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Innovation, Research and Technology Transfer for Mutual Advantage, Entrepreneurship and Collaborative Development in the Information Society

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Introduction

Hopes for economic development and growth have been raised by the evolution of the world's information infrastructure and its applications. The UN Commission on Science and Technology for Development (UNCSTD) has played a leading role from the mid-1990s in evaluating the opportunities and barriers to capitalising on the opportunities ICTs provide for innovation, successful technology transfer, and economic growth and development.[2] From the beginning of the 2000s, particular attention has been given to the way ICTs can be used creatively by developing countries to stimulate commercial activity. The Internet has provided a basis for interactivity and it is providing platforms which are transforming the way larger and smaller businesses in all sectors of the economy and in public sector organisations are organising their internal and external information and communication networks and practices.[3]

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 'leapfrogging' by developing countries is signalled by the declining cost of digital technologies, networks achieving global reach, and software applications for all purposes becoming increasingly ubiquitous.[4] These developments are significantly affecting the relationships between innovation, research, technology transfer, entrepreneurship, and collaborative development – the priority theme for UNCSTD's current discussion.[5] This issues paper focuses directly on links between the changing ICT landscape and new opportunities for 'learning by collaboration' which have the potential to stimulate initiatives in each of the priority theme areas.

These opportunities following from the extension of global connectivity and from increasingly diverse means of enabling local access to networks have been concretised in a set of four documents that are shaping the discussion about the contribution of the digital infrastructure to world development.[6] The concluding paragraph to the World Summit on the Information Society Geneva Declaration of Principles: *Building the Information Society: A Global Challenge in the New Millennium,* summarises the hopes for the development of the Information Society succinctly:

> We are firmly convinced that we are collectively entering a new era of enormous potential, that of the Information Society and expanded human communication. In this emerging society, information and knowledge can

2 (Mansell and Wehn 1998).

3 (UNCTAD 1999; 2001).

4 See section 1 on leapfrogging and see (Soete 1985).

5 These changes are mapped in UNCTAD's recent reports (UNCTAD, 2010) and (UNCTAD 2011).

6 (UN/ITU 2003; 2003; 2005; 2005) and collected together in (UN/ITU, 2005).

> be produced, exchanged, shared and communicated through all the networks of the world. All individuals can soon, if we take the necessary actions, together build a new Information Society based on shared knowledge and founded on global solidarity and a better mutual understanding between peoples and nations. We trust that these measures will open the way to the future development of a true knowledge society.[7]

As a statement of conviction, it firmly subscribes to the concept of an Information Society based upon extended communication and uses both of the terms 'information' and 'knowledge', linking them by indicating that the Information Society provides the basis for a transition to the 'true knowledge society.' However, the process described in this statement may involve conflicts or trade-offs which might impede or deflect the realisation of the goals that are espoused. In addition, it also does not acknowledge a fundamental lesson from the experience of innovation – that building capacities for innovation, absorption and production are essential pre-conditions for achieving major transformation.

Based on these observations, this issues paper is organised in four sections: **1) ICTs, Absorptive Capacity and Learning by Collaboration; 2) Transformations in the ICT Landscape and Absorption Capacity; 3) Enhancing Productive Capacity, and 4) Building Technological Infrastructure for Collaborative Learning.** The opportunities and challenges related to ICTs for innovation, research, technology transfer, entrepreneurship, and collaborative development in the context of developing countries are addressed around the focus of each section. The main objectives and messages from the four sections are as follows:

Section 1: ICTs, Absorptive Capacity and Learning by Collaboration This section provides a concise analysis of the role that ICTs generally, and the Internet specifically, are playing in supporting research and innovation aimed at 'catching up' and 'leapfrogging.' It introduces the process of collaborative learning, which is both enabled and sustained by online interaction. Collaborative learning supports information exchange processes and communication that generate mutual advantage and entrepreneurship and underlie collaborative development efforts that extend beyond the private sector to the education, health and environment sectors.

Section 2: Transformations in the ICT Landscape and Absorption Capacity This section examines in more detail the processes of capability building, both in terms of the 'target' communities and networks intended to be the ultimate beneficiaries of improvements in the links between information and knowledge developments, and in terms of collaborations with those who supply technological solutions and complementary knowledge. Key messages of this section include the need to move beyond 'demonstration' projects and to define sustainable paths for social infrastructure development, the value of more original and critical research concerning the sustainability of capability development projects, and the opportunities for

7 (UN/ITU 2005:23).

collaborative research, development and innovation offered as a consequence of capacity building.

Section 3: Enhancing Productive Capacity This section considers tensions between commercial and non-commercial uses of ICTs for the generation and exchange of knowledge. On the one hand, it is hoped that these technologies will improve entrepreneurial opportunities, enhance the means of earning a livelihood and open opportunities for trade and development. On the other hand, it is hoped that they will support an increase in information exchanges whose value is best described in non-monetary or pre-commercial terms. Ways of improving the translation between information and knowledge are identified, highlighting the emerging and complex interaction between commercial and other forms of organisation that contributes to this translation process. Key messages of this section include the identification of new opportunities for technology transfer involving knowledge brokering and exchange between higher income and lower income countries, the role of such transfer activities in stimulating and supporting entrepreneurship, and the implications of these activities for value chain and production network development and management.

Section 4: Building Technological Infrastructure for Collaborative Learning This section examines developments in physical infrastructure over the past decade that raise questions about whether parallel and complementary developments in social infrastructure are sufficient to deliver the benefits of the Information Society, particularly in low and middle income countries. A key message of this section is that earlier concerns about a broadly inclusive global information infrastructure are increasingly focussed on the distribution of capacity *within* countries rather than the extension of the global information infrastructure *to* countries. This section also considers the rapid evolution of access arrangements and the variety of access arrangements and institutional forms that are rapidly proliferating. These offer important opportunities for public policy and entrepreneurial involvement, but the evidence base for setting private strategy and public policy remains weak and needs further development.

The **Conclusion** pulls together the main lessons learned and identifies areas for further discussion.

Section 1: ICTs: Capacity Building and Learning by Collaborating

ICTs play a fundamental and often transformative role through their capacity 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 to apply ICTs to strengthen the essential absorptive and productive capacities 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 and services. Four basic concepts are used to analyse capacity building. Two are related to the consequences of capability building – catching up and leapfrogging – and two are related to the nature of capabilities – absorptive and productive capabilities.

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. It is now well known that the catching up process is capable of propelling a country to the frontier of technological development. ICTs have played an important role in the most rapidly growing economies in 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. This ordinarily provides competitive advantage stemming from cumulative advantage (the long term incremental improvement in technologies that have been in use for an extended time). 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. The nature and extent of this experience influences the evolution of capabilities in firms and industries.

Leapfrogging, the bypass of some of the accumulative steps in human capabilities and fixed investment, makes it possible to narrow gaps in productivity and output that separate industrialised and developing countries. Because of leapfrogging, catch up in high technology industries has proceeded more rapidly than in other industries. High technology industries have sustained an 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.[8] Even though industries at lower levels of technological sophistication have expanded their share of exports less rapidly than high technology industry, 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. An important factor in catching up and leapfrogging is the emergence of Internet technologies and applications

8 (UNCTAD 2003:15) shows the results until 2000. (US National Science Board 2010) provides the share of high technology products through 2008. In 2007 and 2008 a very slight decline in share occurred while the value continued to increase.

