United Nations E/CN.16/2012/2

Economic and Social Council

Distr.: General
12 March 2012

Original: English

Commission on Science and Technology for Development
Fifteenth session
Geneva, 21–25 May 2012
Item 3(a) of the provisional agenda

Innovation, research, technology transfer for mutual advantage, entrepreneurship and collaborative development in the information society

Report of the Secretary-General

Executive summary

This report presents key processes through which developments in information and communication technologies (ICTs) and the information infrastructure are supporting progress towards the building of knowledge societies that are responsive to the development aspirations of low- and middle-income countries. A central theme is that processes of learning by collaboration are central to innovation, research, technology transfer, and entrepreneurship. The report contains recommendations for consideration by national governments and the international community.

Introduction

1. The Commission on Science and Technology for Development (CSTD) decided to examine "innovation, research, technology transfer for mutual advantage, entrepreneurship and collaborative development in the information society" as a priority theme during its 2011–2012 intersessional period, within its mandate to assist the Economic and Social Council in the follow-up to the outcomes of the World Summit on the Information Society (WSIS).

2. In order to contribute to further understanding of the issues within this theme and to assist the CSTD in its deliberations at its fifteenth session, the UNCTAD secretariat convened an intersessional panel meeting in Manila, Philippines, from 13 to 15 December 2011. The present report is based on the issues paper, the findings of the panel, contributions by members of the CSTD, and other relevant literature.

3. The CSTD, within its original mandate on science and technology for development, has examined the relationships between innovation, research, technology transfer and entrepreneurship, through its work programme on the following themes: (a) science, technology and engineering for innovation and capacity-building in education and research (2007–2009); (b) new and emerging technologies (2010); and (c) technologies to address challenges in areas such as agriculture and water (2011). Some of the key findings and recommendations of the Commission are:

(a) The potential contribution of science, technology and innovation (STI) to the achievement of development goals is, and will continue to be, constrained by structural barriers and systemic weaknesses at local, national and global levels, and by the long lead time required to build indigenous technical and non-technical STI capabilities. The accumulation of capabilities at all levels is a long-term process, which takes decades rather than years;

(b) Indigenous capabilities in STI are essential for the achievement of both short- and long-term development goals. These capabilities, collectively, are the ability to acquire, absorb, adapt, diffuse and adopt existing knowledge and the capacity to produce and use new knowledge. They are crucial for every country, regardless of stages of development. Building these capabilities is the role of STI policy, which should be at the heart of national development strategies;[1]

(c) Building innovative capabilities at the national level requires, inter alia: (a) a clear strategy, and sustained commitment over a long period of time; (b) human capital formation through education and training; (c) the establishment of effective government support for building capabilities in the private sector; and (d) interventions in a range of policy areas;[2]

(d) North–South and South–South transfer of technology, and corresponding knowledge about how to use the technology (in other words, "know-how") play an important role in the development of capabilities. However, efforts at building local innovative capabilities ("know-why") are essential too, for technology to be modified and adapted to local needs. The transfer of technology should not replace but rather

[1] United Nations (2008) and United Nations (2009).
[2] United Nations (2009).

complement domestic capacity-building efforts, which should be supported by domestic policies that foster learning;[3]

(e) In many developing countries, enterprises, especially small and medium-sized enterprises (SMEs) are, collectively, the key drivers of growth. Fostering their development, including their innovative capabilities, is therefore a key policy issue. National governments are encouraged to explore the use of a range of direct policy mechanisms and instruments to stimulate learning and innovation in enterprises, along with other policies including those related to, inter alia, trade, investment and competition policies, industrial or other sectoral policies, labour policies, and – crucially – education, training and research policies;[4]

(f) In addition to technical, financial, institutional and policy mechanisms, stimulating innovation in any economy requires broad and far-reaching shifts in how people and society view change, creativity and learning. Some successful measures to foster an "innovation-friendly" culture include awareness campaigns through the mass media, role models, the dissemination of success stories, and high-profile awards. These contribute towards inspiring confidence, and encouraging risk-taking among the population, especially youth.[5]

4. The Internet has provided a basis for interactivity, and is providing platforms that are transforming the way in which businesses in all sectors of the economy as well as public-sector organizations are organizing their internal and external information and communication networks and practices. The extension of global networks based on the Internet Protocol and the use of wireless technologies and mobile voice and data applications continues to be uneven in developing countries. Nevertheless, there has been a step shift over the past decade in the availability of networks and online applications. The potential for the use of ICTs to enable "catching up" by developing countries is signalled by the declining cost of digital technologies, networks achieving global reach, and software applications for all kinds of purposes becoming increasingly ubiquitous. These developments are significantly affecting the relationships between innovation, research, technology transfer, entrepreneurship, and collaborative development. In particular, the changing ICT landscape offers significant opportunities for "learning by collaboration", which have the potential to stimulate initiatives in each of these areas.

5. At the same time, these developments have raised concerns that developing countries may risk falling further behind due to the digital divides. Recent years have seen concerted efforts from the international community to bridge these divides. However, it has been argued that the focus of international attention has been predominantly on access to ICTs and their adoption and diffusion, whereas more attention ought to be devoted to the shaping of technology development, to ensure that this is responsive and appropriate to the needs in developing-country contexts. ICT priorities in the advanced industrialized countries may not be the same as those in developing countries. Indeed, there has been an emergence of hardware and software innovations from the South which address local needs, conditions, and, often, constraints, such as affordability and illiteracy, or last-mile connectivity challenges. Often termed "constraint-based" or frugal innovation, these cases illustrate the importance of technology development in the South, as well as the potential of South–South collaboration and technology transfer.

