Technology Leapfrogging for Developing Countries

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INTRODUCTION

Information and communication technologies (ICTs) have been acknowledged, in research works on developed and industrialized countries, for their potential in opening up development opportunities. At firm level, ICTs can facilitate communications and coordination of processes within a firm or between firms in a supply chain such as through e-collaboration (Fong, 2005; Hammant, 1995; Jin, 2006; Porter, 2001; Porter & Millar, 1985). These technologies can also improve management decision-making process through better and faster marshalling of information. Gains from these applications may be in the form of scale economies, cost-savings, increased productivity, and improved competitiveness (Bourlakis & Bourlakis, 2006; Farrell, 2003; Hammant, 1995; Howgego, 2002; Pilat, 2004; Porter & Millar, 1985). At industry level, ICTs can improve the functioning or governance of market (James, 2000; Malone, Yates, & Benjamin, 1989; Matsuda, 1994; OECD, 2005). From the social-economic perspective, ICTs can improve quality of life of communities, provide greater access to health and education services, and create economic opportunities for any underprivileged population groups (Mercer, 2001; Oberski, 2004; Reisman, Roger, & Edge, 2001; The World Bank, 2001; UNDP, 2001a; United Nations, 2006). All these improvements in efficiency and access are likely to be aggregated at the national level in the form of economic growth or sustainability, and welfare gains (Madden & Savage, 2000; OECD, 2005).

Developing countries are generally latecomers to the ICT revolution, but if they can emulate industrialized countries in their adoption of ICTs, they will be afforded the same technological opportunities. Successful exploitation of such opportunities by developing countries can significantly narrow the economic gap between them and developed countries as they catch up in economic development.

In ICT's advancement trajectory, the opportunities offered by a newly emerged ICT tend to be superior to those of prior versions of technology. If a developing country leapfrogged to a newly emerged ICT, it would then be exposed to unprecedented potential in alleviating poverty and securing economic growth, as well as the possibility of surpassing developed and industrialized countries in economic development. Thus, technology leapfrogging is an attractive notion to developing countries, but is it a realistic goal?

BACKGROUND

"Technology leapfrogging" refers to the adoption of advanced or state-of-the-art technology in an application area where immediate prior technology has not been adopted. Discussions of ICT leapfrogging have largely focused on developing countries, which generally lag behind on technology adoption, and unlike the developed countries, are not inhibited by entrenched intermediate technology. New and advanced technology provides developing countries with the opportunity to accelerate economic development (Hanna, Guy, & Arnold, 1995; Prayag, 2001; OECD, 2005; UNDP, 2001b). In addition, the advancement of ICTs has reduced costs and imposed lesser demands on the skill of the users due to user-friendly features (Ensley, 2005). The possibility of achieving significant economic growth through advanced and less costly technology thus seems exceptionally attractive to developing countries. It has also been suggested that developing countries do not have any alternative in technology adoption, except to leapfrog to new and advanced technologies (Choucri, 1998; Mansell & Wehn, 1998; Davison, Vogel, Harris, & Jones, 2000).

The concept of technology leapfrogging for ICTs first emerged in the early 1990s (Antonelli, 1991; Lamberton, 1994; Mody & Dahlman, 1992). However, research works in this area were still limited, hindered by a lack of clear empirical data from developing countries, measurement difficulties, the relatively short-time span of newly emerged and advanced ICTs, and the long time span involved in gathering reliable data to understand technology leapfrogging in developing countries (Alzouma, 2005; Ausubel, 1991; Prakash 2005; Sharif, 1989; UNESCO, 1996).

As a result, technology leapfrogging remains a controversial concept. For example, in the case of Africa, Chisenga (2000) believes that the implementation of this concept would facilitate global integration of businesses, and provide a better learning environment for African children, all to the benefit of the economy. Ochieng (2000), on the other hand, believes that investments in ICT compete with the provision of basic necessities for the poor. One of the general arguments against leapfrogging has been that it might turn out to be an expensive trajectory in the short run for developing countries, which tend to bear a high burden of debts (Chen, Farinelli, & Johansson, 2004). In addition, investment in a

new technology is likely to involve a long payback period for developing countries because of the nascent conditions of their market. It has been further argued that the worst possible outcome from this exercise would be when the new investment was displaced by a major breakthrough before these developing countries geared up in their capabilities to sufficiently harness their technology investment. Some commentators believe that the developmental effects of ICT applications have been greatly exaggerated and caution that advanced technology makes little difference and can even inflict harmful effects, such as creating a digital divide, in the lives of people in developing countries (Mansell, 1999; Sussman, 1997; United Nations Commission on Science for Technology and Development, 1997; Van Dijk, 1999; Wang, 1991).