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.[9] These abilities for learning and adaptation are referred to as 'absorptive capabilities.'[10] Efforts to build absorptive capacity require a specific strategy for economic development and for leapfrogging and are at the centre of the process of technology transfer.

Absorptive capabilities are particularly challenging to build in an environment in which relevant information and knowledge are costly to acquire because of the intellectual property rights regime which often creates insurmountable barriers where licenses are needed to copy or employ external information in support of business activities. [11] However, in ICTs and in many of the manufacturing and service industries built upon ICT capability, these patent barriers are reduced by the flexibility and diversity offered by digital technologies – there are many different ways to implement digital solutions and few cases where a particular technique dominates over alternatives.

Productive capabilities – the capabilities to deploy and effectively use technologies that are self-generated or acquired through the use of absorptive capacity – depend upon success in integrating a variety of technologies and fostering new organisational and management skills. A key feature in the development and use of modern productive capabilities is the capacity to build and manage production networks. These networks embrace collections of firms that divide and coordinate labour in a fluid or loosely collaborative manner. In addition, success is needed in developing these capabilities to underpin value chains comprised of collections of firms that are organised in more stable configurations with a vertical division of labour between component, intermediate and final good production.

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 good and component industries, is often made in terms of quality and price, rather than on the basis of long term relationships or national preferences. Collaboration and collaborative development has become more important in production networks because of the demands of international coordination of design, specification and sourcing of products. The closer integration expected within value chain networks benefits from the ability to define common standards and to collaboratively manage

9 (Hobday 1995).

10 (Cohen and Levinthal 1990).

11 (Correa 2000).

product and component design and the flow of intermediate production and distribution stages through the value chain using ICT.

Finally, productive capabilities include specific and local processes of knowledge adaptation and re-combination 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 standalone 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.

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:

1) 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; [12]
2) substantial changes in research accompanying the growth of 'open innovation';[13]
3) substantial growth of outsourcing activities,[14] including the rise of 'contract manufacturing'[15];
4) the growing availability of software applications supporting entrepreneurship in business and changes in supply chain management;[16]

12 (Gereffi, Castillo and Fernandez-Stark 2009) note how with the support of networks 'service suppliers today need not choose between Asia, Europe or America for their offshore operations' since today countries such as Brazil and Mexico can establish themselves as hubs if they create the necessary infrastructure, skills and related trade, tax and legal policies. See also (Cattaneo, Gereffi and Staritz 2010).

13 (Chesbrough 2003). (Wagner 2006) discusses the growing potential for developing countries to engage in international research collaboration networks benefiting from 'grid computing' for online engineering and other science based projects, showing how countries are becoming linked into networks in ways that were not feasible before the spread of ICT-based networks.

14 See (Lacity, Khan, Aihua et al. 2010) and (Willcocks and Lacity 2009) on global outsourcing and the role of ICT systems.

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

16 See (Mateos-Garcia and Steinmueller 2008; Morgan 2010; Berdou 2011).

5) platforms for virtual team working and collaboration employing resources of the information commons and various forms of commons-based peer-production;[17] and
6) unprecedented growth in the variety of 'open' formats for the distribution of information and 'libraries' from which this information can be drawn,[18] which serve in turn as foundations for knowledge management and learning by collaboration.[19]

The next two sections (2 and 3) of this paper examine key areas of change in absorptive capability building that are most closely associated with research, innovation and technology transfer, and productive capability building which are most closely associated with enabling entrepreneurial and collaborative development. These processes generate mutual advantage between collaborating firms wherever they are located. They offer particularly valuable opportunities for gaining mutual advantage from exchange and collaboration between the more industrialised countries and low and middle income countries engaged in catching up and leapfrogging development processes.

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17 On virtual teams see (Pinsonneault and Caya 2008) and (Ale Ebrahim, Ahmed and Taha 2009). (Benkler 2006; 2009) discusses the crucial role of the information commons in building successful online networks and (Cummings, Heeks and Huysman 2006) provide a framework for examining online development networks, giving particular attention to the role of trust and social capital.

18 The development of ICT-based networks for the collection, circulation and processing of open and real time data is receiving a high profile with the UN Global Pulse initiative, http://www.unglobalpulse.org/, which aims to harness digital data and real-time analytics to address issues of pubic health and crisis communication by mapping and visualising locally generated data. This concept has the potential to be applied in applications in the commercial sector as well. The World Bank is promoting its Open Data initiative, http://data.worldbank.org/topic, covering 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, labor and social protection, poverty). In addition, 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 industry sectors including pharmaceuticals, chemistry and agriculture. These applications employ wikis, semantic tagging and other 'enterprise 2.0' applications to improve access to and the flow of digital information, see (Wood 2010). See also (Surhone, Timpledon and Marseken 2009). (Graham and Haarstad 2011) discuss the way ICTs are being used to encourage transparency about the way goods are produced in the global South.

19 (Steinmueller 2000). See also web resources for skills building such as those at www.telecentreacademy.org which include ICT manuals for community activists, multimedia training kits, Microsoft digital literacy, ICTs for information professionals, training on standard software packages, and some region specific information packages such as for the Philippines and Viet Nam, sponsored by IDRC, Microsoft, SDC and others.

In each of these areas the practical consequences of improvements in the information infrastructure and its applications are related to improving the links between information and knowledge and, specifically, in increasing the importance of collaborative learning. The nature and strength of these links is at the centre of many of the successes and the disappointments stemming from ICT projects aiming at stimulating economic growth and development in the low and middle income countries.

Section 4 considers progress and challenges in the development of telecommunication networks with a focus on low and middle income countries. It illustrates the remarkable progress that has been made in connecting countries to global information infrastructure and in extending communication access through mobile networks. It also discusses the challenges to extending this connectivity within countries in order to stimulate technological and organisational innovation. Particular attention is given to the organisational innovation of telecentres – operated both as entrepreneurial small businesses and as sponsored facilities for supporting tele-working and skills acquisition.

Overall, the aim is to highlight the importance of processes of innovation, research and technology transfer that produce mutual advantage among participants and foster entrepreneurship and collaboration. The process of learning by collaboration based on ICT networks and applications has the potential to support the development of 'the true knowledge society' when it heightens the potential for successful catching up and leapfrogging in ways that were not feasible in collaborations involving earlier deployments of the global information infrastructure.

Section 2: Transformations in the ICT Landscape and Absorptive Capacity

The generation of innovation and knowledge through 'recombination' is a major, perhaps even the primary, consequence of developing absorptive capacities.[20] Appropriately used, the Internet is a powerful tool for collecting information that stimulates the imagination and provides clues for new directions in research and innovation. When combined with existing and local knowledge, some directions will be idiosyncratic or ineffective. Others will become candidates for entrepreneurial initiatives and for the development of products and services that can be commercialised, either through the formation of new companies or through the addition of new lines of businesses in existing companies. There are real prospects for developing countries to generate commercially significant new ideas based on either novel ICT applications or the use of existing applications in combination with other technologies through this recombination process.