[3] United Nations (2010).
[4] United Nations (2008).
[5] *Ibid.*

I. ICTs: Opportunities for catching up and leapfrogging

6. ICTs play a fundamental role in stimulating economic activity and innovation in the knowledge-based society, through their potential to augment learning through networked collaborations in which online interactions play a central role. This potential is at the heart of new opportunities for developing countries for catching up and leapfrogging by applying ICTs to strengthen the essential innovative capabilities that make it feasible to exploit the gains from the application of ICTs in stimulating economic activity. This applies to every branch of the economy, from agriculture to manufacturing to services.

7. In the past decade, it has become clear that the use of ICTs has the potential to support the development strategies of catching up and leapfrogging. Catching up involves the innovative process of adapting and improving technologies already in use. ICTs have played an important role in the most rapidly growing economies, offering a "sunrise" industry with enormous growth potential. In addition, in a number of industries, particularly those classified as "high technology", rapid change in the underlying technology reduces the importance of incumbency. Catching-up capabilities are constructed incrementally based upon experience, with high-technology industries demanding a faster and more efficient process of capability-building than less technology-intensive industries.

8. Leapfrogging – the bypassing of some of the accumulative steps in human capabilities and fixed investment – makes it possible to narrow gaps in productivity and output that separate industrialized and developing countries. Because of leapfrogging, catching up has proceeded more rapidly in high-technology industries than in other industries. High-technology industries have enjoyed a sustained increase in the share of international trade for a prolonged period, growing more rapidly than other industrial classes such as primary products and low- and medium-technology products.[6] Even though industries at lower levels of technological sophistication have expanded their share of exports less rapidly than high-technology industries, the deployment of more advanced process technologies, particularly when they involve the use of ICTs as general-purpose technologies, also creates opportunities for improving productivity and quality.

9. An important factor in catching up and leapfrogging is the emergence of Internet technologies and applications supporting the global flow of information and the emergence of online collaborative working in the value chains of production networks. There is ample evidence that new technologies and innovative performance require a process of learning and adaptation in which skills are gained and adaptations are made.[7] These abilities for learning and adaptation are referred to as "absorptive capabilities".[8] Productive capabilities depend upon success in integrating a variety of technologies and fostering new organizational and management skills.

10. A key feature in the development and use of modern productive capabilities is the capacity to build and manage production networks, which embrace collections of firms that divide and coordinate labour in a fluid or loosely collaborative manner. Production networks offer wide-ranging opportunities for collaboration without binding supplier firms to the control of a particular purchaser. They offer important entrepreneurial opportunities because product selection, particularly in producer goods and component industries, is often made on the basis of quality and price, rather than on the basis of long-term relationships or national preferences. Collaboration and collaborative development have become more important because of the demands of international coordination of design, specification and

[6] UNCTAD (2003) :15 and National Science Board (United States) (2010).
[7] Hobday (1995).
[8] Cohen and Levinthal (1990).

sourcing of products. The closer integration expected within value chain networks benefits from the ability to define common standards and to collaboratively manage product and component design and the flow of intermediate production and distribution stages through the value chain using ICTs.

11. Productive capabilities include specific and local processes of knowledge adaptation and recombination that support the productive operations of the firm. These productive capabilities are generally industry-specific, and often have firm-specific features. It is, nevertheless, becoming difficult to find operations whose planning, monitoring or control cannot benefit from the use of ICTs, regardless of whether these ICTs are stand-alone personal computers or parts of globally connected networks. In more advanced contexts, ICTs are deeply embedded in the production process itself, with capital goods employing programmable features and productive operations being coordinated by locally networked computer systems.

12. Finally, the near universality of ICT applications means that catching up and leapfrogging requires the development of capabilities that are fit for purpose in the Internet age. The prospects for building absorptive and productive capabilities have been changing dramatically with the spread of the Internet and its applications, and learning by collaboration online is becoming a ubiquitous phenomenon. Some of the factors that have enabled these developments include:

(a) Growing use of ICT-facilitated international division of labour in research and in key features of the innovation process such as new product development and design and knowledge process outsourcing;

(b) Substantial changes in research accompanying the growth of "open innovation";[9]

(c) Substantial growth of outsourcing activities, including the rise of "contract manufacturing";[10]

(d) The growing availability of software applications supporting entrepreneurship in business and changes in supply chain management;

(e) Platforms for virtual teamwork and collaboration employing resources of the information commons and various forms of commons-based peer production; and

(f) Unprecedented growth in the variety of "open" formats for the distribution of information and "libraries" from which this information can be drawn, which, in turn, serve as foundations for knowledge management and learning by collaboration.

13. The process of learning by collaboration based on ICT networks and applications has the potential to support catching up and leapfrogging in ways that were not feasible in collaborations involving earlier deployments of the global information infrastructure.

[9] There is growing potential for developing countries to engage in international research collaboration networks benefiting from "grid computing" for online engineering and other science-based projects.

[10] Contract manufacturing is used in sectors such as aerospace, defence, computing, food, and energy, often involving complex assembly whereby a firm approaches a contract manufacturer with a design or a formula. See Cohen and Roussel (2005) and Lee, Park, Yoon et al. (2010).

