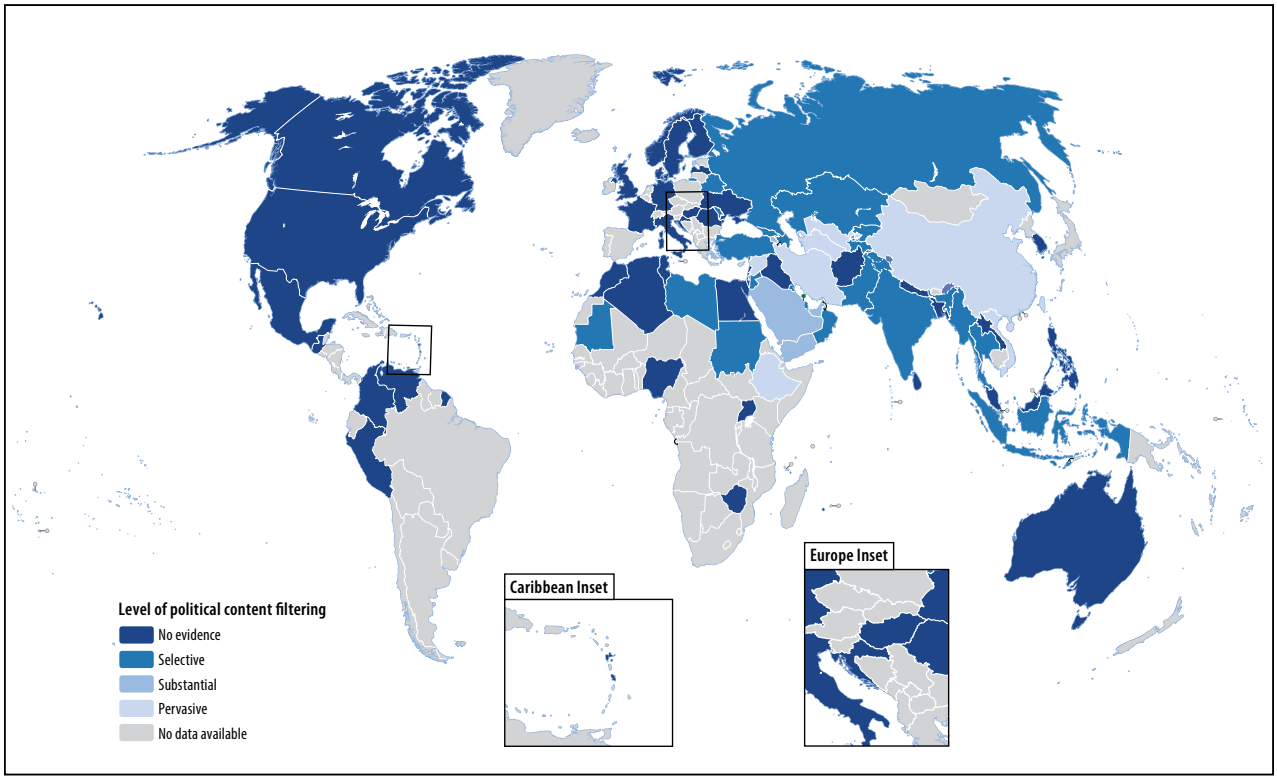
The internet thrives on open information exchange and freedom of expression.[86] One global view shows the range of internet filtering of political speech, from none to pervasive filtering (map 4.1).[87] Another shows, perhaps paradoxically, that concerns over freedom of expression are actually greater among users in countries that have more recently come online than among users from countries with a longer history of internet access.[88] One account of filtering blames filtering policies and software for poor internet performance (slow access speeds).[89] This is an example of a direct cost associated with filtering, but such filtering also leads to indirect costs from the drag on innovation that comes from self-censorship, and the resulting loss of freedom. In this discussion, "filtering" (or censorship of public content) does not include "surveillance" (or monitoring of private content).

Innovation also depends on the ability to protect and monetize intellectual property. Avoiding piracy will rely on striking the right balance between providing access to information and protecting intellectual property rights. Generally, the illegal distribution of copyright material tends to lessen when legitimate ways exist to access that material, for a fair price. Thus, contrary to expectations, peer-to-peer file sharing systems that blossomed in the early 2000s for free sharing of music, such as Napster and Kazaa, started to decline once legal alternatives, such as iTunes or Google Play, became available, without any noticeable impact on the quantity or quality of artistic output.[90] The action has now shifted to film and TV file sharing, but again the availability of legitimate commercial services, such as Netflix or Hulu, is progressively displacing illegal services as they are extended to more territories and have greater content coverage. But there remain large parts of the world where content is not available for download legally, because content licensing and copyright are so complex and fragmented that small markets are too often ignored (chapter 6).[91]

An issue that is more difficult to resolve surrounds the restriction, or filtering, of certain types of online content. Every country has different redlines on content it regards as dangerous or offensive. Germany has restrictions on hate speech, while Thailand monitors comments about its king. There are also certain absolute values, such as restrictions on child pornography. Such restrictions are understandable and justified where they represent a societal consensus adopted by an accountable government. The Supreme Court of India, for example, recently reconsidered its position on free speech issues, potentially lifting existing restrictions on online speech.[92] But few governments have the capability to enforce such content monitoring on their own. Instead, they must cooperate with the major websites and search engines, which then have to apply their own judgment. Google, for instance, publishes a transparency report that provides statistics on government requests to remove content, which have grown significantly since 2011.[93] In the six months ending December 31, 2013, Turkey submitted the most removal requests (895), followed by the United States (481).

Some governments try to block access to content directly, for instance by imposing national firewalls or restricting the use of certain internet applications, such as virtual private networks or voice over IP services. Google reports that, in the first nine months of 2015, six countries had experienced disruptions of

Map 4.1 Evidence of internet content filtering



Source: Open Network Initiative, http://map.opennet.net/filtering-pol.html. Data at http://bit.do/WDR2016-Map4_1.

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traffic to its products—China, the Democratic Republic of Congo, the Islamic Republic of Iran, Pakistan, Tajikistan, and Turkey.[94] Excessive restrictions on use can increase the costs of doing business, particularly for international businesses, which may be dissuaded from investing.[95] In addition, inconsistent and complex content filtering requirements can make it difficult to offer internet services and applications that are global in nature. Policy makers in governments that impose such restrictions have to choose between the relative perceived advantages of controlling certain kinds of information and the economic costs, including lost opportunities, of maintaining such systems.

Cybersecurity: Trust in the internet will come from balancing the security of networks and information with the protection of individual rights

The term "cybersecurity" is a convenient shorthand for a very complex set of issues. It commonly refers to systems and actions aimed at securing data and communications over the internet and even the infrastructure of the internet itself.[96] It also sometimes includes "cybercrime." The more common threats to cybersecurity are malware, denial of service, and phishing attacks (attempts to acquire sensitive information online by someone who is masquerading as a trusted entity), but cyberincidents are increasingly perpetrated by disaffected insiders. So, cybersecurity usually refers to securing data and infrastructure in a civilian context; but acts that might previously have been considered civilian attacks are now being uncovered as acts of states against states via nonstate actor proxies, blurring the lines between acts of cybercrime and cyberwar or cyberterrorism. Threats to personal security online, such as online identity theft, are also growing. This may erode public confidence in e-commerce and e-government applications, and make internet use less attractive, thus suppressing its use for certain applications. Likewise, cybersecurity can include securing critical information infrastructure from acts of nature, such as developing backup facilities in alternative locations.