This has already occurred in the first wave of change in which absorptive and productive capacities were transformed into innovative leadership in the production of electronic goods by the East Asian countries. In the first wave, South Korea, Taiwan,

20 (Gu and Steinmeuller 1996).

Hong Kong and Singapore emerged as global leaders in the production of specific ICTs including mobile phones, flat panel displays, memory chips, personal computers, and disk drives. They are now either at or close to the technological frontier in all of these technologies. A second wave of development is underway now in which networked computers provide opportunities to internationalise service provision, co-ordinate global production networks, and foster international divisions of labour in research and in the design and development processes underlying innovation. This new wave of development involves an even greater level of international collaboration and a more diverse set of industries – ranging from tele-services to biomedical product manufacture.

In order to capitalise on these prospects, a focused strategy of investing in innovative capabilities relating to the customisation and use of online collaborative networking is essential. The challenges in this area are akin to learning a language. As wasargued a decade ago, this sort of mastery can be transformative.

> "[It] leads to the potential for innovation, perhaps beginning by using relatively simple tools to improve the productivity and expand the capacity of existing methods for producing goods or delivering services. ICT-related knowledge can, however, provide the basis for much more profound innovation. ICTs can provide the tools to restructure human interaction with other humans and with their tools in entirely new ways, ways that may bypass or leapfrog construction of human and machine systems that otherwise might have been the only alternative".[21]

The potential for learning this 'new language' is examined in this section which focuses on how absorptive capabilities and enhanced capacities for innovation, research and technology transfer, are built up at the level of the individual and then at the level of the organisation through collaboration. Illustrations of how this has occurred during the past decade are provided.

Digital Literacies for Entrepreneurship: The Individual Journey

Social networks are essential for the filtering, referral, adaptation and, ultimately, the exchange of knowledge involved in the 'transfer' for technology.[22] Recent developments in social networking appear to offer better tools for building and sustaining social networks, but not necessarily ones that are fit for the purposes of building knowledge societies. Sociability can be an end as well as a means. It does not logically follow that particular uses of ICT such as social networking will be related to the generation and exchange of knowledge. This does not detract from the many useful information exchange activities such as advertising jobs and applying for them, providing information that might otherwise be difficult to find, accessing government services, or communicating with friends or family at a distance.

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21 (Steinmueller 2001).

22 The term technology transfer can be misleading and problems with the term are well illustrated in (Roffe and Tesfachew 2002) and discussed further below.

Knowledge has informational content and the problems of organising and accessing information are substantial. This is not because of information scarcity in the Internet age, but because of information abundance. ICT developments promise more information abundance which, in turn, offers opportunities and challenges for building the capabilities to effectively access and exchange knowledge.

The process of individuals gaining capabilities can be portrayed as a 'ladder' with three distinct stages: inclusion, engagement and empowerment. Each stage, in turn, typically is associated with a progression of activities, initially beginning with basic skills. [23] In ascending this ladder (see Figure 1), skills are mastered. However, the processes and activities that are engaged in require an increasing level of purpose or intention as the ladder is ascended. The final step as we move towards empowerment is 'entrepreneurship', which should be interpreted broadly. It is not only about establishing a business, but more broadly the capacity for independent initiative which may apply to commercial, civic, cultural, or political activities.

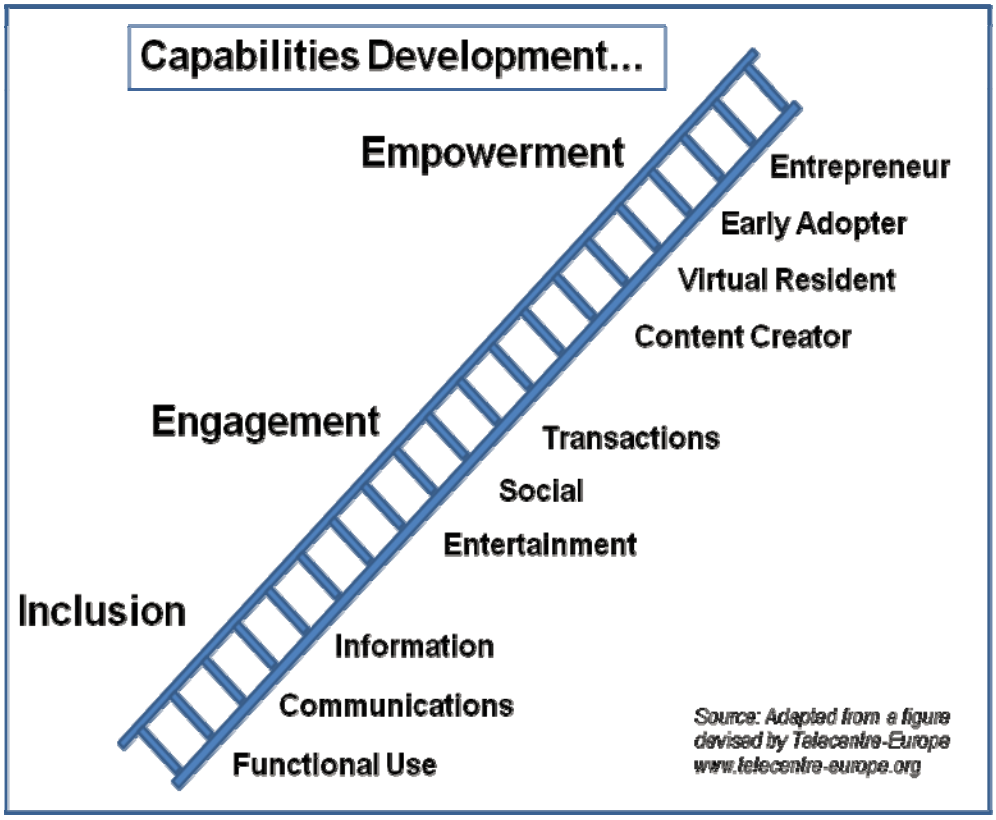

Figure 1. Capabilities Development

23 See Telecentre-Europe, an organisation promoting and serving telecentres throughout the world, http://www.telecentre-europe.org/, accessed 1 December 2011.

In this progression or 'digital journey' towards building increasingly sophisticated skills, there are several observations to be made:

1) The beginning of the process, in which individuals come to be included in Information Society developments is the level at which skills conveyed by training are most relevant. To use ICTs to communicate and gather information of personal relevance is an opening, but it is only the beginning.

2) Proceeding to the level of engagement, two things are happening. The first is that learning becomes more relational or collaborative – it is not only the basic skill, but also a question of which entertainment, social interaction, or transaction to engage in. At this level, interaction with others with similar interests begins in earnest. The local community of users with which the neophyte interacts and also the virtual social community start to be important for aiding in the acquisition of skill and for filtering, referral, adaptation and, ultimately, exchange of knowledge.