II. Capacity-building for innovation, research, technology transfer and entrepreneurship

A. Collaborative learning and absorptive capacity

14. There are real prospects for developing countries to generate commercially significant new ideas based either on novel ICT applications, or on the use of existing and local knowledge in combination with other technologies. Capitalizing on these prospects would require a focused strategy of investing in innovative capabilities.

Capacity-building at the individual level

15. At the individual level, capacity-building efforts should go beyond the provision of simple skills. It is not sufficient to simply provide individuals with "operator" skills; rather, they need to be empowered to filter, adapt and ultimately exchange knowledge, and to undertake independent initiatives that are entrepreneurial. Education is therefore crucial, not only in terms of "broadening horizons", but also, specifically, in fields which emphasize knowledge with an established basis such as science or engineering, or which provide a broad and comparative approach to other fields such as the social sciences or humanities.

16. Also of critical importance are the social context of the individual and the opportunities for learning.

17. Learning is collaborative: Without a local community sharing interests and enthusiasm, few individuals are likely to progress beyond the most elementary of skills. Many capacity-building ICT projects and initiatives, however, tend to overlook the essential role of the community surrounding the use of ICTs. The social context is essential in filtering, referral, adaptation, and – ultimately – the exchange of knowledge involved in the "transfer" of technology.

18. Open source software is especially important because of the potential it offers for learning by collaboration. The development of the open source software movement has enhanced opportunities for individuals to acquire understanding of a documented logic of how advanced software products can be created and deployed in productive sectors of developing-country economies.

19. Individual empowerment is the visible tip of a major trend that is driving an evolving international division of labour that is opening opportunities for those who are able to take advantage of them. Box 1 contains an example from freelance employment which is driving local demand for ICT services and generating income. Recent research highlights a considerable increase in the incidence of virtual teams linking SMEs.[11]

Box 1. Online collaboration in a low-income-country context[12]

According to the Bangladeshi Software and Information Services Association, which is one of a growing number of companies "brokering" the labour of online workers, an estimated 10,000 Bangladeshi freelancers are active online. The majority of these workers provide ICT-related services (e.g. software development, graphic design, search engine optimization, social media marketing, blogging, and data entry) to European and United States clients, usually SMEs. They also work for local government institutions, non-

[11] Ale Ebrahim, Ahmed and Taha (2009).

[12] UNCTAD (2011) :55.

governmental organizations (NGOs) and individuals. Projects vary from building large e-commerce websites to doing product entry on eBay or posting positive feedback for companies on review websites.

Through popular online portals such as www.bworker.com, www.odesk.com and www.freelancer.com, freelancers are hired on an assignment basis to supplement their day jobs or provide for themselves while enrolled in information technology faculties. Average projects can generate a few hundred or a few thousand dollars. While some projects can range up into the tens of thousands of dollars, taking months to complete, the most common are small projects with multiple clients on a day-to-day basis.

Capacity-building at the organizational level

20. Considerable progress has been made over the past decade in broadening and deepening the portfolio of software products available for managing organizations' data and knowledge resources. Most of these developments involve the utilization of networks and, specifically, the use of an Internet browser. Many involve standard platforms, the use of which is motivated by the widespread perception that the capture, storage and analysis of data generated by business operations can provide important gains in planning and taking strategic decisions and in the control and execution of operations. These developments are also providing means for linking to suppliers and customers in ways that are more collaborative and innovative than earlier electronic and non-electronic methods.

21. In addition, new software applications emerge from collaborative discussion concerning the need for and value of new solutions. Over the past decade, important developments have been made in building professional networks and in tools for collaboration – collaboration within companies, and between companies and their suppliers and customers. Examples include (a) customer relations management software; (b) software for computer-supported cooperative work, which is often organized around computer-aided design and manufacturing software; and (c) software for collaborative document creation.[13]

22. Capacity-building at the organizational level often starts with meeting the internal needs of the organization for information collection and processing, followed by initiatives to engage in collaborative learning with other organizations and individuals. Companies begin with applications that address their own immediate informational needs, such as accounting, payroll and inventory systems. The requirements of data entry and reporting lead to the distribution of this information within companies and a process of internal collaborative development. This is often augmented by collaborations with external software suppliers as companies adopt available commercial packages.

23. As companies become more active developers and users of software, they begin integrating their supplier and reseller relationships with their internal systems – a process that requires collaborative development and further interaction with software solution providers. Companies progress from managing their own operations to interacting with their customers and suppliers in creating larger networks – some of which become large-scale platforms for market exchange. An example of this is the development of the business-to-business (B2B) network in China described in box 2.

[13] An important example is the "wiki" – the type of software employed by Wikipedia, one of the world's largest collaborative knowledge-development efforts involving over 20 million articles in 269 languages. Wikis are also employed in content management systems in business, universities and government agencies (Wood, 2010).

Box 2. China experiencing rapid growth in business-to-business (B2B) networks

The Chinese Government has been developing B2B e-commerce, an example of which is the *China National Commodity Exchange Centre.* Established in 1997, this centre currently has more than five million registered members and supports the exchange of 500 classified products in 26 countries, by collecting and distributing information about commodities, firms, online negotiations, bidding, purchasing, settlement and distribution. It has also supported the development of Alibaba, which is an e-market for domestic trade aimed at SMEs, providing online payments and a trusted platform for traders.[14]

24. Similar processes occur upstream in the research process. Organizations in industrialized countries are establishing research and development (R&D) offices overseas with responsibilities for recruiting skilled local scientists or engineers for research. These interactions are not exclusively originating in the high-income countries; middle-income countries are actively investing in research centres in the high-income countries and in other middle-income countries. Often, these "offshore" research teams are actively networked in a collaborative global R&D capability, using advanced ICTs. This makes it possible to communicate in real time, and, through the exchange of data, to develop virtual prototype designs created by means of computer-aided design and engineering software. In some cases, specialized and industry-specific capabilities are enabling the use of ICTs to support gene sequencing, tissue sampling, and a growing array of techniques in materials sciences and chemistry.