However defined, weak cybersecurity is a significant problem worldwide, with both the scale of financial losses, and the costs of preventing them, growing (box 4.8). New breaches of security over

the internet are reported almost weekly. Reliable estimates of the size of the problem are hard to come by because of the definitional problem that compounds a lack of common indicators—and because firms and governments suffering cyberincidents are unwilling to disclose losses and thus to reveal vulnerabilities. Some of the published sources are based on flawed assumptions, and all reports raise as many questions as they answer. The growing centrality of the internet in daily lives around the world, and the increasing use of mobile devices, combined with the "internet of things" (see spotlight 6), appear to have increased exposure to cyberrisks.

Equally important, the incentives to deal with cyberrisks need realignment. For example, individuals sometimes do not take proper precautions to secure their devices or data, passing on the cost of security to society at large. Vendors of hardware and software are in a highly competitive environment and may push products to market at the expense of ensuring proper security features. Cybersecurity is expensive and complex (whether through incurring up-front costs of "prevention" or dealing with costs of restoring security in "recovery and resilience" regimes). It may be economically rational to accept some degree of insecurity for the convenience to transact online.[97]

That said, there are also various ways of identifying the costs involved, including direct and indirect costs, and two types of costs to be considered. First are the costs of the breach (actual loss) and of the remediation efforts to fix it. Second are costs associated with prevention and providing an environment of "trust," as well as understanding the incentives of actors to provide security. The methodology encapsulated in table 4.2 provides a systematic framework for more precisely evaluating "cybercosts" and identifying which stakeholders are most likely affected by particular costs. Aggregating the cumulative costs across all players and cost categories yields an estimate of the total direct, the total indirect, and the total implicit costs. This kind of assessment will be key for policy planning.

Public safety and security in the analog world is a public good, ensured by governments. In the cyberworld, governments also have an obligation, through their policies, laws, and institutions, to ensure the protection of data, communications, and critical infrastructure. One particularly vexing problem in government attempts to address cybersecurity is that much of the infrastructure, and most of the communications, are controlled by the private sector or other nonstate actors. Around the world, governments of both developed and developing economies are taking action at the national level to address cybersecurity concerns. But because of the global nature of the internet and the cross-border nature of cyberincidents, governments should be encouraged to do more to protect themselves and their citizens through cooperation at the international level, for instance by exchanging information on threats. Because of the role of nonstate actors in the provision of infrastructure and services, governmental efforts will have to involve public-private partnerships (working with a variety of nonstate actors beyond the private sector) and find ways of addressing and even overcoming jurisdictional boundaries and barriers. Technical solutions will help, as in combating spam, but these need to be backed by legal measures and enforcement. Collaboration and openness are key.

In the areas of cybersecurity, there are few obvious policy recommendations, and in these areas—

Box 4.8 The costs of cybercrime

Estimates of the costs of cybercrime abound, but many reports are based on weak evidence or overly simplified assumptions. Often the methodology is not disclosed, complicating an assessment of its validity. Damage, typically assessed at a highly aggregated level, is difficult to link to specific incidents. Furthermore, most estimates are developed by companies directly involved in the sector, which may have an interest to overestimate the risks. Nevertheless, the cost estimates are both high and growing:

- A 2014 study put the global costs of cybercrime at between US$375 billion and $US575 billion, or about 0.6 percent of global GDP.[a]
- A 2014 study showed the average per person cost of data breaches ranged from US$51 in India to US$201 in the United States, and had risen 15 percent in a year.[b]
- A 2013 study estimated that the global costs to consumers (excluding businesses) were around US$113 billion, and had risen by half in one year.[c]
- A 2008 study estimated that the global effects of malware were around 0.5 percent of global GDP.[d]

Source: Adapted from Bauer and Dutton 2015, for the WDR 2016.

a. CSIS and McAfee 2014.
b. Ponemon Institute 2014.
c. Symantec 2013.
d. Bauer and others 2008.

Table 4.2 A basic framework for assessing the costs of cybersecurity incidents

	Direct costs										Indirect costs						
Market players	Repair costs	Data loss	Security measures	Fraud	Patch development and deployment	Customer support	Abuse management	Investigation at the organizational level	Law enforcement	Cost of infrastructure	Lost productivity	Revenue loss	Confidentiality breach	Reputation-related revenue loss	Security countermeasures collateral impact	Slower ICT adoption	Slower ICT innovation
End users																	
Home	●	●	●	●	●						●		●		●		
Business	●	●	●	●	●					●	●	●	●	●	●		
e-commerce companies			●	●						●		●		●			
Infrastructure																	
Software vendors			●		●									●			
Internet service providers			●			●	●			●				●	●		
Hosting providers			●			●	●			●				●	●		
Registrars			●			●	●							●	●		
Computer emergency response teams								●									
Law enforcement									●								
Society at large																●	●

Source: Bauer and Dutton 2015, for the WDR 2016, citing Bauer and others 2008.

Note: ICT = information and communication technology.

perhaps more than others—governments can play a role in developing effective policies. The "perimeter security" paradigm that pervades today, born in an era of a few centralized mainframe computers, needs revisiting, putting users—not devices—at the center of the discussion, and thus implying a great role for capacity building.[98] Public policy could be used to change misaligned incentives to achieve security. Given the pace of technological change, these policies should be guidelines or principles, not prescriptive, and be technology neutral. They should encourage interoperability among regimes and legal systems to investigate and prosecute cybercriminals across jurisdictions and to avoid the creation of safe havens for cybercriminals. Finally, work could be done to develop a common set of indicators to measure the economic impact of cybercrime and other cyberrisks.

Protecting personal privacy and data online is essential in building trust in the internet

The other side of the "balance" is protecting privacy and data online.[99] One of the key drivers in the digital economy is the flow of personal data, of which an estimated 90 percent has been added in the last two years. Collecting and analyzing data about individuals is integral to how some of the largest companies in the world do business. For example, Facebook is a company with a US$230 billion capitalization largely through its sales of ads that reach Facebook users.[100] But data also allow small and medium companies to monetize their services.

The World Economic Forum (WEF) has identified data-driven enterprises as part of a strategy for economic development in developing countries.[101]

Protecting personal data online is key for the data-driven economy, since it will increase trust in the internet, and greater trust will foster more use. And privacy is not just a developed-country issue. Some studies show how concerns over maintaining privacy online have more to do with "awareness" of threats to privacy posed by the internet, rather than with relative economic development, debunking the notion that privacy is mainly a western preoccupation.[102] But the issue is not as simple as having and enforcing national laws that protect personal data. Data flows nowadays are global, and privacy regimes need to be interoperable with one another to really enable the internet to be an engine of innovation and economic growth.