3) These processes of social engagement and collaboration continue in the empowerment stage where an individual is now seeking to engage with an audience or fellow community members. This may lead to becoming an early or pioneer adopter of new ideas or techniques and, eventually, to becoming an author or originator of new ideas in an entrepreneurial sense. In this stage, the individual forms ties based upon shared interests and purposes which may or may not be 'local' in the sense of being in common with others in the immediate physical community of the individual.

Figure 1 depicts the experience of a broad range of people in their digital journey from initial inclusion to becoming empowered users of ICTs; similar processes are characteristic of the learning experience of individuals from all walks of life. What is important about social and cultural differences is that the reasons for pursuing this journey towards entrepreneurship depend on the perceived relevance of online interactions. Individuals with interests that are broader than their own immediate physical community (those people with whom they would ordinarily interact on a person to person basis) are likely to more immediately perceive the relevance and benefit of continuing to build their skills.

These characteristics will be more typical of individuals with broader and higher levels of education. This is due to the general principle that education 'broadens horizons' and, specifically, will apply to individuals who are educated in fields that emphasise knowledge with an established basis such as in science, medicine, or engineering or who have experienced a broad and comparative approach to other fields such as in the social sciences or humanities. The digital journey depicted in Figure 1 is therefore linked to the nature and extent of education.

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 the opportunity for individuals who have access to the Internet to acquire understanding, not only of the tools, but a documented logic of how advanced software products can be created and deployed in productive sectors of developing country economies. Taking advantage of these opportunities requires a background knowledge that can be provided by a relatively modest level of technical education and, even more importantly, access to personal computers and, ideally, the Internet. Many of the leading programmers in the industrialised world are self-taught, despite the creation of the university discipline of computer science and awarding of degrees in this subject.

Another prominent example of the development of digital literacy at the individual level is the growth of free lance workers which is a global phenomenon. As the case below illustrates, this is an example of how individuals can progress up the capabilities ladder to take on employment drawing upon a wide range of skill levels – from basic activities such image tagging to advanced coding tasks. Recent research highlights a considerable increase in the incidence of virtual teams linking small and medium sized enterprises (SMEs).[24]

Online Collaboration in a Low Income Country Context[25]

According to the Bangladeshi Software and Information Services Association (BASIS), around 10,000 Bangladeshi freelancers are active online. The vast majority of them work for clients in the United States and Europe – usually SMEs – but they also work for local government institutions, non-governmental organizations (NGOs), and individuals. They provide a range of ICT-related services, such as software development, graphic design, search engine optimization, social media marketing, blogging, and data entry. Projects vary from building large e-commerce websites to doing product entry on eBay or posting positive feedback for companies on review websites.

Online portals such as www.freelancer.com, www.odesk.com and www.bworker.com, where freelancers can be hired on an assignment basis, are popular among "micro-workers" in Bangladesh, who export services over the web in an informal manner. Many of the freelancers have a day-time job or are students in IT university faculties. The revenues generated by the most successful individuals can be in the tens of thousands of dollars, while the average is around a few hundred to a few thousand dollars. Although some freelancers work on high-value projects, which take months to complete, the most common situation is to be involved in small projects with multiple clients on a day-to-day basis.

Despite freelancers' low visibility in the country, BASIS reckons that they have now overtaken the formal IT- and ICT-enabled services industry in sales volume, although there are no official statistics to verify this.

BASIS is one of a growing number of companies 'brokering' the labour of online workers, one of the consequences of a growing number of individuals having reached higher levels on the capability development ladder depicted in Figure 1.

24 (Ale Ebrahim, Ahmed and Taha 2009).

25 This case is drawn from (UNCTAD 2011:55).

Digital Literacies for Entrepreneurship: The Organisational Journey

Considerable progress has been made in broadening and deepening the portfolio of software products available for managing company data and knowledge resources over the past decade. Most of these developments involve the utilisation of networks and, specifically, the use of the Internet browser as the primary human computer interface. Many involve standard platforms such as those produced by Microsoft, SAP, Oracle and Infor Global Solutions. The use of these tools 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 methods and non-electronic methods.

Throughout the history of ICT development, innovation and early adoption has often been led by private businesses seeking improvements in productivity and cost reduction. Individual solutions can often be idiosyncratic or ineffective – one-off solutions to the day-to-day problems of a business. When these solutions are constructed by individuals who have attained a higher (empowered) level of individual ICT capability, however, it is far more likely that he or she will perceive specific problems in a larger context. With such perceptions, individuals and groups of like-minded individuals are likely to identify the potential for generalising from specific solutions to more general products or services. These may then be sold to customers in other companies and, ultimately, to customers in other countries.

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 (discussed further in Section 3) and in tools for collaboration – collaboration within companies and between companies and their suppliers and customers. Examples include customer relations management software,[26] software for computer supported cooperative work which is often organised around computer aided design and manufacturing software,[27] and software for collaborative document creation.[28]

This organisational process of collaborative learning can be compared with the individual digital journey. Organisations begin with applications that address their own

26 (Steinmueller 2003).

27 (D'Adderio 2004).

28 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. Wiki's are also employed in content management systems in business and universities.

immediate informational needs – e.g. accounting, payroll, and inventory systems. The requirements of data entry and reporting quickly make it desirable to distribute this information within companies and to begin a process of internal collaborative development. This is often augmented by collaborations with external software suppliers as companies adopt available commercial packages. This initial development process is hastened by online SaaS (software as a service) applications which do not require companies to establish their own systems for managing data security and integrity (protection against data theft or loss).

As companies become more active developers and users of software, they become interested in integrating their supplier and re-seller relationships with their internal systems, a process that requires collaborative development and further interaction with software solution providers. Just as individuals progress from individual information needs to becoming engaged with other users to share and exchange, 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 such as the following example.

China Experiencing Rapid Growth in Business to Business (B2B) Networks

The Chinese government has been developing B2B e-commerce such as the China National Commodity Exchange Center which since its establishment in 1997 now 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 which has more than seven million users aimed at SMEs, providing online payments and a trusted platform for traders.[29]

Similar processes occur 'upstream' in the research process. Organisations in industrialised countries are finding that instead of importing 'guest' research workers, it often makes sense to establish a foreign R&D office with responsibilities for recruiting skilled local scientists or engineers capable of participating in research. These interactions are not exclusively originating in the high income countries – middle income countries are actively investing in research centres in the rich countries and in other middle-income countries. Contrary to historical experience, many of these 'offshore' research teams are not working independently on projects defined by the 'home office' R&D laboratory, but 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 experimental data, to develop virtual prototype designs created using computer aided design and engineering software. In some cases, specialised and industry specific capabilities are enabling the use of ICTs to support gene sequencing, tissue sampling, and a growing array of techniques in materials

29 See (Zhao, Wang and Huang 2008).

sciences and chemistry. These research activities can be conducted using both virtual and physical experiments.