Kojima (2003, p. 1), however, highlighted that the concept of technology leapfrogging requires selective and discerning application. She noted that technology leapfrogging is applicable to certain technologies such as ICTs but not to emission control technology, a field where developing countries should wait for developed countries to test out the emerging technology before adopting it.

LEAPFROG TO WIRELESS ICTs

It has been claimed that leapfrog technologies are largely those that do not rely on tangible grid. These include mobile phones, satellite communications, and decentralized power sources like solar power (Article 13, 2005). Wireless ICTs, such as mobile phones, have emerged as a leading leapfrog technology (BBC News, 2002; Nkwae, 2002; Cascio, 2004). Mobile phone communication technology has even substituted the traditional fixed networks in developing countries such as China and many African countries.

Leapfrog wireless communications technologies (ICTs) have often generated significant benefits for communities. For example, villages in Robib, Cambodia, were reported to have leapfrogged from an agricultural to an information economy through wireless network (oneworld radio, 2006). The villagers were able to access medical and health services, and a global marketplace for their cottage industry through wireless communications technology. In Africa, information available through mobile phones enabled farmers in Senegal to double the prices of their crops and herders in Angola to locate their cattle through GPS (global positioning system) technology (oneworld radio, 2006). In another study by Williams on "The relationship between mobile telecommunications infrastructure and FDI in Africa" (as cited in Vodafone, 2005), at least 50% of small businesses surveyed in South Africa and Egypt attributed profit increases to mobile phone usage. The same study also found that more than 75% of respondents in Tanzania and South Africa experienced improvement in contact and relationships with close ones because of mobile phone communications technology (Vodafone, 2005). In all these cases, however, the actual benefits from leapfrogging were yet to be ascertained at the aggregate level.

Technology by itself does not solve problems, but the availability and use of ICTs are a prerequisite for economic and social development in developing countries. In other words, ICTs are not a standalone solution to development problems. Developing countries characteristically lack many of the conditions needed to harness and sustain leapfrog-type development offered by new and advanced technology. Because the conditions in developing countries are usually weak or inadequate, cultivating, building, and deepening these conditions to support the mastery, applications, diffusion, and innovation of leapfrog technologies are unlikely to prove easy or straightforward. It is therefore anticipated that developing countries would not be able to fully utilize or exploit the potential of advanced technology at the early stage of leapfrogging due to their limited infrastructure. Despite this, there is no point for developing countries to go through the fiber optic building process for their telecommunication infrastructure when they could start out with wireless telecommunications. Leapfrogging to wireless communications technology is a valid strategy based on the promising technology's potential for economic advancement, and the lower costs and resources involved in setting up a telecommunication infrastructure. It has been estimated that wireless technologies cost about 20% of traditional wired installations (United Nations General Assembly and Economic & Social Council, 2000). Developing countries should develop and strengthen their infrastructure within the framework of advanced technology rather than time- and resources-consuming intermediate technology that is likely to prolong their subservient position in development. In capabilities development and learning processes for example, developing countries should be exposed to and educated in the skills required by higher-level technologies.

However, technology leapfrogging may pose very high risks to developing countries if immature or unproven technologies are involved. Despite this, the risks can be managed and minimized by careful planning and evaluation, to capitalize on the opportunities of leapfrog technology. Otherwise, they are likely to end up as expensive failures. In the planning and implementation of any technology leapfrogging process, developing countries need to take into consideration a number of factors (shown in Figure 1) which are likely to impact on the time span involved in the mastery, applications, diffusion and innovation of the technologies involved.

Figure 1 includes certain conditions such as literacy and education that cannot be immediately emulated or leapfrogged despite their undoubted importance in reaping the greatest advantages from advanced ICTs. The nurturing of human capabilities requires substantial investment in

Table 1. Factors relevant to conditions for technology leapfrogging

Factors	Example of issues	Source
Market condition: • Market demand • Market competition	• Market competition for rational pricing of ICT & access, • Development of locally relevant content and languages to promote advanced technology uptake, • Foreign participation through investment to break down monopoly structure.	Adzadi, 2001; Alzouma, 2005; Choucri, 1998; Davison et al., 2000; Ensley, 2005; Garcia & Gorenflo, 1999; Grace et al., 2001; Haddad & MacLeod, 1999; International Telecommunication Union, 2004; Mansell, 1999; Mbambo, 1996; Nkwae, B. (2002); OECD, 2005, 2006; Praskash, 2005; Pringle & David, 2002; Raji et al., 2006; Sehrt, 2003; Sinha, 2005; UNDP, 2001a, 2001b; United Nations General Assembly and Economic & Social Council, 2000; Vodafone, 2005; Wijkman & Afifi, 2002.
Institutional capacity	• Support for intellectual capital development, • Development of stable learning and attractive investment environment, • Ensuring security and stability in the environment, • Establishment of an enabling regulatory and legislative framework, • Economic, social, and political stability.	
Social	• Ensuring equity in digital access, • Narrowing or erasure of digital divide.	
Human capabilities	• Improvement of literacy and computer literacy levels, • Nurturing of requisite skills and expertise. • Continuous investment.	
Government	• Definitive guiding policies, • Strategic deployment of ICT, • Coordination and linkages among actors in the system.	
Stakeholders	• Interaction and strategic links among actors in the system, • Regional and international cooperation and collaboration, • Identification of e-champions and e-leaders to spearhead technology leapfrogging projects.	
Utility infrastructure	• Electricity, transportation networks, etc.	

