FUNDAÇÃO GETÚLIO VARGAS
ESCOLA DE ADMINISTRAÇÃO DE EMPRESAS DE SÃO PAULO

LEE CATHERINE BOOKER

THE PROMISED LAN:

The Transformative Power of Information and Communications Technology in Developing Countries

A Revision of Current Best Practices and Measurements

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Campo do Conhecimento:
Gestão e Competitividade em Empresas Globais

Orientador Prof. Dr. Antonio Gelis Filho

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RESUMO

Este tese analise as implicações dos investimentos em tecnologia de informação e comunicação (ICT) em países ainda em desenvolvimento, especialmente em termos de educação, para estimular a implementação de uma infra-estrutura mais moderna em vez da continuação do uso de métodos tradicionais. Hoje, como o interesse e os investimentos em ICT estão crescendo rapidamente, os módulos e as idéias que existem para medir o estado de ICT são velhos e inexatos, e não podem ser aplicados às culturas de países em desenvolvimento. Políticos e investidores têm que considerar estes problemas quando estão pensando em investimentos ou socorros para programas em ICT no futuro, e investigadores e professores precisam entender os fatores importantes no desenvolvimento para os ICTs e a educação antes de começar estudos nestes países. Este tese conclue que investimentos em tecnologias móbeis e sem fios ajudarem organizações e governos ultrapassar a infra-estrutura tradicional, estreitando a divisão digital e dando o resulto de educação melhor, alfabetização maior, e soluções sustentáveis pelo desenvolvimento nas comunidades pobres no mundo de países em desenvolvimento.

PALAVRAS CHAVE: ICT, educação, investimentos, divisão digital, leapfrog, infra-estrutura, internet, móbil, tecnologia, desenvolvimento, indicadores, WiFi

ABSTRACT

This thesis analyzes the prospects and implications of investment in Information and Communications Technology (ICT) in developing countries, particularly in terms of education, to spur the implementation of a more modern infrastructure versus conversion of traditional methods. Given the rapid pace of interest and investments in ICT, current readiness models and capability measurements have become outdated, inaccurate, and inapplicable to developing cultures. Policymakers and financiers must be cognizant of these considerations when evaluating investments in or aid for future ICT initiatives around the world, and researchers and educators should understand the factors involved in development for both ICTs and education before beginning studies in poor areas. This paper concludes that investments in mobile and wireless technologies will allow organizations and governments to leapfrog traditional infrastructure, narrowing the digital divide and resulting in enhanced education, higher literacy rates, and sustainable solutions for development in impoverished communities in the developing world.

KEY WORDS: ICT, education, investment, digital divide, leapfrog, infrastructure, internet, mobile, technology, development, indicators, WiFi

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The completion of this project would not have been possible without my thesis advisor, Professor Antonio Gelis Filho, who helped me through every stage of the process and taught me about the *jeitinho* during my first year in Brazil. I would also like to acknowledge Devinder Thapa, who introduced me to the efforts of Mahabir Pun in Nepal and was always happy to share his own publications with me. Finally, I would like to thank Professor Daniele Archibugi for taking time out of his family's vacation in Paris to meet with me at length and discuss his work on Information and Communications Technology indicators, which inspired my final product. I would be remiss if I didn't offer my sincere gratitude to my family for their continued love and support throughout all of my academic endeavors.

Dedication

One evening in the early 1990s, my father took the whole family out to dinner for a celebration. As we waited for our meal, he presented my sister and me with small slips of paper with an odd string of letters. “These are your new email addresses,” he said; “this is a big deal.”

We had no idea what email was at the time, but by my 12^{th} birthday I could type fluently as a result of hopping online after school every day to chat with my friends. The advent of internet also gave me access to online shopping, and I begged my mother to buy me every item from every link my friends would send. She finally got tired of always saying “no” after I showed her an online advertisement for Birkenstocks that lauded them as *The Stradivarius of Sandals*. “Write me an essay on why it’s good to be the Stradivarius of Sandals and maybe you can have them,” she hedged.

This thesis is dedicated to my parents, who ensured that I grew up straddling the worlds of cutting-edge ICT and well-written persuasive arguments.