Virtual Prototyping for Energy-Efficient Electric Motors for Automotive Applications

A design team works on virtually redesigning electric motors by using worldwide resources. With a head office in Toronto, it locates its R&D and factories in Singapore, China, and Thailand, with sales offices in Japan, China, South Korea, Europe (Germany) and the US.[30]

Capability building at the individual level crucially depends upon the social context of the individual and opportunities for learning. Learning is collaborative and involves a progression from individual skills to collaborative learning. Without a local community sharing interests and enthusiasm, few individuals are likely to develop the absorptive capacities or remain motivated to progress beyond the most elementary of skills. Further progress in capabilities building, for most individuals, will require engagement with others by learning through collaboration with those with whom the individual may identify and interact 'offline' and with a growing number of individuals who are only encountered in a virtual context where there are intrinsic shared interests. When these pre-conditions exist, individuals have opportunities to move into freelance type employment – driving local demand for ICT services and generating income. 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 progress on their digital journey.

At the organisational level, meeting the internal needs of the organisation for information collection and processing is followed by initiatives to engage in collaborative learning with other organisations and individuals. The ability of the organisation to grasp these opportunities often depends upon the existence of individuals who have, themselves, developed their absorptive capacity and progressed from meeting their information needs towards collaboration with others involving information sharing and exchange. When fully developed, these new organisational capabilities make it possible to profit from inter-organisational networks such as B2B e-commerce and to organise and co-ordinate research within a country and, ultimately, on a global basis.

30 See http://www.mqitechnology.com/downloads/motor_design/VirtualMotor-FuelPump.pdf, accessed 1 December 2011.

Section 3: Enhancing Productive Capacity

This section addresses topics of importance in the construction of productive capacity. Many productive capacities are linked to specific industries. The topics are: 1) the leading role of value chains and international production networks in constructing productive capacities, 2) the emerging role of international collaborations involving 'open data' and the addition of value to these resources for entrepreneurial activities in the private sector and for social needs in health, education public safety and environmental improvement, and 3) the role of networks intended to link together professionals for knowledge sharing or brokering technology transfers. These exemplify facets of productive capacity building which involve collaborative learning and are illustrated by specific examples.

The Leading Role of Production Networks and Value Chains in Developing Productive Capacities

The coordination of supply networks and vertical chains of production is driven by commercial need and often is able to access 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 sub-system supply must be coordinated across organisational and international boundaries. In addition, the increasing pace and volume of trade in commodities on a global basis has demanded improved coordination in production of primary sector goods (agriculture, petroleum and mining). Some of these productive activities are subject to relatively predictable cycles and open market coordination. The historical use of arms-length and market-driven procurement using traditional telecommunication facilities such as telephony or fax, for a time may continue to be adequate to facilitate international coordination in these situations.

In many other cases, however, more timely information or information that is more detailed with regard to product qualities, production and logistical timing, convey additional economic value by supporting more effective coordination of supply and demand. This is particularly important in situations where price volatility, inter-dependencies of components in larger systems, and the need for coordination between production and use, are needed. The Internet is an ideal communication network for supporting these productive needs and the capacities to use the Internet for these forms of coordination are key productive capacities that companies are developing. Developing these capabilities involves collaborative learning in which data standards for ordering, invoicing, product specification, and logistics must be agreed along with many other specialised arrangements that are industry specific as illustrated here.

Mexican Agricultural Exports to the United States and Canada

The North American Free Trade Agreement (NAFTA) opened major opportunities for Mexican agricultural exports to the United States. Following 9-11, 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, systems of video monitored freight loading were combined with freight transit monitoring using 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.[31]

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 and supply chain management and traceability, financial services (mobile payments and mobile banking), farm extension services, access to sector experience, research and related resource information, commodity exchanges and warehouse receipt systems.[32] 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 (see section 4).

Production networks and value chains are important 'lead users' in developing uses for the Internet and providing demand for telecommunication network capacity. The historical processes of telecommunication involving episodic and modest levels of data exchange are being supplanted by more sophisticated systems. Newer systems involve the instantaneous communication of large volumes of data detailing product specifications, production timing data and electronic monitoring of goods in transit using RFID, GPS (global positioning satellite) or other systems. Similar developments are occurring in the service industries and these developments are being extended to low and middle income countries.

ICT Networks Supporting Remote Tracking among Coffee Growers in Costa Rica

ICT systems are enabling the product to be certified as meeting organic and fair trade standards. A system was development by SourceTrace, www.sourcetrace.com, a private company with 25 clients working with local cooperatives and firms. One of the software modules enables data errors to be reduced and improves information analysis, leading to reductions in the need for training. A web-based dashboard developed with the cooperative, Coopetarrazú, enables visualization of the supply chain and its management. SourceTrace is also operating in India to support agricultural trade in Mumbai, emphasizing 'complex simplicity' to provide point of sale

31 See (Borbon-Galvez 2011).

32 See (Deloitte 2011).

devices and other e-services relating to transactions. A range of mobile banking applications is also being developed. [33]

These developments in vertical supply chains are relevant to supplier networks and markets as this example from the steel industry highlights. Of particular interest, is that this market platform is established and managed by an Indian company.

Online Auction for Buying and Selling Steel

Metaljunction.com provides an online auction which is used by TATA Steel and other steel companies in India and is managed by TATA. The platform provides an online forward auction and bidding can be done via a desktop online platform or through a mobile application. This is the largest e-marketplace for steel in the world with a buyer community of more than 5,400, including traders, fabricators, re-rollers and end users. Partners in this venture include banks and IBM and it is accredited by NASSCOM, the Confederation of Indian Industry and the specialist professional association. [34]

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

Sasken Communication Technologies in Bangalore

Sasken relocated its headquarters to Bangalore after having been founded in the United States and the original office became a sales office. The firm has developed strong networks that allow it to collaborate internationally to work on the hardware-software interface without having direct physical access to mass production facilities.[35]

The coordination of production networks and value chains provides an important lead user role for the use of advanced telecommunication capabilities. To create and utilise these networks collaborative learning is required to coordinate standards and other elements required for the conduct of business and research on a globally distributed basis.

'Open Data' and Networks for Productive Capacities

The Internet offers outstanding potential for global collaboration in the creation of the 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

33 See Bloomberg, http://www.youtube.com/watch?v=tnfpP2s4sbM, accessed 1 December 2011.

34 See http://www.metaljunction.com/about-us.php#casestudies, accessed 1 December 2011.

35 See (Parthasarathy and Aoyama 2006).

variety and volume of 'open data' are rapidly expanding as in the case of chemicals data as below. The availability of such resources is a major challenge for strengthening absorptive capacities, especially for 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 capabilities, often through processes of collaborative learning, either for deepening or extending markets or for meeting social needs.

Online Data Resources for 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 human constructed chemical compounds, their properties, preparation, and possible uses. Some of these compounds have been patented and, among 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.[36]

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 UN Secretary General's initiative United Nations Global Pulse,[37] and the World Bank's Apps for Development challenge.[38]

The distribution of generally available information in open networks has important implications for meeting social needs. An example is health care networks where there are numerous experiments with advanced technologies enabling consultation regarding patient health. In these cases, communication between health care workers and data on specific patients can be exchanged for purposes of diagnosis and treatment.[39] These types of networks have not been deployed sustainably in countries without well developed infrastructures. This suggests that the costs of their establishment and maintenance at the expense of other healthcare provision have not been seen as worthwhile within budgetary constraints. Examples of similar types of networks in public health, veterinary practice, agronomy, and environmental monitoring can be identified.[40] In all these cases, there are demonstrations of success in providing the technical capacity for such open networks, but there are few examples of sustained deployment.