Privacy concerns range from the personally sensitive (personal health information or precise locational information) to the seemingly trivial (search or browsing history). But even the most innocuous data can become harmful when used by third parties in unauthorized or unexpected ways.[103] Most internet users are willing to surrender personal data—or control over it—for more convenience (gift suggestions based on their past purchases), for possible gain (the chance to win a holiday), and to avoid payment (notably, when downloading and using free mobile apps). But few users have the means to challenge data use policies or even make the effort to read the small print.[104] Privacy online is also a balance. It may be economically rational to relinquish some degree of privacy for the convenience of transacting online. But beyond respecting users' choice in how they transact online, public policy choices involve determining what other measures are necessary to afford appropriate privacy protections. The key is to ensure that users are made aware of the risks of diminished privacy.

One of these privacy challenges[105] is the growing use of "big data."[106] Data mining has been routinely used, especially by social media and e-commerce companies, to create value. The business model of Twitter or Facebook, for instance, is to grant users free storage, communication, and functionality in return for privileged access to the content they create. Such companies then aggregate and analyze user-generated content to sell value to advertisers wishing to reach targeted audiences. This classic two-sided market approach can make for a more intelligent and convenient user interface, but at the risk of alienating users if they find the use of their data too intrusive.[107] Mobile call data records (CDRs), which record basic data like the time, duration, location, and direction of calls, can also be mined to extract trend information.[108]And many applications are potentially valuable, as in traffic analysis[109] or epidemiology.[110]

Like big data, the internet of things also poses new privacy challenges, notably in the ability it offers to develop detailed user profiles.[111] The number of connected devices in use worldwide is set to rise significantly as consumer goods companies, auto manufacturers, health care providers, and other businesses continue to invest in connected devices.[112] Data collected are generally anonymized, but users may be unwittingly relinquishing control of their personal data. Open data initiatives by governments raise similar concerns about "anonymization," data breaches, and unauthorized or unintended re-use.

Privacy concerns need to be balanced against other important issues such as transparency, freedom of expression, proportionality, and security.[113] There is tension between protecting the privacy of individuals and keeping them safe from terrorism or criminals. Law enforcement and national security agencies need access to CDRs, and legal call interception, to track criminals, but they should do this by having appropriate safeguards in place to seek authorization, and not by using blanket surveillance measures. The exposure of indiscriminate snooping by governments has, ironically, encouraged large internet content providers to make far wider use of encryption, and operating system manufacturers are following suit.[114] Outside the domain of law enforcement, legislation should give users more control of their data at the point of use (if not at the point of collection). Consider the Electronic Health Record System in Estonia, which is based on the principle that citizens own their own health records and can easily access them and transfer them between doctors.[115]

Privacy policy concerns also need to be balanced against countervailing public policy issues such as freedom of expression and government transparency in the internet context. A recent decision from the European Court of Justice,[116] popularly known as the right to be forgotten, highlights this debate. Users in Europe now have greater control of the data about them on the internet.[117] This right can be exercised against search engines, such as Google or Bing, and would include seeking to remove search results pointing to documents held elsewhere in the cloud. But the decision does not offer clear guidelines for applying the right. Beyond that, once something is online, it is virtually impossible to ensure that all copies are deleted. Complying with user demands to delete personal data will impose additional costs on businesses and governments.

One sign of the growing awareness of public policy concerns is the surge in new privacy laws, even while there has been divergence among countries (such as

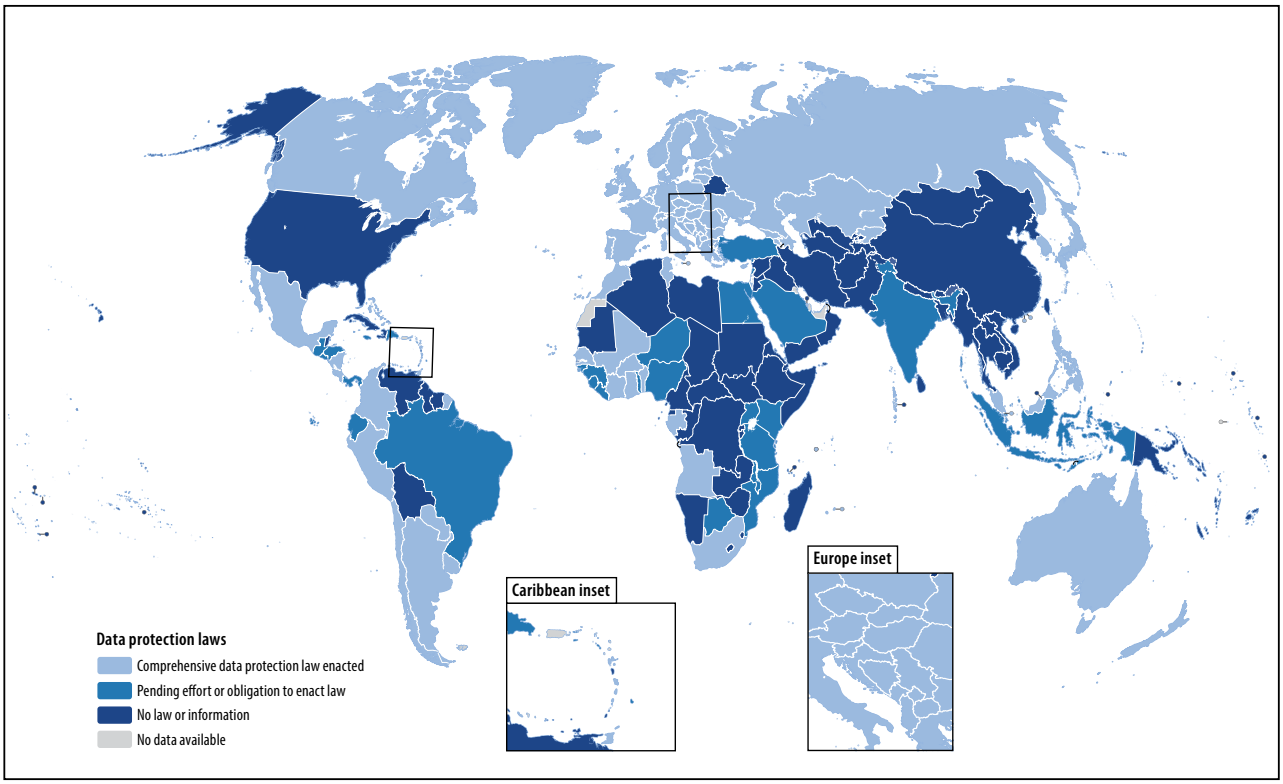
in the European Union and the United States) in their approach.[118] According to the United Nations Conference on Trade and Development (UNCTAD), 107 countries had privacy laws or bills in place as of 2014, but only 51 of them were developing countries (map 4.2).[119]