education and skills transfer, and also government intervention to expedite the development and accumulation of human capabilities. Governments, besides being providers of national education, can use incentives to encourage private initiatives in the provision of training resources.

In regard to market conditions, telecommunication markets that are operated by a monopoly which charges high access fees represent a serious obstacle to advanced technology uptake and investment. The ITU (2004) observed that mobile markets of competitive structure have significantly higher rates of mobile penetration than monopoly markets, even where per-capita incomes are the same. Competition is important for making access cost affordable to users, and for developing products and services that meet users' requirements. This in turn would help to generate substantive market demand and confidence in future technology investment.

In addition to achieving competitive market conditions, strong legislative frameworks must be introduced to provide environmental stability and security, such that businesses are confident to invest and consumers are confident to uptake new technology and trial its sophisticated potentials. Governments in developing countries are likely to face the challenge of designing an appropriate regulatory environment to support and enable effective operation of a sophisticated telecommunication infrastructure. However, an appropriate regulatory environment could be achieved through goodwill assistance from experienced international aid agencies and developed countries. Such assistance should not be limited to regulatory or legislative environment; developing countries in fact require partnerships and long-term support at the local, national and international levels for their capabilities and other institutional capacity building, research and development, and innovation of leapfrog technologies.

It must also be noted that a new and advanced technology, which is capable of offering development opportunities to developing countries, may also be capable of creating a digital divide within these economies. Therefore, advanced technology adoption and diffusion must be user-focused rather than technology-focused, as social issues can turn out to be a formidable barrier to technology leapfrogging. To prevent the emergence of digital divide, government-donor-community-enterprise partnerships may be initiated to support ongoing projects of expanding wireless communication access to rural areas. To advance the goals of a country's leapfrogging strategy, commitments from a strong network of governmental and nongovernment participants including e-leaders and e-champions, are vital for its success.

FUTURE TRENDS

In communications technology adoption, wireless and mobile technologies offer a relatively quicker and less costly way to leapfrog the more expensive and time-consuming task of building fixed-line telephone networks. In addition, these technologies are built on an easily deployable infrastructure. As a result, wireless and mobile communication technologies will become a dominant medium in developing and transitional countries in the coming years.

The wireless mobile phone industry is in the early phase of deploying its third generation (3G) technologies, which are capable of sophisticated communication features. These technologies have the potential to integrate data communications and computing capabilities into handsets such as mobile Internet. The full deployment of 3G technologies will change industry value networks through their wide range of nonvoice services.

CONCLUSION

Technology leapfrogging is likely to be difficult and challenging for developing countries. Rather than start out with traditional fixed-line solutions, developing countries should leapfrog to wireless technologies which offer a relatively quicker and less costly way of building a telecommunication infrastructure. However, economic development benefits may not quickly accrue to developing countries in their leapfrogging efforts. These countries are likely to take a considerable period of time in building their capabilities to absorb, master, use, and innovate leapfrog technologies. Nevertheless, the process may be expedited by the deliberate policies and guidance of governments in these countries, with support from the international arena. At the same time, governments in these countries must constantly reassess the impact of policies and align them with the social objectives so as to remain user-focused in the need to harness the technology quickly.

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KEY TERMS

Digital Divide: Refers to the disparity between two or more groups of people in their access to digital technology. Digital divide can occur at national level (between different groups within the economy) and/or global level (between different countries or regions).

E-Collaboration: A process by which internal and external individuals and/or groups work together on a practical endeavour through integrated electronic networks enabled by ICTs or coordination technologies.

GPS: A global positioning system that uses satellites, computers, and receivers. It can be used for navigation and tracking purposes, based on computer calculation of time difference between signals emitted from satellites and received by receivers.

ICT: Encompasses all the technology that facilitates the processing, transfer and exchange of information and communication services.

Productivity: In economic terms, is the value of output produced using one unit of input. Workplace productivity generally means output per worker. For a considerable period of time, economists failed to determine the relationship between investments in ICT and productivity. This phenomenon was known as "productivity paradox". Although evidence of this relationship has emerged from studies at the firm level in recent times, measures of it at the aggregate or industry level remain nebulous (Pilat, 2005).