25. When fully developed, new organizational capabilities make it possible for companies to profit from inter-organizational networks such as B2B e-commerce and to organize and coordinate research within a country and, ultimately, on a global basis.

B. Collaborative learning and productive capacity

26. With regard to building productive capability, the role that production networks and value chains play as lead users in building collaborative learning is crucial. Research, technology and innovation are undergoing important and rapid changes in this area. Greater international division of labour is occurring in research, and innovative product design and development processes are being fostered and supported by ICTs and the Internet. International cooperation in the provision of open data and resources, and collaboration in building platforms addressing social needs, are parallel developments. In both cases, new tools for collaboration and technology transfer are aiding the process.

The leading role of production networks and value chains in developing productive capacities

27. The coordination of supply networks and vertical chains of production is largely driven by commercial need, and often increases access to investment resources. Increases in the global division of labour, which help account for the continuing rise in intra-industry trade flows, mean that component and subsystem supply must be coordinated across organizational and international boundaries. In addition, the increasing pace and volume of trade in commodities on a global basis has demanded improved coordination in the production of primary sector goods (agriculture, petroleum and mining).

[14] See Zhao, Wang and Huang (2008).

28. In many other cases, more timely information, or more detailed information with regard to product qualities, production and logistical timing, conveys additional economic value by supporting more effective coordination of supply and demand. This is particularly important in situations characterized by price volatility, interdependencies of components in larger systems, and a need for coordination between production and use. The Internet is ideal for supporting these productive needs, and the ability to use the Internet for these forms of coordination is key. Developing such abilities involves collaborative learning in which data standards for ordering, invoicing, product specification, and logistics must be agreed, along with many other specialized arrangements that are industry-specific, as illustrated in box 3.

Box 3. Mexican agricultural exports to the United States and Canada

The North American Free Trade Agreement created major prospects for Mexican agricultural exports northwards. However, following the attacks on the United States on 11 September 2001, international border inspections became more time-consuming and subject to significant delays, threatening the economic value of perishable goods in transit. In order to avoid these delays, video-monitored freight loading was combined with freight transit monitoring using radio frequency identification (RFID) and encrypted data container seals to offer sufficient security to bypass ordinary border inspection delays, resulting in the delivery of perishable products in a timely and predictable way.[15]

29. The example of Mexican agricultural exports highlights the role of ICT-enabled systems in agriculture more generally. ICTs are being used to support access to market information, distribution supply-chain management traceability, financial services (mobile payments and mobile banking), farm extension services, sector experience, research and related resource information, commodity exchanges, and warehouse receipt systems. In all of these applications, a process of collaborative learning between multiple stakeholders is necessary for successful planning and implementation of such systems. In areas that are well served by advanced telecommunication networks, many of these developments can proceed simultaneously. In low- and middle-income countries with less well developed communication networks, the higher-value applications of data communication are being implemented using satellite data-communication networks. To create and utilize these networks, collaborative learning is required in order to coordinate standards and other elements required for the conduct of business and research on a globally distributed basis.

30. The historical processes of telecommunication involving sporadic and modest levels of data exchange are being supplanted by more sophisticated systems. The newer systems involve instantaneous communication of large volumes of data, detailing product specifications, production timing data and electronic monitoring of goods in transit by means of RFID, the Global Positioning System (GPS) or other systems. Similar developments are occurring in the service industries, and these developments are being extended to low- and middle-income countries.

31. The process of building productive capabilities is consistent with the international mobility in production and research. Improvements in the quality of telecommunication networks, the development of supporting infrastructure, and market conditions for technically skilled employees can support the relocation of firms to low- and middle-income countries.

[15] See Borbon-Galvez (2011).

"Open data" and networks for productive capacities

32. The Internet offers potential for global collaboration in the creation of information resources that can be shared by all and used as a foundation for building entrepreneurial initiatives in the private sector and for meeting social needs. The variety and volume of "open data" is rapidly expanding (e.g. data on chemicals, as described in box 4). The availability of such resources is a major challenge, especially when conceiving how these resources might be recombined and how value might be added to them in order to innovate in products and services. It is also a major opportunity for developing productive capacities, often through processes of collaborative learning, either for deepening or extending markets or for meeting social needs.

Box 4. Online data resources on chemicals

One of the richest resources at the boundary between science and technology is chemistry. For decades, chemists have built data resources systematically, cataloguing the natural and man-made chemical compounds, their properties, preparation, and possible uses. Some of these compounds have been patented and, of these, many patents have expired or not been renewed. Commercial applications have not yet been found for many other compounds. With the development of online resources, this rich collection of data, which is generally accessible, is providing a basis for new research and commercial opportunities.[16]

33. In addition to scientific and engineering data, open data encompasses the growing array of social, cultural and economic data that is freely available, much of which provides a basis for applications meeting social needs. Examples include the United Nations Secretary-General's Global Pulse initiative,[17] and the World Bank's Apps for Development challenge.[18] Also, in the area of healthcare networks, there are numerous experiments with advanced technologies enabling consultation regarding patient health.[19] In the field of knowledge management, the prospects for improving linked enterprise data are growing as practical applications for working with metadata are developed for sectors including pharmaceuticals, chemistry and agriculture. These applications employ wikis, semantic tagging and other "enterprise 2.0"[20] applications to improve both access to digital information and the flow of that information.