List of Figures and Tables

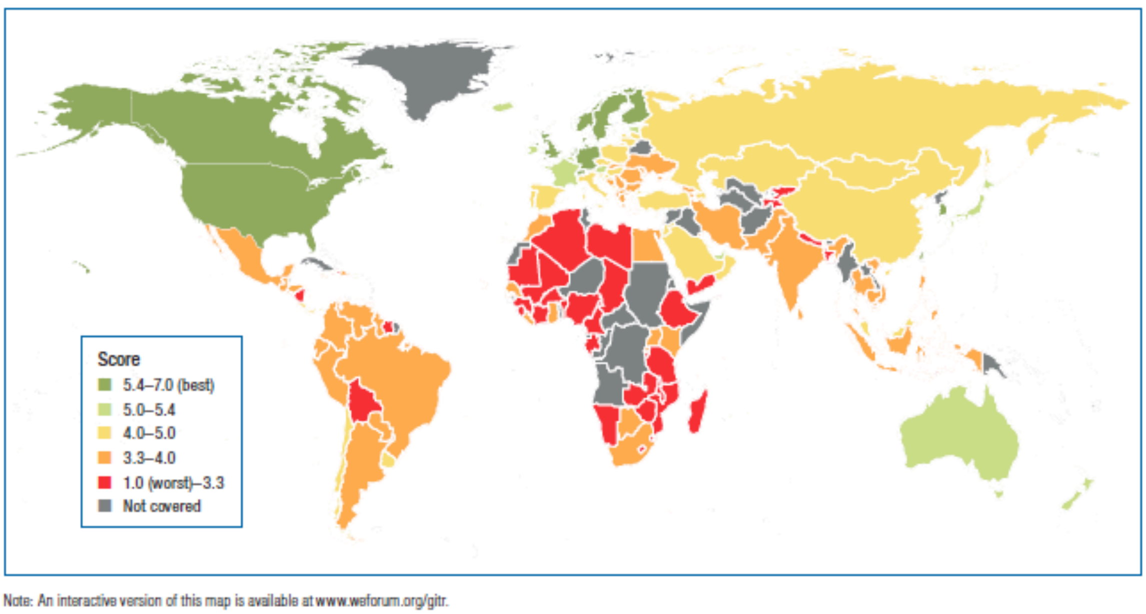

Figure 1. Worldwide Coverage. Bilbao-Osorio, Dutta & Lanvin, 2013, p. 16.

List of Abbreviations and Acronyms

Acronym/Abbreviation	Full Name
3G	Third generation of mobile communications technology
4G	Fourth generation of mobile communications technology
APM	Assets Pentagon Model
ArCo	ArCo Technological Capabilities Index
ATM	Automated Teller Machine
BRIC	Brazil, Russia, India, China
BYOD	Bring Your Own Device
CEO	Chief Executive Officer
CT	Communications Technology
ENIAC	Electronic Numerical Integrator And Computer
GDP	Gross Domestic Product
GNI	Gross National Income
GSM	Global System for Mobile Communications
GSMA	Global System for Mobile Communications Association
HDI	Human Development Index
HiWEL	Hole-in-the-Wall Education Limited
IBM	International Business Machines
ICT	Information and Communications Technology
ICT4D	Information and Communications Technology for Development
IT	Information Technology
ITU	International Telecommunications Union
LTE	Long Term Evolution
MIE	Minimally Invasive Education
MNC	Multi National Company
Mpbs	Megabits per second
NGO	Non-governmental Organization
NRI	Networked Readiness Index
NWNP	Nepal Wireless Networking Project
OECD	Organization for Economic Co-operation and Development
OLPC	One Laptop per Child
PC	Personal Computer
R&D	Research and Development
RAND	Research and Development Corporation
SARI	Sustainable Access in Rural India
SMS	Short Message Service
SOLE	Self-Organised Learning Environment
TAI	Technology Achievement Index
TED	Technology, Entertainment, Design
UN	United Nations
UNDP	United Nations Development Program

WEF	World Economic Forum
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WMAN	Wireless Metropolitan Area Network

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1 Introduction

Advances in Information and Communications Technologies (ICTs) play an integral part in driving economic and social development. Consequently, numerous studies seek to quantify ICT capability or readiness among countries; while the indicators employed vary significantly, most use general metrics to assess technology development, infrastructure, and human skills or education. Universally it has been demonstrated that developing countries severely lack resources in human development, education services and especially in technology. Because of this, certain areas of infrastructure (power and telephone lines) have automatically relegated them to "unready" or "not capable" status.