At the international level the United Nations General Assembly has adopted a Resolution, introduced by Brazil and Germany, on the Right to Privacy in the Digital Age.[120] The Africa Union Convention on Cybersecurity includes data protection.[121] The OECD, in 2013, published its updated *Privacy Guidelines*, revising work originally carried out in the 1980s.[122] The Asia-Pacific Economic Cooperation followed up on its Privacy Framework with a cross-border privacy arrangement in 2010.[123] The European Union is conducting an overhaul of its data protection framework.[124] while the United States is also considering options.[125]

The data protection story is becoming more complex. There is some evidence of convergence: the newly proposed EU data protection framework includes a directive looking closely at the protection of data as they relate to security and defense issues, a long-standing concern in the United States about which Europe had been more hesitant. The U.S. administration unveiled a blueprint for a consumer privacy bill of rights that would address consumer privacy more comprehensively. At the same time, in reaction to the Edward Snowden revelations (discussed below), the European Court of Justice issued its opinion in the *Schrems* case effectively invalidating the "Safe Harbor" agreement reached between the European Union and the United States permitting the handling of European data in the United States.[126]

Different approaches, however, are making it difficult to develop truly global internet services and applications because local adaptations are required to comply with differing national privacy laws, imposing additional compliance burdens and costs on businesses (see chapter 6).[127] Diverging rules also stifle trade and innovation. In addition, the threat of "data nationalism"[128]—the idea that a country's data should be stored within its borders, recently embodied in a new Russian law, for example, that requires the local storage of the personal data of Russian citizens—has

Map 4.2 National data protection and privacy laws and bills



Source: UNCTAD 2015. Data at http://bit.do/WDR2016-Map4_2.

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grown since the revelations by Edward Snowden about the U.S. government's surveillance of foreign internet traffic, which was subsequently declared to have been illegal.[129] That puts an additional burden on companies seeking to build services that rely on cloud-based networks.[130]

What is clear, however, is that getting the data protection and privacy piece of the puzzle right is, together with cybersecurity, a key element in engendering trust in and confidence in use of the internet. Even before "Snowden," users in countries of all regions were concerned that they should be careful about what they say online, as more and more perceived that their actions would be monitored.[131] While data protection and privacy are essentially matters of local law, a preponderance of privacy laws around the world are based on a common set of international, durable, and recognized principles. Moreover, interoperability of data protection regimes will encourage cross-border data flows and decrease the propensity for data nationalism. As discussed, data protection is not solely a preoccupation of advanced economies. Unlike investments in infrastructure, ensuring that good practice in data protection is part of the overall internet enabling environment makes sense for a country interested in the internet as a means of economic development.

Does net neutrality matter?

One of the more confounding issues around the internet today is "net neutrality." The term, euphemistically derived out of debates in the United States, has become a shorthand for a debate about the management and prioritization of scarce resources—notably bandwidth—over the internet. Thus the debate has pitted users and content providers against network providers.[132] In oversimplified terms, content providers want an "open" and "free" internet where every data bit, or IP packet, is treated equally, while network providers seek to charge higher rates for services chewing up more bandwidth. In the United States, the debate over net neutrality was mainly about the bandwidth consumed by video downloads. After announcing new rules in February 2015, opponents of the rules in the United States (mainly network providers) have claimed that compelling the openness of the internet imposes on their rights as a corporation to determine which content to make available. In other parts of the world, the debate over net neutrality is recognized as a matter of freedom of expression or access to information for individuals—a human rights issue.

So, depending on where one sits, the issue can be taken up as an issue of scarce bandwidth or of free speech. As with other resources where capacity is scarce, as on mobile networks, carriers attempt to use price discrimination to manage traffic. Network providers argue that regulators should grant them more flexibility to manage their traffic flows. But others argue that traffic management should not become an excuse to block certain traffic streams, content, or expression, to give preference to others, or to impede competition. The recent trend to develop services in which some basic content can be accessed free of data charges (such as Facebook's Free Basics or Internet.org), while other content is subject to data charges, would appear to be the antithesis of net neutrality and a distortion of markets.[133] Nevertheless, some defend the practice as a means of extending internet use in low-income countries.[134] In India, following protests, some participating organizations withdrew support to Airtel Zero and Internet.org, as the regulator indicated that these platforms do not provide equal treatment to all online services.[135]

An open and free internet is also a key contributing factor to innovation in the digital economy, making it critical to protect this openness. Care should be taken to ensure that users have the greatest possible access to internet-based content, applications, and services of their choice. But traffic management measures, while legitimate, should not reduce the enjoyment of fundamental rights and freedoms, particularly freedom of expression. The balance here should be carefully calibrated so that network operators continue to have incentives to build out and continuously improve networks and network capacity. Recognizing the balance to be sought in this debate, the Council of Europe in 2010 announced its policy on "net neutrality" (without calling it such), emphasizing the rights-based aspect of the issue.[136]

Much of the early debate on net neutrality in the United States was focused on the classification of the internet under the 1996 Telecommunications Act; in the rest of the world, the issues argued under the same moniker look at the impact of traffic management techniques, such as deliberately slowing (or "throttling") data streams, on human rights, and the continuing impact of the internet as a driver of innovation. Access to information is not solely a "developed" or "developing" country preoccupation. Not only is it a fundamental human right, inherent in Article 19 of the International Covenant on Civil

and Political Rights,[137] it is also an essential element in the online innovation ecosystem, and therefore an economic development issue. In whatever form a country would wish to use the internet for development purposes, its public policies should ensure that technical management of internet traffic is not used to suppress a tool of innovation.

Promoting the digital economy

The internet as an open access ecosystem

Once the internet is widely available and affordable in a country, and public trust that the internet is a safe and open platform for doing business or storing personal information has been established, it can become an unrivaled platform for promoting entrepreneurial opportunity. Indeed, 9 of the top 20 people in the Forbes 2015 billionaires list made their money from the sector.[138] Initially, internet entrepreneurship was associated with the dot-com bubble of the late 1990s, but the networks of the day lagged behind the aspirations of entrepreneurs. As one subsequently said, "A lot of the business plans were deeply flawed, but a lot of the ideas would have worked had there been broadband."[139] Since 2008, when broadband crossed the threshold of 10-percent penetration worldwide, a new and more sustained period of internet entrepreneurship has developed.