34. These applications are likely to become more sustainable if they can be organized within a collective model of network access. These are all examples of "lead uses" for the infrastructure and applications. These applications also require collaborative learning in order to adapt and customize prototypes and experimental designs to make them valuable adjuncts to existing local practices.

35. The creation and use of geographical mapping applications is currently advancing rapidly. "Crowdsourcing" of real-time data in response to crisis situations is providing

[16] Curry, Freitas and O'Riain (2010).

[17] See http://www.unglobalpulse.org/. The network aims to harness digital data and real-time analytics to address issues of public health and crisis communication by mapping and visualizing locally generated data.

[18] See http://appsfordevelopment.challengepost.com/. The initiative covers topics including agriculture and rural development, energy and mining, the environment, the financial sector, infrastructure, and private-sector initiatives, as well as social policy issues (education, gender, health, labour and social protection, and poverty).

[19] See Blaya, Fraser and Holt (2010), Kaplan (2006) and Moahi (2009).

[20] Enterprise 2.0 is the use of emergent social software platforms within companies, or between companies and their partners or customers (McAfee, 2006).

numerous opportunities for entrepreneurial provision of digital data platforms on which local information can be placed (see box 5).

Box 5. Open and real-time data: mapping and crowdsourcing

OpenStreetMap, at http://www.openstreetmap.org, provides an editable map that can be viewed and edited anywhere in the world using geographical data, and can be used in support of relief workers and disaster management experts.

Open source information crowdsourcing platforms such as Ushahidi, and open mapping and data initiatives such as OpenStreetMap, are enabling citizens in developing countries to generate and disseminate information that is critical for their lives and livelihoods. These technologies are often used in conjunction with commercial online services for publishing and sharing content such as YouTube (a video-sharing platform) and an array of digital media (such as GPS devices and video cameras).[21]

36. The commercial and social benefits of open data and networks are built upon a basic principle of the information society, namely that the common availability of data provides an important input to productive activities. Exploiting the opportunities of open data requires the absorptive capabilities and new patterns of collaborative learning, including crowdsourcing, which make it possible to build social and commercial value on these data foundations.

Professional networks and information sharing and exchange

37. The exchange of scientific and technical knowledge has become a major market in which a growing array of "knowledge brokers" and other intermediaries operate.[22] The exchange of such information is also organized through social networks created and used by scientific and technical professionals. Low- and middle-income countries face a series of paradoxes: On the one hand, membership and participation in scientific and technical societies is open and inclusive (although not without cost). On the other hand, access to and use of a considerable, and likely growing, share of scientific and technical information and knowledge has become more commercialized and, therefore, less accessible or usable.[23]

38. These paradoxes have not been overlooked by scientists, engineers and medical researchers. Scientists in many countries have contributed to building improved means of access to scientific and technical knowledge and to forming international collaborative networks that better link professionals across the globe.

39. The result of these concerns is the rise in recent years of a number of knowledge brokerages with a specific interest in addressing development issues. While many of these brokerages are organized on a non-profit basis and have specific interests in global issues, such as the environment, commercial enterprises are engaged in these activities too.

[21] Berdou (2011).

[22] Arora, Fosfuri and Gambardella (2001).

[23] There are cases where commercialization of scientific and technical knowledge can be of value to low- and middle-income countries, especially when local knowledge becomes of global importance and local discoveries become internationally important.

III. Building technological infrastructure

40. Exploiting the opportunities that ICTs provide in terms of creating capabilities requires continuous improvement in the technological infrastructure related to collaborative learning. Many developing countries have limited technological infrastructure, largely due to the poor state of their physical infrastructure and the low levels of access to the Internet and its applications. This situation limits the benefits of ICTs to these countries.

41. There are two kinds of measures to overcome this digital divide and to ensure that physical infrastructure is in place to complement and support the development of social needs. The first kind is technological, i.e. the use of alternative methods for overcoming the impediments to connectivity within countries. The second kind is organizational, i.e. improvements in the ways individuals in low- and middle-income countries are gaining access to the Internet or using ICTs in entrepreneurial ventures.

A. Enhancing global connectivity: accessing global and local networks

42. Investments in modern telecommunication infrastructures (which are largely based upon packet-switching[24] technologies) offer the opportunity for access to international data communication networks. The development of the global fibre infrastructure provides unprecedented prospects for the global reach of data communication networks. Contemporary developments are opening major access prospects for countries that would otherwise be isolated. This is comparable to other infrastructure developments in transport and trade: the priority is connection to the most economically important location, i.e. air travel to major cities or shipping to ports. Thus, while access development is opening opportunities for country-level access, it also tends to focus initially on major cities and ports that already have a substantial lead in development compared to other regions of low- and middle-income countries. These developments heighten “enclave” or “dual tract” patterns of development and contribute to increasingly rapid urbanization – a feature of modern development with very mixed consequences.[25]

43. Furthermore, reproducing the “universal service” available in high-income countries and striving for higher levels of broadband Internet services for individual homes is a prohibitively expensive public project for many low- and middle-income countries and is unlikely to be an economically justified investment in business terms. However, new forms of access that mitigate within-country disparities in access can be achieved. Significant progress has been made over the past decade in fixed networks and in mobile networks.