Many policymakers use these rankings to make the case that, even if provided access to technological resources, low-income countries would be unable to employ them in a sustainable manner in the long-term. They claim countries with poor literacy rates – and nearly negligible ICT literacy rates – will not benefit from opportunities provided by technological upgrades or initiatives. When considering increases in foreign aid or government subsidies for technology diffusion programs that help the poverty-stricken learn to use computers and the internet, policymakers point to these rankings as justification for denying funding.

However, such traditional ICT capability measurements may no longer be applicable for either infrastructure or human skills or education indicators. In the past decade developing countries have leapfrogged traditional technology rungs with innovative infrastructure design, increasingly employing alternative power sources, sending data on pay-as-you-go mobile devices rather than PCs with subscription services, and jumping straight onto high-powered WiFi or 3G networks instead of waiting for the

construction of wired broadband. Those without mobile devices frequent internet cafes, thereby rendering useless indicators such as number of computer owners or internet subscribers to tell the story of how many people are online (CID, 2006).

Perhaps more importantly, developing countries may be on the verge of leapfrogging developed ones in educational innovations with modern ICT infrastructure models, thereby diminishing the gap in quantity and quality of schooling. For decades now, academics who study teaching methods have tried to convince developed countries that effective implementation of ICT in education has the potential to change the way we learn and hence the pace of learning. Recently these educators have directed efforts toward developing countries, where local teachers welcome any research that might help efforts in the world's poorest communities. Experiments like Sugata Mitra's (2005) "Hole-in-the-Wall," which monitored children in Indian slums exposed to computers and the internet for the first time, have been extremely revealing. Mitra, who won the 2013 TED Prize to spark global change, found that the children in his experiments taught themselves to use the computer and the internet within a few days – and despite speaking only the local language at the beginning of the experiment, within months the children were reading and writing in English online.

In light of these studies, this paper analyzes the prospects and implications of investment in ICTs in developing countries, particularly in terms of education, to spur the rapid implementation of modern infrastructure versus the conversion of traditional methods. Given such investments, concepts of readiness and capability measurements become outdated, inaccurate, and inapplicable to developing cultures. Policymakers and financiers must be cognizant of these considerations when evaluating investments in or

aid for future ICT initiatives around the world, and researchers and educators should understand the factors involved in development for both ICTs and education before beginning studies in poor areas. Investments in mobile and wireless technologies will allow organizations and governments to leapfrog traditional infrastructure, narrowing the digital divide and resulting in attainable education, skyrocketing literacy rates, and sustainable solutions for development in impoverished communities.

This paper begins by discussing and familiarizing the reader with the current ICT measurement methods and indices as well as dissecting the drivers and problems with rankings. After introducing the measurement systems, evidence is presented to demonstrate that developing countries now have the ability to leapfrog traditional infrastructure with wireless and mobile technologies, thus narrowing the digital divide. The sharp increases in mobile and wireless usage in impoverished communities, examples of a successful project connecting rural areas of Nepal, and differences in methods of mobile and internet use in developing countries all point to transformations of the ICT status quo. The implications of this leapfrogging are then investigated, with a specific focus on education. The obstacles and failures of the current educational system in both developed and developing countries call for significant changes, and studies show that ICT implementation in and out of the classroom may be the best way to bring about those changes. Many of the same studies also suggest that ICT training is not necessary for the effective use of new technologies, further complicating arguments against investment in ICT and education in developing countries. This paper presents the cases for and against this investment, including examples of several countries yielding positive returns and gives policy recommendations for improving and increasing investments.

Finally, the conclusion looks toward the future, touching on the implications of burgeoning developments like big data and proposing that current valuation systems of ICT readiness be reassessed.

2 Argument

2.1 A Note on Terminology

2.1.1 Country Classifications

The World Bank classifies world economies based on gross national income (GNI) per capita, with revisions every July. The current classifications are: Low income, for countries with a 2012 GNI of $1,035 or less; Lower middle income, with 2012 GNIs of $1,036 to $4,085; Upper middle income, from $4,086 to $12,615; and High income, for $12,616 or more. These classifications help determine a country's lending potential and eligibility. Changes from 2012 to 2013 are displayed in Table 1, with major moves highlighted (The World Bank, 2013d). For the complete 2013 classification tables from The World Bank, please see Appendix 6.5.