The U.S. economy has so far been the main beneficiary of the internet as a source of innovation and entrepreneurship.[140] This success is exemplified by the Silicon Valley technology cluster. Many countries have tried to imitate it.[141] Few have succeeded. The ingredients of success for ICT clusters have traditionally included close collaboration between academia and industry, easy access to venture capital, high levels of government research spending, and a physical environment and climate that is attractive to footloose, highly paid workers. However, in recent years, certain cities with doubtful climates have also developed a vibrant tech entrepreneurship scene, notably Bangalore, Berlin, Hangzhou, London, Nairobi, and New York. This suggests that the internet is creating a new set of geographical preconditions for innovation districts that are more about density and bandwidth than about sunshine and golf courses.[142] Specifically, the serendipitous "collisions" between like-minded individuals that create innovative ideas are more likely to occur in high-density urban environments than in lower-density locales where high-technology industry has traditionally flourished.[143]

Governments are generally not very good at picking technology winners. Nor can they easily create technology clusters, which tend to grow organically, where the right conditions are in place, as firms draw upon the same talent pool and startups spin off from established enterprises. From the recent development of tech hubs and FabLabs—for instance, there are now more than 555 FabLabs across 77 countries[144]—it is unclear if all of them would have come up organically, though government involvement in most of them has been minimal (box 4.9 and map 4.3). But government policy can help to sustain an emerging technology cluster, for instance by instituting favorable tax regimes or liberal policies on awarding employment permits to skilled workers ("tech visas"). Israel shows how government can stimulate the growth of an ICT cluster once it becomes established (box 4.10). Government procurement can also help create opportunities for local companies to flourish without infringing commitments to free trade, for instance by unbundling large ICT projects into smaller components. But governments also can unwittingly undermine a local ICT sector, with lax rules on intellectual property protection or burdensome taxes on the import of ICT goods and components.

National ICT strategies

In recent years, it seems to have become ever more complicated to develop a coherent set of policies to regulate and promote a nation's ICT sector. Rapid technological change, coupled with disruptive changes in the supply side of the industry and growing challenges on the demand side, requires flexibility. But industry players demand predictability in policy setting and a level playing field. ICT users are becoming ever more vocal, and expertise that may once have been centralized is now dispersed throughout government. So, coordination becomes all the more important.

When countries take a conscious decision to develop a national strategy for broadband, or their ICT sector more generally, they are rewarded with

Box 4.9 Tech hubs in Africa

The recent development of tech hubs across Africa (see map 4.3) exemplifies how technology clusters create a snowball effect whereby initial preconditions for success generate additional, mutually reinforcing innovation drivers. Though nowhere similar in scale to Silicon Valley, technology clusters in Africa nevertheless demonstrate that close collaboration between academia, government, and the private sector can help develop a vibrant ecosystem that facilitates ongoing innovation and market entry. Tech hub clusters, such as in Cape Town, Lagos, and Nairobi, show that once a certain threshold is passed, new hubs and ongoing entrepreneurial activity can be stimulated through enhanced access to finance, services to entrepreneurs, and the demonstration effects of successful "first mover" startups. The development of Nairobi's tech cluster dates to the founding of iHub in March 2010. Growth has spread, first to the rest of the Bishop Magua Centre where it is located (including Nailab, m:lab East Africa, and the longer-established Ushahidi), and then to nearby Strathmore University (where iBiz and iLab are located) and along Ngong Road to the GreenHouse and 88 mph/Startup Garage.[a]

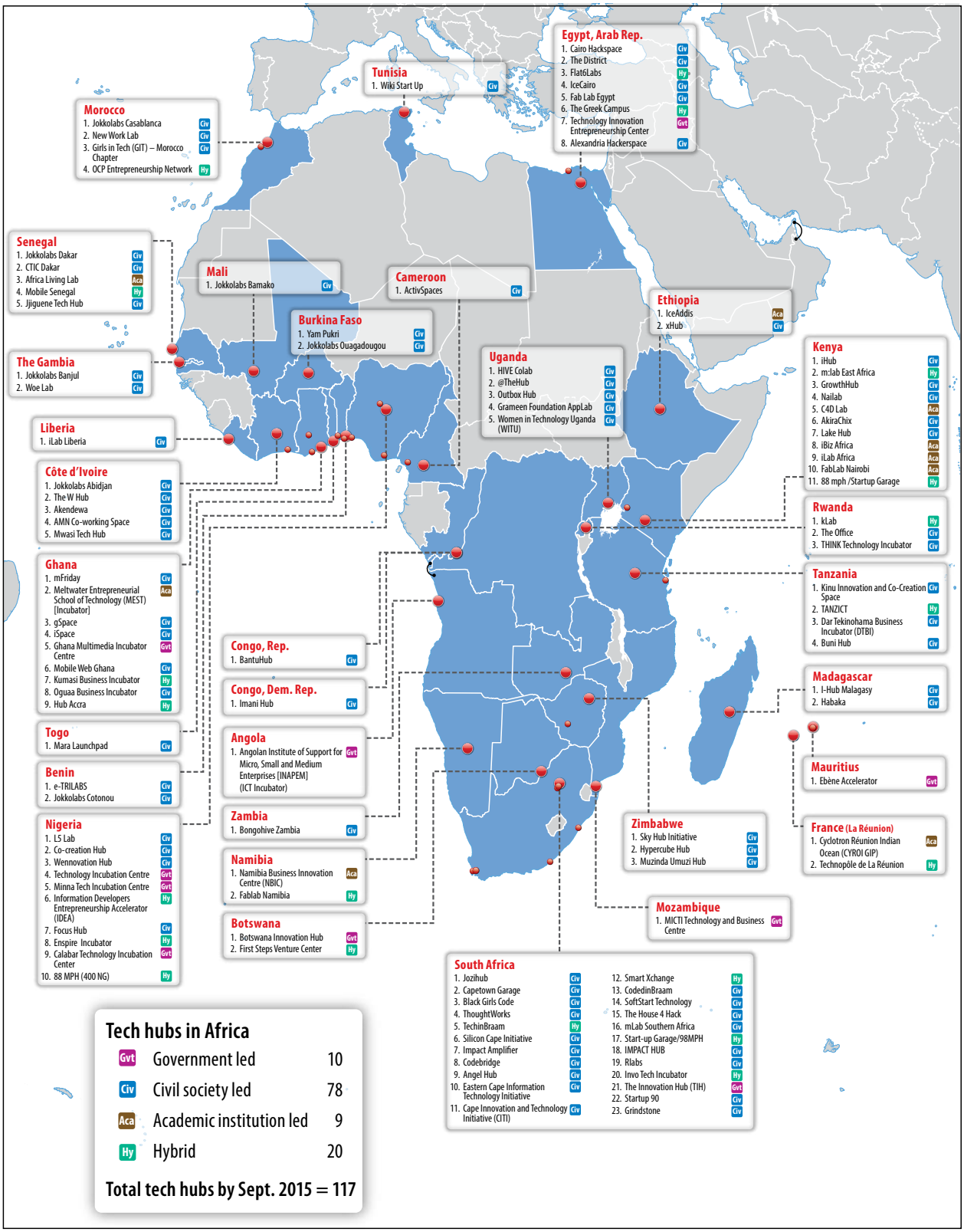
As with the creative destruction of the original dot-com bubble, many new startups, including some of the hubs themselves, have overestimated market demand for their products and services and ended up with short lifespans. Thus the turnover of hubs and incubators in Africa has been relatively rapid over the last five years,[b] but the growth path is still upward, with a net increase of around 15 percent since the start of 2014. Tech hub performance also depends on context-specific dynamics, and the situation of the local business community. However, the comparative success of certain clusters, while others remain stagnant, suggests that organic, multistakeholder ecosystems work better than initiatives led by government, the private sector, or academia alone.

a. Firestone and Kelly 2015.
b. http://www.gsmaentrepreneurshipkenya.com/GSMA_KENYA-AR2014-060214-WEB-SINGLE-PGS.pdf.

higher rates of service take-up.[145] As of mid-2013, some 134 countries had already developed national broadband plans, and a further 12 planned to do so. Once developed, plans need to be regularly refreshed and updated, ideally on a cycle of three to five years, according to the United Nations Broadband Commission, which has set a target that all countries should have a national broadband plan by 2015, with at least 40 percent of households in developing countries served with broadband.[146] National broadband plans are also more effective when they include specific benchmarks, or targets, that are relevant, measurable, realistic, and actionable. For example, Estonia has set a target that at least 100 Mbit/s broadband service should be available to each citizen by 2015.