36 (Curry, Freitas and O'Riain 2010).

37 See http://www.unglobalpulse.org/ accessed 1 December 2011.

38 See http://appsfordevelopment.challengepost.com/ accessed 1 December 2011.

39 See (Blaya, Fraser and Holt 2010), (Kaplan 2006) and (Moahi 2009).

40 For animal health see http://www.researchintouse.com/nrk/RIUinfo/PF/AHP12.htm, for a range of applications see (Kalil 2009) and (Hanna 2010).

These applications are likely to become more sustainable if they can be organised 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 customise prototypes and experimental designs to make them valuable adjuncts to existing local practices.

One set of applications that is developing rapidly is the creation and use of geographical mapping. 'Crowd sourcing' of real time data in response to crisis situations is providing numerous opportunities for entrepreneurial provision of digital data platforms on which local information can be placed. The following signals the variety of activities underway in this area.

Open and Real Time Data: Mapping and Crowdsourcing

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

Open source information crowdsourcing platforms, like Ushahidi, and open mapping and data initiatives, like OpenStreetMap, are enabling citizens in developing countries to generate and disseminate information 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 geographical positioning system (GPS) devices and video cameras). [41]

The commercial and social benefits of open data and networks are built upon a basic principle of the Information Society - the common availability of data provides an important to productive activities. Exploiting the opportunities of open data requires the absorptive capabilities discussed in Section 2 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

The exchange of scientific and technical knowledge has become a major market in which a growing array of 'knowledge brokers' and other intermediaries operate.[42] The exchange of such information is also organised through social networks created and used by scientific and technical professionals. Low and middle income countries face a series of paradoxes in the contemporary environment. 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

41 See (Berdou 2011).

42 (Arora, Fosfuri and Gambardella 2001).

growing, share of scientific and technical information and knowledge has become more commercialised and, therefore, less accessible or usable.[43]

These paradoxes have not been overlooked by scientists, engineers and medical researchers.[44] In the wealthier countries and in low and middle income countries, scientists have contributed to and are seeking to build improved means of access to scientific and technical knowledge and to form international collaborative networks that better link professionals across the globe.

The result of these concerns is the rise in recent years of a number of knowledge brokers with a specific interest in addressing development issues. While many of these knowledge brokerages are organised on a non-profit basis and have specific interests in global issues such as the environment, commercial enterprises are also engaged in these activities. There are no systematic studies of the market and non-market brokerage organizations for development related knowledge with respect to whether well-intentioned non-commercial efforts are effective relative to the commercial offerings.

Coordinating Knowledge Exchange

Global Knowledge Partners (GKP) is an international multi-stakeholder organisation devoted to knowledge sharing for international development and growth. Founded in 1997, the organisation operates throughout the world and brings together professionals engaged in the burgeoning field of ICT4D (ICT for development). Among the projects undertaken by GKP are initiatives to bring together organisations involved in building and operating telecentres, e-commerce initiatives serving areas and companies that do not have the facilities to engage in international trade, and educational programmes to the enhance the participation of youths. GKP activities span both absorptive and productive capacities and this is an example of collaborative learning.[45]

This section has examined several facets of the development of productive capacities. Generalisations about productive capacities are difficult because these capacities are often specific to particular sectors, each of which has its own applications for ICT, uses of networks, and demands for collaboration and innovation. A major impetus to the building of productive capabilities, however, comes from efforts to coordinate global production networks and value chains, the creation and exploitation of open data for commercial and social purposes, and growing efforts to create networks among

43 There are also cases where this commercialisation 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.

44 See for example, (Committee on Issues in the Transborder Flow of Scientific Data -- U.S. National Committee for CODATA 1997) and the continuing activities of CODATA (International Council for Science: Committee on Data for Science and Technology) at http://www.codata.org/ [Author disclosure: I am a member of one of CODATA's task forces]

45 See www.globalknowledgepartnership.org accessed 1 December 2011.

professionals engaged in science, medicine, engineering and development efforts. To exploit the opportunities for innovation and the building of mutual advantage through the acquisition of these capabilities, continued improvements in the technological infrastructure for collaborative learning are needed. This is the subject of the next section.

Section 4: Building Technological Infrastructure for Collaborative Learning

The visible and persistent issue for developing countries is the potential for being left out of technological advances that are widely promoted as being central to innovation, growth and, ultimately, to prosperity. In the Internet age, a common response is to seek measures to bridge digital divides,[46] divides that involve access to the Internet and ICTs.[47] The previous sections highlight the profound transformation that is underway in the way that information and knowledge can be used collaboratively to strengthen absorptive and productive capacity and to foster social and economic development. This section focuses on the proliferation of methods for accessing global and local networks. These methods are technological – the growing use of alternative methods for overcoming the impediments to connectivity within countries **and** organisational – improvements in the ways individuals in low and middle income countries are gaining access to the Internet or using ICTs in entrepreneurial ventures.

Enhancing Global Connectivity

It is often argued that access to the currently available global information infrastructure is inexpensive relative to the opportunities it provides. Access is a by-product of the productive capacity development discussed above and involves installing a modern network or upgrading existing networks.

Investments in modern telecommunication infrastructures (which are largely based upon packet switching technologies) offer the opportunity for access to international data communication networks. The development of the global fibre infrastructure provides unprecedented opportunities for the global reach of data communication networks. Contemporary developments open important access opportunities for countries that would otherwise be isolated. This is comparable to other infrastructure

46 There is a vast literature on digital divide policies which is not reviewed here, see (Heeks 2008), (Mansell 2006), (Norris 2001), (van Dijk 2006), and (Warschauer 2003).

47 ICTs include the panoply of technologies that are increasingly bound together by the Internet. Most visibly, they include the 'terminals' permitting information access and communication, but less visibly, they also involve the telecommunication and computational infrastructures that connect these devices and make the operation of the Internet possible. In the industrialized world, the Internet has been built upon a well-developed telecommunication infrastructure offering near-universal connectivity which is being technically upgraded daily to afford ever greater capacities. There are also non-Internet based ICTs which play an important role in establishing links within and between communities.

developments in transport and trade – the priority is connection to the most economically important location – air travel to major cities or shipping to ports that are, or can be, developed to accommodate container cargo shipments. Thus, while the conditions of access development are opening opportunities for country-level access, they also tend to focus initially on major cities and ports which 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 urbanisation, a feature of modern development with very mixed consequences.[48]

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. A case of entrepreneurial initiative in Nigeria encapsulates this recent history.

The Case of Nigeria

Beginning of the Decade[49]

Owerri is a sprawling town 50 kilometres from the oil city of Port Harcourt and Nigeria's recently inaugurated 5-Gb/s undersea fibre optic connection to the outside world. Since the cable landed in the commercial capital of Lagos in December 2001, little has been done to hook up the many businesses, schools, and other entities that could benefit from it.