The World Bank acknowledges that low- and middle-income economies may be referred to universally as "developing economies" or "developing countries." They note that the use of "developing" for those economies "is not intended to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development," but that it is simply a convenient moniker (The World Bank, 2013b). They further note that income classifications may not correlate to development status (The World Bank, 2013b).

ECONOMY	**OLD GROUP**	**NEW GROUP**
Albania	Lower middle	Upper middle
Antigua and Barbuda	Upper middle	High
Belize	Lower middle	Upper middle
Chile	***Upper middle***	***High***
Fiji	Lower middle	Upper middle
Hungary	High	Upper middle
Iraq	***Lower middle***	***Upper middle***
Latvia	Upper middle	High
Lithuania	***Upper middle***	***High***
Marshall Islands	Lower middle	Upper middle
Mauritania	Low	Lower middle
Russian Federation	***Upper middle***	***High***
South Sudan	Lower middle	Low
Tonga	Lower middle	Upper middle
Uruguay	***Upper middle***	***High***

Table 1: Changes in Classifications, 2013 (The World Bank, 2013d).

In academia, governments, NGOs, media, and the business world, "developing country" often refers to the broad range of states not included in the original 20 OECD members, and does not indicate a specific income or development level. The United Nations Statistics Division (2013) lists developed regions as Northern America, Europe, Japan, Australia, and New Zealand; and categorizes Africa, Central and South America, the Caribbean, Asia (except for Japan), and most of Oceania as still developing. Generally speaking, China and South Korea fall into the "developing" category alongside Burkina Faso and Nepal – despite extremely disparate income and development levels

between the four countries (United Nations Statistics Division, 2013; A. Gelis, personal communication, October 7, 2013).

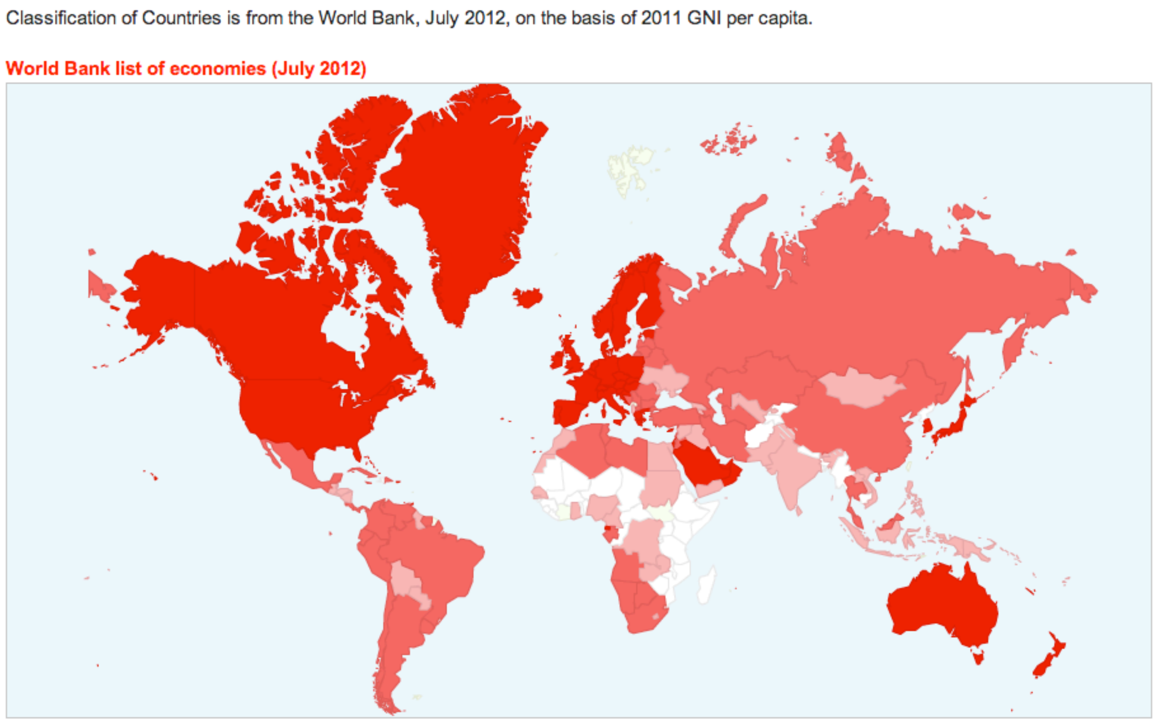

Figure 2. Country Classification by GNI per Capita. Pasquali & Aridas, 2013.