44. A principal issue for policy is the increasing complexity of information infrastructure provision. There clearly is an enormous expansion in physical capacity and its utilization, but complaints about the cost and availability of access continue in many countries. One of the major factors is that, while policies aimed at improving competition have been implemented with a view to addressing these pricing and availability issues and have had a positive impact, there are remaining bottlenecks.

45. For example, despite the availability of submarine fibre capacity, the use of very small aperture terminal (VSAT) satellite communication systems remains prevalent throughout West Africa and in other parts of the world. VSAT services are often less cost-

[24] Packet switching refers to the method of data communication over shared networks in which all transmitted data, regardless of content, type, or structure, is grouped into suitably sized blocks.

[25] World Bank (2009), and Mansell and Wehn (1998).

effective solutions in areas which are also served by wired or wireless infrastructure.[26] The widespread use of VSAT satellite infrastructure is an indicator of problems in the organization or pricing of terrestrial physical infrastructure supply. Challenges remain in exploiting opportunities offered by developments in the global information infrastructure. There is a clear need for a more up-to-date, critical and comprehensive consideration of the delivery of data communication services on a global basis.

B. Extending the mobile access infrastructure

46. The problems of extending information access are being addressed to some extent by the mobile-telephone revolution in Africa and Latin America. In all areas of the world, mobile-telephone data communications are burgeoning. In the developing world, mobile telephones are addressing two of the major access issues, namely the investment costs for terminals and the "getting started" costs of digital literacy as preconditions for the use of digital services.

47. The development of mobile telephony applications is having an impact on extending access to those engaged in entrepreneurial activities and in the provision of social services. Some of the new opportunities include (a) better information about market possibilities; (b) the ability to distribute informational messages to larger numbers of subscribers without the use of Internet infrastructure; (c) telemedicine consultation opportunities; and (d) mobile remittance services, such as M-Pesa in Kenya.[27]

48. As successful as mobile services are, however, they have important limitations. Firstly, mobile services remain expensive despite progress in encouraging market competition, partly because mobile telephone services provide a tax base in countries where the means to collect taxes are limited. Secondly, the commercial success of mobile telephony has stimulated companies to build infrastructure more quickly with a view to generating short-term profits. This is creating an access infrastructure that may hinder or prevent more sophisticated data communication applications, because of limitations present in infrastructure that has not been constructed for data communication and other advanced telecommunication services.[28] For instance, it is clear that mobile phones are capable of supporting poverty alleviation initiatives and improving the conditions of life for those with the least income.[29] However, it is less clear how the mobile revolution has supported or can support the activities of more complex information-sharing and information-exchange activities in which intensive data-communication and display needs outrun the capacities of the mobile phone.[30] Thus, any assessment of the development of global information infrastructure needs to be supplemented by an assessment of wireless developments, including a critical assessment of the opportunities for and limitations of mobile applications.

[26] This is the case regardless of whether that infrastructure is based upon copper or fibre capacity, and whether wireless capacity is cell-based (GPRS or 3G) or employs a more cost-efficient data communication standard such as WiMAX.

[27] Jack and Suri (2011).

[28] Beard (2008).

[29] Samarijiva (2011), De Silva, Ratnadiwakara and Zainudeen (2011), and Smith, Spence and Rashid (2011).

[30] This is the case, notwithstanding the development of smart mobile phones which offer improved capacities but remain limited in their capabilities relative to the personal computer used as a data terminal for accessing the Internet.

C. Local facilities and networks

49. The issue of access to ICTs has been considered in terms of universality, i.e. the costs and barriers to offering access to entire populations, particularly in low- and middle-income countries. Access to some ICTs and associated services may be better distributed more unevenly, at least initially, because there are trade-offs between the feasibility of extending access broadly and the practicality of concentrated and limited provision. Although this may seem to reinforce the possibility of increasing digital divides – creating larger gaps within societies – the costs of network extension may have this effect in any case. As such, concentrating efforts in denser areas where impacts will reach more people may be warranted to generate initial momentum.

50. A primary tool in extending access is through investment in physical sites, where access can be provided and equipment and skills can be shared. These are commonly organized as private entrepreneurial activities often called cybercafés or internet cafés, or may be organized as government-sponsored or subsidized "telecentres". Either form of organization may support absorptive and productive capability-building, including education and support for local employment.

51. These physical sites offer a means for mitigating access problems in contexts where (a) widespread access is problematic; or (b) the costs of individual or family access are prohibitive, relative to income levels; or (c) there are substantial shortcomings in available skills or knowledge.

52. Because cybercafés or government-sponsored telecentres can address each of these problems, they have been employed both to serve less favoured regions in high-income countries and to extend access in developing countries.[31]

53. However, the success of these physical sites faces three particular challenges:

(a) **High risk:** Like other small businesses with uncertain demand that are entrepreneurially led, cybercafés are subject to considerable business risk. Not only does a degree of success attract additional entry with the possibility of saturating the local market, but it is also to estimate demand inaccurately, or to rely upon a class of users (such as foreign tourists) whose demand is sporadic.

(b) **Sustainability:** For telecentres, there are questions about whether the activities conducted are able to generate incomes that offer sustainability for the operators of the centres. Telecentres sponsored by public funds or by NGOs seem to experience similar problems as cybercafés funded by private investors: although resources may be available to establish such centres, investments often do not include ongoing support for the costs of personnel and maintenance of the facility.