Perhaps no one is more impatient [to gain access] than Aloy Chife, the president and CEO of portal and application service provider SocketWorks, based in Lagos […]. Chife dreams big: starting with his company, he wants to nurture Nigeria's neophyte IT industries into an outsourcing powerhouse to rival India's. "The idea is to leapfrog industrial development. We haven't even scratched the surface of IT in Nigeria," says Chife, who also points out that "This country could blossom, but the cost of the Internet is too expensive."

The Present (from a current website)

Dr. Aloy Chife is now President and CEO of SW Global which claims to be "one of the first globally competitive technology companies to emerge from West Africa and penetrate the global information technology (IT) market."[50] This new company focuses on a 'software as a service' business model for financial intermediation, consumer aggregation and application service

48 See, for example, (World Bank 2009) and (Mansell and Wehn 1998).

49 Paraphrased from (Goldstein 2004:49, 50-51).

50 http://www.swglobal.com/corporate/ accessed 25 November 2011.

provision.[51] The company he founded, Socketworks (which specialises in access), complements SW Global and is engaged in projects on an international basis.

From a one-man shop, SocketWorks has grown to become an employer of over 300 people in Ghana, Nigeria, Kenya, Sierra Leone, Liberia and Uganda, and its products impact the lives of thousands of African students. It is expanding operations in Asia and is expected to become operational in India, Pakistan and Sri Lanka. Its institutional investors and shareholders include the World Bank (IFC) and Zenith Bank Plc (the largest Bank in Nigeria.[52]

This case illustrates the complexity of the process involved in the development of access opportunities. From initial frustrations with the inability to bring undersea cable fibre capacities into use, to the formation of a dynamic international company offering access and software services, there is a story of breakthrough and transformation. It demonstrates that development processes *are* underway in some cases and that there is validity to the claims and promises about opportunities offered in the Information Society.

On a larger scale, experience in West Africa is illustrative of telecommunication network connection in low and middle income countries. Initially developed as a cooperative investment by OECD member countries and developing country companies, the SAT-3/WASC cable was meant to extend telecommunication and Internet access to Côte d'Ivoire, Ghana, Benin, Nigeria, Cameroon, Gabon, and Angola. Relatively high prices and restrictions on connection initially imposed by national communication authorities limited capacity utilisation.

However, it appears to have begun to operate near capacity (taking into account a major upgrade of capacity achieved in 2007 and another to come on line in 2011).[53] The robust demand is reflected by the construction of competing cables. These include MainOne, operated by private investors with links to NITEL, the former incumbent telecommunication network operator, GLO-1 by Nigeria's second largest telecommunication service company Globalcom and the planned construction of ACE (Africa Coast to Europe) by a consortium of telecommunication service companies. Capacity is approximately 9.5 terabits(tb)/sec and will exceed 14.5 tb/s assuming ACE comes online in 2012 as planned. This is a significant amount of capacity, equivalent to about 200 million simultaneous telephony connections, or over 300,000 T3 data communication lines.[54]

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51 Ibid.

52 http://allafrica.com/stories/200705020639.html accessed 25 November 2011.

53 (Jagun 2008).

54 T3 is the US standard of 44.736 Mbit/s. Over 400,000 data communications at E3, the European standard of 34.368 Mbit/s will be possible. As an illustration, the data communication needs of a medium sized university in an industrialized country can usually be served by a single T3 or E3 connection.

A principal issue for policy is the increasing complexity of information infrastructure provision. There clearly is an enormous expansion in physical capacity and its utilisation, 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 the aim of addressing these pricing and availability issues and have had a positive impact, there are remaining bottlenecks.

For example, despite the availability of submarine fibre capacity, the use of VSAT (very small aperture terminal) satellite communication systems is prevalent throughout West Africa and in other parts of the world. VSAT services are often less cost-effective solutions in areas which are also served by wired or wireless infrastructure.[55] The widespread use of a VSAT satellite infrastructure is an indicator of problems in the organisation or pricing of terrestrial physical infrastructure supply. In summary, challenges remain in exploiting opportunities offered by developments in the global information infrastructure that are highlighted here for West Africa, but which are also present in other low and medium income countries.

Extending the Mobile Access Infrastructure

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 is burgeoning. In the developing world, mobile phones address two of the important issues of access – the investment costs for terminals and the 'getting started' costs of digital literacy as a pre-condition for the use of digital services. As successful as mobile services are, however, there are important limitations. Mobile services remain expensive despite progress in encouraging market competition, in part, because mobile service provides a tax base in countries where the means to collect taxes are limited.

In addition, the commercial success of mobile 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 in an infrastructure that has not been constructed for data communication and other advanced telecommunication services.[56] It is clear that mobile phones are capable of supporting poverty alleviation

55 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 standards such as WiMAX.

56 (Beard 2008).

initiatives and improving the conditions of life for those with the least income.[57] It is less clear how the mobile revolution has or can support the activities of more complex information sharing and exchange activities in which intensive data communication and display needs outrun the capacities of the mobile phone.[58]

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:

-- better information about market opportunities;[59]

-- ability to distribute informational messages to larger numbers of subscribers without the use of Internet-infrastructure;[60]

-- tele-medicine and tele-veterinary consultation opportunities;[61] and

-- mobile remittance services such as M-Pesa, a successful system implemented in Kenya.[62]

An issue that has not been considered adequately is the impact of mobile phone network development on the prospects for further development of fixed networks. Despite considerable success in extending telecommunication access through mobile phones, the problematic issue is that reduced interest in the fixed network discourages investment in its modernisation and upgrading. This has consequences for its ability to serve both the back haul needs of mobile networks and the use of fixed data communication terminals.

To summarise, the past decade has seen a major expansion in country level connection to the global information infrastructure. Nonetheless, there remain substantial imbalances and within country networks lag behind major or capital city developments.

57 A special issue of the *Journal of Information Technologies and International Development*, contains articles supporting this claim (Agüero, de Silva and Kang 2011; Samarajiva 2011; de Silva, Ratnadiwakara and Zainudeen 2011; Smith, Spence and Rashid 2011; Zainudeen, Samarajiva and Sivapragasam 2011).

58 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.

59 (Heeks and Jagun 2007).

60 (Etzo and Collender 2010).

61 (Etzo and Collender 2010).

62 (Jack and Suri 2011).

Extending the Bridge – Local Facilities and Networks

The issue of access to ICTs has been considered in terms of universality – the costs and barriers to offering access to entire populations, particularly in low and middle income countries. Access to some of these technologies and services may be better distributed more unevenly, at least initially because there are tradeoffs between the feasibility of extending access broadly and the practicality of concentrated and limited provision. This may seem to reinforce the possibility of increasing digital divides – creating larger gaps *within* societies, but the costs of network extension (discussed above) may have this effect in any case.

A primary tool in extending access is the 'telecentre' – investment in physical sites where access can be provided and equipment and skills can be shared. Telecentres may be organised as private entrepreneurial activities often called 'cyber-cafes' or they may be organised as government-sponsored or subsidised facilities. Either form of organisation may support absorptive and productive capability building including education and support for local employment in tele-service type occupations.