This paper uses the term "developing country" in the loose manner of the UN Statistics Division, to refer to a broad range of states dissimilar in income and development level, but generally recognized as not yet "developed." It takes this approach for two reasons: first, the admittedly ambiguous "developed" versus "developing" terminology is that employed in all the relevant research, and though it may be somewhat confusing when considering different GNIs, it does tend to encapsulate the disparities in ICT usage and development worldwide. Second, this paper would like to call attention to the fact that most of the world's poorest people are no longer concentrated in the world's very poorest countries. Twenty years ago 93% of the world's poor lived in low-income countries; today 960 million poor people, a shocking 72% of the impoverished in the world, live in stable, middle-income countries. Nearly half of the

poorest individuals live in rapidly-growing India and China, while only roughly one quarter remain in sub-Saharan Africa (Sumner & Kanbur, 2011). Poverty can no longer be tied to low-income countries, and solutions to global poverty should consider investments for states more broadly defined as "developing."

2.1.2 IT, CT, and ICT

Understanding the metrics of ICT capability and the factors that contribute to it enables governments to adjust their efforts appropriately and give their citizens the greatest advantages in ongoing development. The first step in this process is dispelling the confusion regarding the differences between Information Technology (IT), Communications Technology (CT), and Information and Communications Technology (ICT). Common usage of IT to ubiquitously refer to any technology obscures its true meaning, which is the application of technology to store or manipulate information or data. CT pertains specifically to communications and given the transition of communications to platforms that also manage data, CT is typically contextualized by ICT. This paper concentrates specifically on the ICT sector, the unified and integrated communications between data networks and devices.

Spurred in large part by the spread of web-capable mobile devices, such as smart phones, tablets, and laptops, that provide access to data-sharing services, what was once an overlap between IT and CT is now nearly a complete convergence (Bilbao-Osorio & Dutta, 2012). Cloud computing provided the major impetus for this convergence; as telecommunications move their systems and data into the cloud, best practices and standards that once applied specifically to IT or CT now apply to both sectors. CT today no longer revolves around traditional voice services, but includes data and

applications that require integrated mobile networks for operation. Similar advances in IT no longer focus on data alone, but on the seamless mix of data into everyday life on all devices, even including music players and electronic readers (Bilbao-Osorio & Dutta, 2012). Fixed infrastructure is moving to mobile and optic networks, and any individual can connect his phone, telephone, television, tablet, and even light switches at home (Bilbao-Osorio & Dutta, 2012). The boundaries are sufficiently blurred that the distinction between IT and CT has nearly ceased to exist. Today, IT and ICT are used almost interchangeably, and both usually refer to ICT.

2.2 ICT Measurement and Indices

Policy analysts, academic researchers, and governments share an interest in defining and utilizing measures of ICT capability or readiness, as ICT improvements often lead to significant social, political, and economic progress (Archibugi & Coco, 2005). Readiness or capability measurements show to what point a country is ready or willing to embrace ICT and its benefits, typically through a mix of indicators that impart information on the status of that country's infrastructure, education, government policies, levels of innovation, international openness, and usage. In addition to providing potential investors with metrics, the indicators help countries that struggle with ICT capability or readiness determine what steps to take to improve (Dada, 2006).

This section discusses the system of ICT preparedness indices and the way in which they measure readiness or capability. After an overview of the history and assumptions of some relevant indices, a short description of the most common indicators in ICT measurement follows. Ranking methods are next broken down to demonstrate how countries can move up or down by improvements in various indicators. Finally, a note on the concerns with rankings and indices for understanding ICT readiness details the issues inherent in attempting to quantify capabilities and compare heterogeneous states.