What seems to be important is not so much the plans themselves, which vary enormously in quality and scope, but the consultation process for developing them and whether they can be easily implemented. In the same way that international internet governance has evolved toward a multistakeholder model, so too national strategies can benefit from ensuring that there is an opportunity for all stakeholders to express their views and that those views are reflected in policy making and regulation. In an era in which mobile subscriptions exceed the world's population, and with each internet user having within easy reach a vast library of global knowledge, ICT policy is too important to be left to the bureaucrats. Broad multistakeholder collaboration is the key. Equally important is the fact that digital development strategies need to be broader than they are today, strengthening the country's ICT infrastructure, but also the foundation underpinning its digital economy—an issue explored in the next chapter.

Map 4.3 African tech hubs



Source: WDR 2016 team. Interactive map and source data available at http://bit.do/WDR2016-Map4_3.

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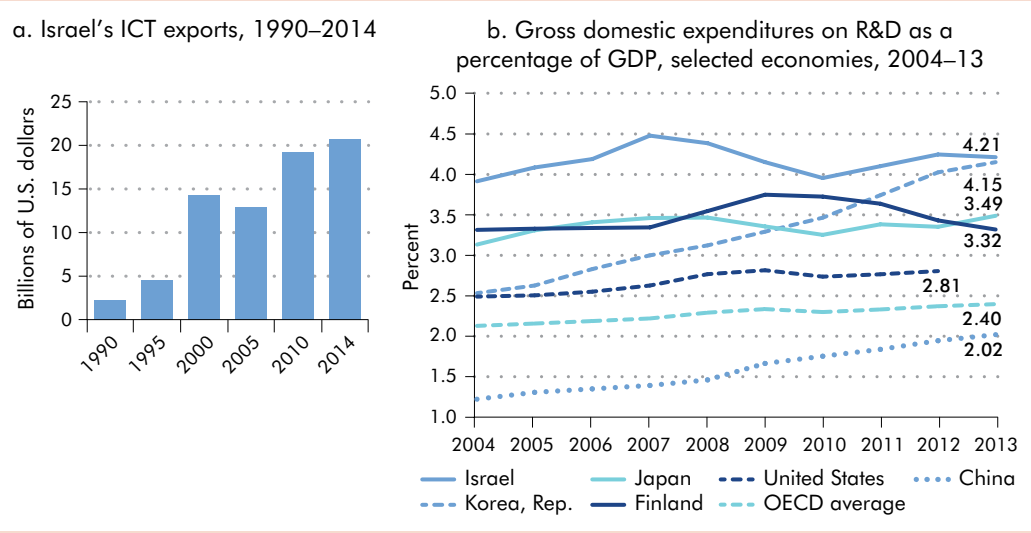
Box 4.10 Israel as a startup nation

The term "startup nation" was used to describe Israel in a 2011 best-selling book.[a] It takes as its starting point the 6,000 startups created between 2000 and 2010, more than twice the rate of the previous decade. In 2013, the information and communication technology (ICT) sector in Israel made up 16 percent of GDP and 26 percent of exports and employed 8.5 percent of its workforce.[b] It was also the fifth largest exporter of computer software and services in 2012, according to the World Trade Organization,[c] as ICT exports have increased almost tenfold since 1990 to over US$20 billion (figure B4.10.1, panel a).[d] A key ingredient in the success of the startup nation has been the role of the Israeli government, which designed its interventions so as not to hamper the emergence of the private sector.

Many Organisation for Economic Co-operation and Development (OECD) governments play an active role in funding innovation but Israel's program, from the very start in the late 1960s, has been particularly geared toward "sector-neutrality"—meaning that the government did not try to "pick winners." The program's design avoided crowding out private investment and stimulated additionality.[e] Recent programs have included the Tnufa program (since 2000), supporting entrepreneurs in the very first stages of development; Magneton (since 2001), supporting industrial/academic cooperation; the Public Technology Incubator Program set up in the early 1990s to help assimilate a wave of immigrants from the former Soviet Union; and the Yozma Fund, a venture capital fund set up in 1993 for technology companies. As a result, Israel consistently scores the highest level of gross domestic expenditures on research and development among OECD economies, although the Republic of Korea is catching up (figure B4.10.1, panel b).

But government support for firms in the ICT sector is not the whole story. Israel's government has promoted a high level of investment in education, and the sector has benefited from the innovativeness of the firm's themselves, which have been particularly successful in fields such as cybersecurity, mobile phone apps, and voice over internet protocol. Recent tech startups include Taboola (a content distribution and discovery platform), Silverbyte Systems (providing hotel management software), and Ceragon Networks (a wireless backhaul provider), while longer-established ones include Waze, which provides a location-based navigation app, and Wix, offering a cloud-based web development platform.

Figure B4.10.1 How Israel stays ahead in high-tech entrepreneurship



Source: OECD STI Indicators, available from http://www.oecd.org/sti/msti.htm. Data at http://bit.do/WDR2016-FigB4_10_1.

Note: In panel b, the percentages shown on the figure are for 2013, except for the U.S. percentage, which is for 2012. GDP = gross domestic product; ICT = information and communication technology; OECD = Organisation for Economic Co-operation and Development; R&D = research and development.

a. Senior and Singer 2011.
b. Getz and Goldberg 2015.
c. See https://www.wto.org/english/res_e/statis_e/its2014_e/its14_trade_category_e.htm.
d. Israel, Central Bureau of Statistics 2014.
e. Lach, Parizat, and Wasserteil 2008.