(c) **Displacement of private sector:** While initial investments may bring rewards to specific individuals, these rewards are rarely widespread or large enough to maintain the telecentre. In exceptional cases, the telecentre becomes the physical place of work for some individuals who engage in "teleservice businesses". While more sustainable, this model is a close substitute for entrepreneurial-led establishment of teleservice businesses and related workplaces. This means that there is some risk that the struggle to achieve sustainable government- and NGO-sponsored telecentres may displace private-sector initiatives.

54. The initial investment in these access arrangements and some part of the continued costs of personnel and maintenance can be seen as part of a country's training and

[31] Gomez (2010), Madon (2009), and Rothenberg-Aalami and Pal (2005).

education infrastructure. This does not resolve the problem of sustainability, but it makes more visible the trade-offs between investment in digital literacy and skills and other types of literacy, training and education. It is these objectives of telecentre operation that are most closely related to strengthening absorptive and productive capacity-building.

55. There has been a rapid acceleration of Internet access opportunities at the country level, as well as challenges and complexities in extending this physical access in developing countries. These challenges are not confined to developing countries. Middle-income and wealthier countries also face problems of ensuring inclusion in access to physical infrastructure. Despite substantial improvements, the development of physical access remains an important challenge. It is characteristic of transformative innovation processes that expectations outrun achievements.

IV. Findings and suggestions

56. *The intersessional panel of the CSTD puts forth the following findings and suggestions for consideration by the Commission:*

Main findings:

(a) Processes of learning by collaboration are central to innovation, research, technology transfer, and entrepreneurship. Collaborative learning involves a capacity-building process which has two crucial dimensions – absorptive and productive capacities. These capacities are gained through a developmental process at the individual and the organizational level;

(b) Policy discussion needs to consider how innovation, research, and technology transfer are supported through networked collaborative learning and the strengthening of absorptive and productive capabilities. It is crucial to understand the means by which people and organizations build the capabilities required to achieve greater capacities for entrepreneurship and collaborative development;

(c) Both in practice and in policy discussion, greater attention needs to be paid to the growing array of scientific and technical resources that are available online and that are relevant for global participation in scientific and technical communities;

(d) There is a need to gather and exchange information about the adaptation and use of open source software as well as the social networks by which capabilities are built in low- and middle-income countries. These could provide insights for other types of knowledge-generation and knowledge-exchange activities in support of development purposes;

(e) Research is needed that provides a critical and comparative insight into the role of community development in the use and sustainability of ICT initiatives;

(f) There is a need to strengthen the evidence base on the effectiveness and availability of commercial and non-commercial knowledge brokerages relevant to developing-country needs, with a view to providing an improved foundation for public policy and private investment;

(g) Assessment of global information infrastructure development needs to be supplemented by an assessment of wireless developments, including a critical assessment of the opportunities for and limitations of mobile applications;

(h) The proliferation of various access arrangements and institutional forms provides important entrepreneurial activities, but also creates complexities for solving remaining barriers;

(i) In recent years there has been increasing evidence of constraint-based innovation from the global South. There is a need to understand the factors that have contributed to this success and to gain insight into the implications for policymaking.

Suggestions:

1. National Governments would be advised to consider the following:

(a) Encourage and support efforts of learning and capacity development at the firm and industry level through the provision of an enabling environment;

(b) Provide support to firm-centred organizational arrangements and training/learning facilities to strengthen the knowledge base needed by firms, both in advance of and subsequent to technology transfer projects, through such measures as meeting some of the costs of seconding local personnel for training, in collaboration with donors;

(c) Promote and support the development of capabilities that are "fit for purpose" for the Internet age including through leveraging opportunities for collaborative learning;

(d) Identify, through a multi-stakeholder approach, the local needs of communities in order to design ICT access strategies within countries, balancing short-term and long-term considerations;

(e) Promote the dissemination of successful experiences, including of constraint-based innovations, to foster an innovative culture through mechanisms such as the creation of awards and mass media campaigns;

(f) Organize ICT trade shows and promote access to global markets;

(g) Promote the development of ICT platforms, involving national research institutes and universities, with a view to participating in international research networks and benefiting from the opportunities for collaborative learning;

(h) Encourage countries, especially developed ones, to support exchange and collaboration between their scientific and research institutions and those in developing countries, in particular in the least developed countries (LDCs).

2. The international community is called on to:

(i) Explore intellectual property–related policies and new initiatives necessary to promote the transfer and dissemination of technology, benefiting developing countries in particular, and adopt appropriate measures to enable developing countries to fully take advantage of such transfer;

(j) Ensure that multilateral governance mechanisms and the standardization bodies of ICT and global networks are democratic, fair, and coherent, with an effective participation of the developing countries;

3. The CSTD should consider the following:

(k) Share and analyse evidence on development of innovative capacities at the firm level, with a view to understanding the social and economic dimensions of these processes and providing insights for the development of public policy;

(l) Provide a forum for the sharing of good practices and experiences in the use of ICTs for capacity-building in education and research, with greater attention to the growing array of scientific and technical resources that are available online;

(m) Share and analyse empirical evidence on ICT production in developing countries as well as research on linkages between local firms and transnational corporations;

(n) Continue, in its role as a “torch-bearer” for innovation, to raise awareness amongst policymakers about the process of innovation and their role in it, and about the particular opportunities for developing countries in innovation. Special attention should be placed on new trends in innovation that can offer novel possibilities for developing countries.