2.2.1 Basic Concepts of Index Theory

Understanding the gaps in ICT preparedness of various countries helps delineate opportunities for improvement that will help with development (Ifinedo, 2005). Many of the common readiness indicators are correlated with GDP per capita, which automatically sets developed countries ahead of developing ones in rankings and indices (Castellacci &

Archibugi, 2008). Technological advances require effort and investment to take hold, and a higher GDP per capita eases the weight of that burden on the government (Archibugi & Coco, 2004). Indicators typically consider the extent of technology available as well as the use of that technology, and connect that to increase in welfare or growth (Álvarez & Magaña, 2007). This limits the true understanding of actual ICT capability in a country, since it ties capability to GDP per capita – and, therefore, development level – almost inextricably. In ICT measurements, GDP is not usually considered as its own indicator, but must be considered as biasing results in general.

In a report by Harvard University's Center for International Development, economist Jeff Sachs notes that the "Readiness for the Networked World" analysis is meant to serve as a general guide to aid in "creating a strategic approach to planning for developing world communities," not to outline a specific path or set of requirements to achieve readiness (CID, 2006, p. 3). Such guides, he continues, are meant for the purpose of identifying weak areas that may be addressed so that developing countries can begin to bridge the digital divide (CID, 2006). In fact, some evidence suggests that just the process of researching indicators for networked readiness starts the domino effect of increased ICT in developing countries, as experts and institutions begin networking with academics and each other, discussing the ramifications of the research results and talking with government officials about possibilities for the future (Dada, 2006).

2.2.1.1 A Short History of ICT Measurement

The Organization for Economic Co-operation and Development (OECD) began standardizing science and technology indicators in the late 1970s with the goal of providing comparable statistics across OECD countries so that policy makers and

investors could quickly and easily understand what new and improved measures might be emerging where. Notably, the OECD did not attempt to use the indicators to rank countries by innovation or ICT readiness, nor does the OECD today produce any index that collates relevant indicators (Grupp & Mogee, 2004). Many other modern scoreboards, however, have moved away from the OECD example and do focus on rank through indices that consider a variety of indicators.

In the past ten years, several measurement systems for ICT capabilities have emerged from academics and public policy experts. Archibugi & Coco (2005), two of the foremost scholars on ICT capability measurement, caution that social indicators are inherently flawed; assigning one number to measure a country's Gross National Income (GNI) or Human Development Index (HDI) makes any academic uneasy about whether the ranking holds true. Archibugi & Coco (2005) continue that technology is particularly difficult to measure, as "one of the key features of technology is precisely its variety; research activities, infrastructures, human skills, the stock of capital, and many other components constitute the technological capabilities of a country" (Archibugi & Coco, 2005, p.176). Nonetheless, such indicators are necessary when attempting quantitative comparisons of country development, and even if slightly incorrect individually, they tend to be helpful when examined together.

2.2.1.2 Understanding Synthetic Indices

"Synthetic" indices combine several indicators to evaluate a state not easily measured by one "catch all" proxy. Like many science and technology innovation indicators, ICT readiness or capability has no good surrogate. Research and Development (R&D) does demonstrate innovation generation and the facilitation of

innovation dissemination, thereby explaining differences in some technological capabilities across particularly heterogeneous countries; however, it fails to hold up for similar groups of countries. As a result, most ICT capability measurements are determined by an analysis of multiple variables in a composite, or synthetic, index. Synthetic indices distill necessary information about complex topics such as ICT readiness into a quickly-interpreted number that policymakers and investors might easily understand, and are particularly useful for comparing differences between similar sets of countries (Archibugi et al, 2009). Unfortunately, these indices also have shortcomings: many production functions and typical efficiency measurement methods cannot be represented in an index, and complications of multicollinearity lurk beneath any conclusions drawn from the eventual coalescence of data points (Grupp & Mogee, 2004).

2.2.1.3 Basic ICT Index Assumptions

Composite indices for technological capabilities rely upon three assumptions in order to make logical comparisons. The first is that it makes sense to weigh countries against each other; this assumes that each national innovation system disseminates ICT capability to the entire country. The second assumption is that international comparisons must hold relevance. Comparisons are stronger between similar countries, as they can more clearly show convergences and divergences unmarred by other factors. Broad international comparisons, therefore, often require fewer, broader indicators in order to tell a consistent story. Finally, there needs to be a reason to combine different types of statistical data into one index. Mathematically, this may not make perfect sense. Many individual indicators may be correlated – for example, literacy rates with years of education – which may lead to a much higher score for a country with compounded

indicators. Here, Archibugi et al (2009) make the analogy of the vitamin intake of a man who eats an apple and an orange, two different types of fruit, versus the man who eats no fruit at all; in such a situation, like that of certain ICT indicators, cross-pollination of statistical data points does make sense. If these three assumptions do not hold, the index becomes defunct and no longer valuable for measuring ICT capabilities.