Notes

1. "High-speed internet" in this chapter is equated with fixed-line broadband service (such as digital subscriber line, cable modem, and fiber optics) and fourth-generation (4G) mobile services. Internet usage is much higher, at around 40 percent, but this is generally at slower speeds and is not necessarily affordable or "always on."
2. See chapter 1 and Kim, Kelly, and Raja (2010).
3. Markovitch 2013.
4. Qiang 2010.
5. UN Broadband Commission 2013.
6. Levinson 2007.
7. Internet protocol (IP)–based networks used packet-switching, a technology developed in the 1960s, that packages information into uniform chunks of digital data, or "packets," that can be used to transmit voice, text, video, or data. IP-based networks thus combine into a single network those functions that were previously handled by separate and distinct networks (Mathison, Roberts, and Walker 2012).
8. Wu 2010.
9. See Heeks (2014), notably figure 8 on the changing focus of ICT4D priorities over time.
10. IDATE 2014.
11. Cleland 2014.
12. Wheeler 2015.
13. The United States followed a different model of private ownership, but even there the monopoly of AT&T initially prevailed, as this was considered essential to achieving "universal service," a telephone in each home. An antitrust suit launched in 1974 eventually broke up AT&T into seven separate regional operators and a national long-distance and international carrier a decade later, opening the door for competition (Crandall 1991).
14. Harper 1997.
15. Cho 2002.
16. OECD 1999.
17. Ungerer 2000.
18. See http://ec.europa.eu/priorities/digital-single-market/.
19. The 69 World Trade Organization member countries that made commitments in telecommunications in 1997 have now risen to 108; see https://www.wto.org/english/tratop_e/serv_e/telecom_e/telecom_e.htm.
20. ITU 1997.
21. Wellenius and Stern 1995.
22. The cover photo illustrates a failing in all three ingredients for a successful digital policy: Djibouti Telecom is fully state-owned and enjoys monopoly status, contributing in part to its high prices for mobile service. But neighboring Somalia currently lacks a national communications act and sector regulator, which means that local operators function without internationally recognized licenses. Thus Somali migrants cannot roam in neighboring countries without changing their SIM cards.
23. Ampah and others 2009.
24. See https://gsmaintelligence.com/, although other sources such as Gallup World Poll show lower coverage.
25. ITU 2001.
26. See "WhatsApp Shows How Phone Carriers Lost Out on US$33 Billion," *Business Standard*, February 28, 2014, at http://www.business-standard.com/article/international/whatsapp-shows-how-phone-carriers-lost-out-on-33-bn-114022200022_1.html.
27. In the first half of 2014, Netflix accounted for 35 percent and YouTube 13 percent of internet data traffic to users in the United States, during peak periods on fixed networks, according to Sandvine (2014).
28. Cisco 2015.
29. Cisco 2015.
30. Regional average data from GSMA at www.gsmaintelligence.com.
31. Minges 2015.
32. Evans, Groves, and Croft 2014.
33. Stock market valuations change constantly, but on May 18, 2015, China Mobile had a market valuation of US$276.45 billion on revenue of US$103.21 billion, while Alibaba had a market valuation of US$217.26 billion on revenue of just US$12.26 billion, according to Yahoo Finance.
34. Investment in constant U.S. dollars fell to US$248 billion in 2013, down from US$357 billion in 2008, before the financial crisis, according to data on private sector investment in telecoms, sourced by the Public-Private Infrastructure Advisory Facility (PPIAF) and available at http://data.worldbank.org/indicator/IE.PPI.TELE.CDcountries/1W?display=default.
35. Office of Legislative and Public Affairs 2003.
36. The announcement of the transition was on March 14, 2014, by the National Telecommunications and Information Administration of the U.S. Department of Commerce, but the completion date was later delayed by one year to September 2016. For more information, see https://www.icann.org/resources/pages/process-next-steps-2014-10-10-en and http://www.ntia.doc.gov/blog/2015/update-iana-transition.
37. For more information on different national research and education network models, see the South-South Exchange of Research and Education Experience, at https://openknowledge.worldbank.org/handle/10986/12367.
38. See the regulatory information section of ITU's ICT Eye database, at http://www.itu.int/icteye.
39. As an example, the Communications Authority of Kenya, for the financial year ending June 30, 2012, records a surplus of around K Sh 7.0 billion (around

US$74 million) on income of K Sh 8.8 billion (US$98 million), a surplus of around 80 percent. This is over and above other taxes and other financial contributions from the sector. See the *Communications Authority of Kenya Annual Report, 2012–13*, http://www.ca.go.ke/images//downloads/PUBLICATIONS/ANNUALREPORTS/Annual%20Report%20for%20the%20Financial%20Year%202012-2013.pdf.

40. Blackman and Srivastava 2011.
41. Rijkers, Freund, and Nucifora 2014.
42. *Economist* 2012.
43. See GSMA at https://gsmaintelligence.com/.
44. ITU estimates that some 95 percent of the world's population lived within range of a mobile signal in 2015 (ITU 2015).
45. This aggregate statistic (68 percent) is derived from GSMA (http://www.gsmaintelligence.com), which estimates that, as of Q4 2014, some 98 percent of the citizens of developed economies and 62 percent of developing ones lived within range of a 3G signal. The equivalent figures for 4G/LTE were 88 percent and 15 percent, giving an aggregate of 26 percent.
46. Mayer and others 2008.
47. As an example, the Comoros opened its mobile market to competition in 2007, but the incumbent operator, Comoros Telecoms, was successfully able to resist interconnection due to weak regulation, and the market entrant, Twama Telecom, never started service (World Bank 2014). The Comoros announced a license award for a new second operator, won by Telma, in October 2015.
48. Third-generation (3G) and fourth-generation (LTE) operate in multiple spectrum bands, but mainly at 1,800, 2,300, and 2,600 MHz. In countries where the transition to digital broadcasting is complete, the more valuable spectrum of 700 MHz can be released for mobile communications. This is more attractive to investors as fewer cells are needed to cover the same territory (Dahlman and others 2007).
49. See Partnership for Measuring ICT for Development 2014.
50. Ros and Banerjee 2000.
51. Wellenius 2002.
52. GSMA (Global System for Mobile communications Association) 2013.
53. Minges and others 2014.
54. UN Broadband Commission 2015, 64–69.
55. See http://www.fcc.gov/encyclopedia/connecting-america.
56. See http://ec.europa.eu/digital-agenda/ and https://ec.europa.eu/digital-agenda/en/connecting-europe-facility#the-connecting-europe-facility-to-support-eu-infra.
57. This calculation is based on projects that have received a waiver from the European Commission for the use of state aid in the deployment of broadband networks (see http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf).
58. Marino García 2015a.
59. Coleago Consulting 2013.
60. Plum Consulting 2013.
61. Moore 1965.
62. See http://www.mkomo.com/cost-per-gigabyte-update.
63. Biggs and Kelly 2006.
64. *Economist* 2015.
65. This is sometimes referred to as Amara's Law.
66. See http://articles.latimes.com/2006/jul/16/business/fi-overheat16.
67. Samarajiva 2010.
68. Genakos and Valletti 2014.
69. Littlechild 2006.
70. Kemei and Kelly 2015.
71. ITU 2014.
72. http://www.oecd.org/sti/broadband/price-baskets.htm and http://www.oecd-ilibrary.org/docserver/download/5k92wd5kw0nw.pdf?expires=1419284221&id=id&accname=guest&checksum=70B5A3123B6297371A59AC6F4C97AC55.
73. ITU 2014.
74. ITU 2014.
75. Boston Consulting Group 2012.
76. World Bank, forthcoming.
77. See https://www.washingtonpost.com/news/the-switch/wp/2015/09/22/dig-once-the-no-brainer-internet-policy-the-white-house-just-endorsed/.
78. Packet Clearing House 2015.
79. Kende and Hurpy 2012.
80. Kende and Rose 2015.
81. Regulation (EC) No. 2887/2000 of the European Parliament and of the Council of December 18, 2000, on unbundled access to the local loop, at http://europa.eu/legislation_summaries/information_society/internet/l24108j_en.htm.
82. Klein and Wendel 2014.
83. See https://apps.fcc.gov/edocs_public/attachmatch/DOC-327104A1.pdf.
84. See http://www.washingtonpost.com/blogs/the-switch/wp/2014/12/23/fcc-confirms-that-680000-net-neutrality-comments-weremissing-from-the-public-record/.
85. See http://www.nytimes.com/2015/02/27/technology/net-neutrality-fcc-vote-internet-utility.html?_r=0.
86. UNESCO. See, specifically, Article 19 of the International Covenant on Civil and Political Rights (ICCPR); Article 13 of the African Charter of Human Rights (ACHR); Article 9 of the African Charter; and Article 10 of the European Court of Human Rights.
87. See Open Network Initiative at http://map.opennet.net/filtering-pol.html.