References

Ale Ebrahim N, Ahmed S and Taha Z (2009). Virtual R&D teams in small and medium enterprises: A literature review. *Scientific Research and Essays.* 4 (13): 1575–1590. Available at http://ssrn.com/abstract=1530904.

Arora A, Fosfuri A and Gambardella A (2001). *Markets for Technology: The Economics of Innovation and Corporate Strategy.* MIT Press.

Beard DJ (2008). Developing telecommunications infrastructure for mass access in sub-Saharan Africa. Unpublished doctoral thesis. School of Policy Studies. University of Bristol.

Berdou E (2011). *Mediating Voices and Communicating Realities: Using Information Crowdsourcing Tools, Open Data Initiatives and Digital Media to Support and Protect the Vulnerable and Marginalized.* Vulnerability and Poverty Reduction Research Team. Institute of Development Studies. University of Sussex. Final project report. DFID Project PO 40035949.

Blaya J, Fraser H and Holt B (2010). E-health technologies show promise in developing countries. *Health Affairs.* 29 (2): 244–251.

Borbon-Galvez Y (2011). Capabilities meet regulation: The compliance processes of Mexican food supply chains with United States biosecurity regulations. Science and Technology Policy Research. University of Sussex.

Cohen S and Roussel J (2005). *Strategic Supply Chain Management: The Five Disciplines for Top Performance.* McGraw Hill.

Cohen W and Levinthal DA (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly.* 35 (1): 128–152.

Curry E, Freitas A and O'Riain S (2010). Case study: ChemSpider – Open data curation in the global chemistry community. In: Wood D, ed. *Linking Enterprise Data.* Springer. Dordrecht.

De Silva H, Ratnadiwakara D and Zainudeen A (2011). Social influence in mobile phone adoption: Evidence from the bottom of the pyramid in emerging Asia. *Information Technologies and International Development.* 7 (3): 1–18.

Gomez R (2010). Structure and flexibility in global research design: Methodological choices in landscape study of public access in 25 countries. *Performance Measures and Metrics.* 11 (3): 231–258.

Hobday M (1995). East Asian latecomer firms: Learning the technology of electronics. *World Development.* 23 (7): 1171–1193.

Jack W and Suri T (2011). Mobile money: the economics of M-PESA. National Bureau of Economic Research. Working paper 16721. Cambridge, Massachusetts.

Kaplan WA (2006). Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries? *Globalization and Health.* 2 (9): 1–14.

Lee L, Park G, Yoon B et al. (2010). Open innovation in SMEs – an intermediated network model. *Research Policy.* 39 (2): 290–300.

Madon S (2009). Digital inclusion projects in developing countries: processes of institutionalization. *Information Technology for Development.* 15 (2): 95–107.

Mansell R and When U, eds. (1998). *Knowledge Societies: Information Technology for Sustainable Development.* Published for the United Nations Commission on Science and Technology for Development. Oxford University Press.

Marcelle G (2011). Firm-level innovation: implications for policy and practice. Paper prepared for the 2011-2012 intersessional panel meeting of the United Nations Commission on Science and Technology for Development. December.

McAfee A (2006). Andrew McAfee's Blog. The Business Impact of IT. http://andrewmcafee.org/2006/05/enterprise_20_version_20/ (accessed on 9 March 2012).

Moahi KH (2009). ICT and health information in Botswana: Towards the Millennium Development Goals. *Information Development.* 25 (3): 198–206.

National Science Board (United States) (2010). *Science and Engineering Indicators 2010.* National Science Foundation. Washington D.C.

Rothenberg-Aalami J and Pal J (2005). Rural telecentre impact assessments and the political economy of ICT for Development (ICT4D). Berkeley Roundtable on the International Economy. Working paper 164. University of California, Berkeley. http://escholarship.org/uc/item/18q2282h;jsessionid=7A19E75CB7ACFEAA45EF830A2CC0F5A2 (accessed on 9 March 2012).

Samarajiva R (2011). Mobile at the bottom of the pyramid: Informing policy from the demand side. *Information Technologies and International Development.* 7 (2): iii-vii.

Smith ML, Spence R and Rashid AT (2011). Mobile phones and expanding human capabilities. *Information Technologies and International Development.* 7 (3): 77–88.

United Nations (2010). New and emerging technologies: renewable energy for development. Report of the Secretary-General. E/CN.16/2010/4.

United Nations (2009). Science, technology and engineering for innovation and capacity-building in education and research. Report of the Secretary-General. E/CN.16/2009/3.

United Nations (2008). Science, technology and engineering for innovation and capacity-building in education and research. Report of the Secretary-General. E/CN.16/2008/4.

UNCTAD (2003). *Investment and Technology Policies for Competitiveness: Review of Successful Country Experiences.* United Nations publication. UNCTAD/ITE/IPC/2003/2. New York and Geneva.

UNCTAD (2010). *Information Economy Report 2010: ICTs, Enterprises and Poverty Alleviation.* United Nations publication. Sales no. E.10.II.D.17. New York and Geneva.

UNCTAD (2011). *Information Economy Report 2011: ICTs as an Enabler for Private Sector Development.* United Nations publication. Sales no. E.11.II.D.6. New York and Geneva.

Wood D, ed. (2010). *Linking Enterprise Data.* Springer. Dordrecht.

World Bank (2009). *World Development Report 2009: Reshaping Economic Geography.* Washington D.C.

Zhao J, Wang S and Huang WV (2008). A study of B2B e-market in China: E-commerce process perspective. *Information and Management.* 45: 242–248.