2.2.2 A Selection of ICT Indices

In the late 1990s, investment and development in ICT skyrocketed. In response, by the early 2000s, indices to determine ICT capabilities blossomed. Some of the early indices that most influenced today's measurement systems include:

- *The World Economic Forum Technology Index (WEF)* compares growth competitiveness and current competitiveness in ICT. The WEF manages to reduce some of the errors inherent in measuring human capital by including macroeconomic environmental conditions and business environment factors, but unfortunately the index fails to consider additional forms of human capital that could be helpful (Archibugi & Coco, 2004).
- *The UN Industrial Development Organization Industrial Development Scoreboard* combines skills and infrastructures, which obscures many of the differences between developing countries with poor infrastructure and increasing skills versus increasing infrastructure and poor skills. Since improvements to infrastructure and skills require divergent policies, this combination frustrates attempts to proscribe recommendations (Archibugi & Coco, 2004).
- *The Science and Technology Capacity Index from RAND* considers eight indicators in three categories: Resources (expenditures); Embedded Knowledge; and Enabling

Factors, which attempts to form an idea of the social and economic environment by looking at GDP, education, and other statistics (Archibugi & Coco, 2004). Unfortunately, this index is not widely available for a significant number of countries in recent years.

- *The United Nations Development Program Technology Achievement Index (UNDP TAI)* looked at four areas of technology: Creation of technology; Diffusion of newest technologies; Diffusion of oldest technologies; and Human skills. While the breakdown of old and new technologies is particularly interesting, the UNDP TAI ceased generating new data in 2003 (Archibugi & Coco, 2004).

Archibugi & Coco (2004) developed their *ArCo Technological Capabilities Index (ArCo)* after evaluating the indices described above and many others. ArCo pays special attention to innovative activity, such as patent applications, and human capital. ArCo also considers both old and new technology infrastructure rather than separating mobile from fixed telephony. In an updated tool, Archibugi & Coco (2005) include import technology, FDI, tech licensing payments, and capital goods imports.

More specific indices, such as one created by Maugis et al (2005) to focus on e-readiness for banking, tend to use many more indicators to provide readers with a better understanding of the issue at a micro level. An index created by Filippetti & Peyrache (2011) takes a simple, global approach like the ArCo, but restricts countries studied to 42 and weights indicators differently depending on their perceived importance. Other works try to probe the relationship between ICT investment and productivity gains; these studies provide interesting insight into the impact of indicator development, though unfortunately conclude that it may still be too early to determine the effects of investment on

productivity in developing countries (Dedrick, Kraemer & Shih, 2011).

Finally, the World Economic Forum's (WEF's) annual *Networked Readiness Index (NRI)* specializes in comparing ICT competitiveness across global economies in order to aid policymakers and investors in their ICT decisions. The NRI uses indicators to measure a country's economic and political environment toward ICT ("friendliness"); societal preparation to use affordable ICT; in-country work to increase ICT usage and capacity for ICT usage; and the social and economic impacts that will create (or are already creating) a greater propensity for ICT usage (Bilbao-Osorio & Dutta, 2012; Bilbao-Osorio, Dutta, & Lanvin, 2013). The WEF continues to produce the NRI, so it exemplifies the current thinking and development on ICT indices. For 2013 rankings and index breakdowns of the NRI, see the Appendix (Section 6.1).

2.2.3 Indicators Common to ICT Measurement Systems

E-readiness indices typically employ indicators that consider economic growth, often measured in GDP per capita, and ones that focus specifically on readiness for the society to utilize and benefit from ICTs (Bridge Organization, 2001, as quoted in Ifinedo, 2005). ICT readiness indicators usually fall into one of five categories: human skills/education, tacit knowledge, infrastructure, usage, and availability/affordability. Not all indices consider all these factors, but they do make up the base of most measurement systems.