It is widely appreciated that telecentres offer a means for mitigating access problems in contexts where widespread access is problematic, where the costs of individual or family access are prohibitive relative to income levels, or where there are substantial shortcomings in available skills or knowledge. Because 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.[63]

In terms of numbers, the largest numbers of telecentre-type access points are most likely cybercafés. Many, if not most, cybercafés are organised as private enterprises with equipment investment and network access charges paid through the rental of access on an hourly basis. 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 easy to mis-estimate the extent of demand or to rely upon a class of users (such as foreign tourists) whose demands are episodic. Moreover, as is the case with other types of telecentres, there are questions about whether the activities conducted are able to generate incomes that offer sustainability for the operators of the centres.

The problem of economic sustainability is a classic 'bootstrap' type development problem facing NGOs and public agencies that seek to extend ICTs through telecentres. Without affordable access, it is unlikely that people will find ways of creating incomes through the use of cybercafés or sponsored telecentres. 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. Because of the substantial

63 See (Gomez 2010), (Madon 2009), (Rothenberg-Aalami and Pal 2005) and (Sey 2008).

optimism about the social and economic value of Internet access, it is often expected that such bootstrapping simply will succeed, especially when there is strong community engagement as in the case of Jamaica (see below). Public and NGO sponsorship of telecentres seems to experience similar problems to those faced by private investors in cybercafés.

Community Engagement with Jamaican Telecentres

In a study of 16 Jamaican telecentres the formation of off and online networks is highlighted as an important feature in relation to a natural disaster and in a sustained context. After the hurricane, some of the telecentres had electricity and Internet and users remained active in communicating with friends and family. This greatly assisted disaster relief. Telecentres also helped to reduce tensions between teen groups in the community and contributed to health care awareness in coping with diabetes and HIV/AIDS.[64]

While it may be established that initial investments bring rewards to specific individuals, these rewards are rarely widespread or large enough to maintain the telecentre. In exceptional cases, the telecentre becomes a workplace where individuals come regularly to engage in tele-service type jobs. While more sustainable, this model is a close substitute for entrepreneurial-led establishment of tele-service businesses and related workplace. This means that there is some risk that the struggle to achieve sustainable government and NGO-sponsored telecentres may displace private sector initiative.

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 education infrastructure. This does not resolve the problem of sustainability but it makes more visible the *tradeoffs* 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.

This section highlights the rapid acceleration of Internet access opportunities at the country level and the challenges and complexities of 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 improvement, development of physical access is an important challenge. It is characteristic of transformative innovation processes that expectations outrun achievements and the efforts of both serial entrepreneurs and serial attempts to innovate eventually have been shown to bear fruit if actors and expectations persist so at to carry forward their experience.

64 (Bailey 2009).

Conclusion and Points for Discussion

This issues paper documents key processes through which developments in ICTs and the information infrastructure of the Information Society are supporting progress towards knowledge societies that are responsive to the development aspirations of low and middle income countries (as well as the less well resourced areas of higher income countries). A central theme is that processes of learning by collaboration are central to innovation, research and technology transfer, support for entrepreneurship and mutual advantage in trade and exchange. Collaborative learning involves a capacity building process which has two crucial dimensions that are the principle focus in this paper - absorptive and productive capacities.

Absorptive capacities are gained through a developmental process at the individual and organisational levels. This process begins with personal interests in information in the case of individuals and internal organisational needs for data capture and processing. Moving beyond this initial individual or internal stage, digital skills become central to processes of collaborative engagement and learning and this is more demanding. For individuals, the complementary of local and online networks of individuals with shared interests is essential for gaining the absorptive capability to exploit opportunities and, eventually, to undertake entrepreneurial initiatives. A similar process is involved for organisations – initially internally focussed, companies develop an outward focus and engagement with suppliers and customers so that they are able to negotiate and collaborate with partners to co-ordinate their activities.

A key issue in absorptive capability development is whether the social processes supporting collaborative learning are fit for purpose in the Internet age. Much of the literature and promotion of Internet opportunities focuses on the mastery of technological related skills. Less attention is paid to how these skills are coupled into activities that are beneficial and sustainable for individuals. The existing literature is also more concerned with identifying successful organisations than with analysing the *processes* through which they construct their success.

Discussion Point 1: How can a greater emphasis on the processes by which individuals and organisations acquire more advanced capabilities needed to engage in entrepreneurship be encouraged?

In the case of productive capability, the role that production networks and value chains play as lead users in building collaborative learning in order to transfer technology effectively and build mutual advantage 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 ICT and the Internet. International cooperation in the provision of open data and resources and collaboration in building platforms that are capable of addressing social needs is a parallel development. In both cases, new tools for collaboration and technology transfer are aiding the process.

Discussion Point 2: What incentives are needed to encourage debate about the collaborative aspects of research and innovation to highlight the specific contributions of approaches such as open data provision and the capabilities and resources needed by private and other organisations that are supporting these developments?

Networks of professionals play a central role in collaborative innovation processes which give rise to stronger productive capabilities. There are organisations that are addressing this issue – some of which serve as commercial knowledge brokers, while others are approaching this issue from a development assistance perspective.

Discussion Point 3: What is the appropriate balance between commercial and non-profit approaches to building networks of professionals? How can professional associations of scientists, medical professional, technologists and other practitioners be more strongly engaged in establishing such networks for mutual advantage?

Developments in the information infrastructure which have evolved rapidly over the past decade have been highlighted, emphasising that distribution of connectivity within countries and problems of access and the cost of access continue to be challenges. One response is a proliferation of other access modalities including mobile networks, VSAT satellite communication, and wireless networks. The proliferation of access arrangements is providing important entrepreneurial opportunities but it is also creating some complexities for resolving remaining barriers.

Discussion Point 4: What encouragement can be given to ensure that studies of the predominance of and balance between alternative global information access methods are undertaken with the goal of assessing how problems are impeding the development of the infrastructure needed to support collaborative learning through global networks?

The evolution of the telecentre – defined as encompassing entrepreneurial cybercafés and 'sponsored' facilities (more commonly called telecentres) is central to addressing issues of access. These developments are supporting a range of entrepreneurial and innovative activities, but the larger question of the sustainability of these facilities is not being addressed sufficiently and needs to be higher on the policy agenda.

Discussion Point 5: What policies are needed to better secure the sustainability of telecentres? Are telecentres likely to be overtaken by more direct means of access and what are the challenges of building the social networks that are essential for motivating people and organisations to build higher-level ICT skills?

Opportunities for the advance of the Information Society are considerable but there are important challenges. Policy discussion needs to advance by considering the way innovation, research and technology transfer are supported through networked

collaborative learning and the strengthening of absorptive and productive capabilities. The social and economic dimensions of these processes are often neglected in discussion about the inherent benefits of ICTs. It is crucial to understand the means by which people and organisations build the capabilities required to achieve greater capacities for entrepreneurship and collaborative development in a way that sustains and augments the mutual advantage to both individuals and organisations.

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