88. Dutton and others 2013.
89. Clover 2015.
90. Waldfogel 2011.
91. Internet Society 2014.
92. See http://www.ndtv.com/india-news/supreme-court-reserves-orders-on-validity-of-section-66a-of-it-act-742758.
93. See http://www.google.com/transparencyreport/.
94. See http://www.google.com/transparencyreport/traffic/.
95. See http://blogs.wsj.com/chinarealtime/2015/02/12/china-internet-restrictions-hurting-business-western-companies-say/.
96. This chapter similarly adopts an expansive view of "cybersecurity" and delves more deeply into some aspects of cybersecurity—such as privacy and cybercrime—separately.
97. See Bauer and Dutton (2015), citing other sources.
98. Bauer and Dutton 2015.
99. Article 17 ICCPR; Article 11 ACHR; Article 8 ECHR; and UNGA resolution 68/167 (2013) on the right to privacy in the digital age.
100. YCharts, Facebook Market Cap (June 10, 2015); see http://ycharts.com/companies/FB/market_cap.
101. WEF 2014.
102. Dutton and others 2013.
103. FTC 2013.
104. See http://www.washingtonpost.com/blogs/the-switch/wp/2014/11/13/facebook-rewrites-its-privacy-policy-so-that-humans-can-understand-it/.
105. Polonetsky, Tene, and Jerome 2014.
106. World Bank and Second Muse 2014.
107. See http://georgemdallas.wordpress.com/2014/06/05/making-sense-of-internet-platforms-network-effects-and-two-sided-markets/.
108. Haddad and others 2014.
109. Berlingerio and others 2013.
110. See http://www.economist.com/news/leaders/21627623-mobile-phone-records-are-invaluable-tool-combat-ebola-they-should-be-made-available.
111. See Article 29 Data Protection Working Party 2014.
112. See https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-staff-report-november-2013-workshop-entitled-internet-things-privacy/150127iotrpt.pdf.
113. Recent jurisprudence from both the European Court of Justice (ECJ) and the European Court of Human Rights (ECHR) support striking this balance. In *Digital Rights Ireland Ltd v. Ireland* (Joined Cases C-293/12 and C-594/12 *Seitlinger and Others*, April 8, 2014), the ECJ ruled the Data Retention Directive to be in violation of the EU Charter of Fundamental Rights. In *S and Marper v. UK* 30562/04 [2008] ECHR 1581 (December 4, 2008), the ECHR, using a proportionality analysis, found the United Kingdom to be in breach of Article 8, holding that the long-term retention of both fingerprints and DNA samples interfered with an individual's right to privacy.
114. See http://www.bbc.com/news/technology-29276955.
115. Doupi and others 2010.
116. *Google Spain and Google vs. Agencia Española de Protección de Datos (AEPD) and Mario Costeja González* [Case No. 131/12, 2014] European Court of Justice.
117. Ausloos 2012.
118. See Schwartz and Solove (2014). The EU generally prefers legal instruments that position privacy as a human right, whereas the United States relies more on self-regulation, seeing privacy as a consumer protection issue.
119. UNCTAD 2015
120. UN General Assembly 2013.
121. See the African Union Convention on Cybersecurity and Personal Data Protection (July 27, 2014).
122. OECD 2013. The *OECD Privacy Guidelines* incorporate a "Recommendation Concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data."
123. See http://www.apec.org/Groups/Committee-on-Trade-and-Investment/Electronic-Commerce-Steering-Group/Cross-border-Privacy-Enforcement-Arrangement.aspx.
124. European Commission (EC 2010).
125. White House 2012.
126. *Maximilian Schrems vs. Data Protection Commissioner* [Case No. C-362/14, 6 October 2015] European Court of Justice.
127. The recent decision by the European Court of Justice about the "right to be forgotten" *(Google Spain and Google vs. Agencia Española de Protección de Datos [AEPD] and Mario Costeja González* [Case No. 131/12, 2014]), which requires search engines to remove links to data upon request if they are inadequate or irrelevant, throws into question not only the balance of data protection and freedom of expression rights, but also extraterritorial application of law and perhaps irreconcilable compliance obligations of multinational companies processing data across borders.
128. See https://www.huntonprivacyblog.com/2015/01/articles/deadline-for-compliance-with-russian-localization-law-set-for-september-1-2015/.
129. See http://www.theguardian.com/us-news/2015/may/07/nsa-phone-records-program-illegal-court.
130. Castro 2013.
131. Dutton 2015.
132. The origins of the debate around net neutrality are the U.S. Communications Act of 1996, as amended. Under the act, "telecommunications services" are regulated under common carrier rules, and other communications services, such as data, are regulated differently. In the United States, the internet

has been classified as a data service and therefore not subject to the same regulatory rules as telecommunications services. In most other jurisdictions, the distinctions found in the act do not apply, although the term *net neutrality* (though derived out of specific statutory language) has come to be applied globally.

133. See http://trak.in/tags/business/2015/04/17/trai-airtel-zero-internet-org-against-net-neutrality-violate-free-internet/.
134. West 2015.
135. See http://www.bbc.com/news/technology-32334181.
136. Council of Europe 2010.
137. See http://www.ohchr.org/en/professionalinterest/pages/ccpr.aspx.
138. See http://www.forbes.com/billionaires/list/#version:static.
139. Citation from entrepreneur Mark Simon, quoted in Madslien 2010.
140. Kushida 2015; Minges 2015.
141. Bresnahan, Gambardella, and Saxenian 2001.
142. Katz and Wagner 2014.
143. See http://fortune.com/2012/05/09/the-random-collision-theory-of-innovation/.
144. FabLabs are similar to Tech Hubs, but focus more on making physical prototypes than software, content and applications development; see, for instance, Tokushima and Tanaka (2015).
145. The United Nations Broadband Commission (UN Broadband Commission 2013) reports that the 134 countries that had a national broadband plan as of mid-2013 had, on average, some 2.5 percent higher fixed broadband penetration and 7.4 percent higher mobile broadband penetration.
146. See http://www.broadbandcommission.org/about/Pages/default.aspx.

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