2.2.3.1 Human Skills/Education

A widespread belief exists that without sufficient human skills and education the people of a society cannot properly appreciate or even use ICTs. Some literature focuses on the need for skills in order to create technology; some posit that advanced human

skills are necessary for imitation and even adoption (Filippetti & Peyrache, 2011, p. 4). In the NRI, the skills pillar accounts for four variables out of a total of fifty-four, and focuses on literacy and education (Bilbao-Osorio, Dutta, & Lanvin, 2013). ArCo counts development of human skills as one third of the index and includes one indicator each for: tertiary science and engineering enrollment, mean years of schooling over 14 years old, and basic literacy rate (Archibugi & Coco, 2004). Noticeably, this does not put a premium on human skills specific to technology, which other indices tend to do. However, when pressed on this subject, Archibugi ruefully notes that the absence of these skills in the indicators does not reflect a lack of importance, but a lack of data (D. Archibugi, personal communication, August 6, 2013). Similarly, the ArCo creators struggled to find sufficient job qualifications data to shed light on learning-by-doing and learning-by-using and so were unable to make justified comparisons between countries (Archibugi & Coco, 2004). Even in a small index to test nine African economies, Ifinedo (2005) dedicates roughly a fifth of his indicators to literacy rates, school enrollments, English language speakers (instructors?), the United Nations Development Program Technology Achievement Index, skilled workforce, and spending on education. Unfortunately, the work concluded that all of Africa appeared unfavorable for ICT capability; with the measurements on a scale of 1-5, each of the nine countries ended up below the average of 3 (Ifinedo, 2005).

Education and skills may be more important for increased ICT access and diffusion in developing countries than in developed ones. Some technologies, like the telephone, will grow faster in developing countries; ones that require higher literacy rates, like those involving computers and the internet, have higher associations with education

rates and developed countries (Álvarez & Magaña, 2007). When it comes to education, studies of poor nations found that measuring tertiary education rather than average years of schooling produced better results. In developing countries, tertiary education is more likely to incorporate ICT and skills helpful for ICT development and production than basic education. Since ICT diffusion in schools tends to be driven by unit cost per pupil, computers usually enter the university level first and trickle into basic levels last (CID, 2006). This difference did not show up in developed countries, where basic education may already make use of ICT in the classroom – or where students have access to computers and the internet at home (Kiiski & Pohjola, 2001; Dedrick, Kraemer & Shih, 2011).

Archibugi considered students enrolled in science and technology degrees in his ArCo index, but notes that measuring both technical skills and education can be extremely tricky. When using tertiary education in science and technology as a proxy for technical skills, the quality may vary so widely as to make a comparison useless. Even among developed countries, he says that in some universities the classroom could have hundreds of students in lecture halls or center around virtual teaching, whereas "in Sweden you have a few students per teacher so quality is much better, for example" (D. Archibugi, personal communication, August 6, 2013).

"Readiness for the Networked World," the report put forward by Harvard University's Center for International Development, creates categories of evaluation that match up to typical indicators. For education and skills, they test Networked Learning, asking those using the tool, "Does the educational system integrate ICTs into its processes to improve learning? Are there technical training programs in the community

that can train and prepare an ICT workforce?" (CID, 2006, p. 7). They break the indicators down into schools' access to ICTs, as measurable by number of computers, physical access to the technology, types of computers, diffusion of the network, access to and organization of electronic content, and quality and speed of connectivity in the school; enhancing education with ICTs, calculated by teacher training and curricula incorporating ICTs; and developing the ICT workforce, which considers opportunities for ICT training and potential work for those with ICT skills (CID, 2006).

2.2.3.2 Tacit Knowledge

While education, or learned "know-how," can be described and quantified to some extent, tacit knowledge cannot. Tacit knowledge is the inherent understanding of education's practiced techniques. For a complex technology process to succeed, workers must possess both tacit and learned skills (Nelson, 2003).

Tacit knowledge in no way replaces education or human skills; in fact, due to its intangible nature and its virtual uselessness in a vacuum, tacit knowledge does not play heavily in ICT indicators. Some indices consider education a proxy for tacit knowledge, but this both distorts education indicators and ignores the basic concept of tacit knowledge (Archibugi et al, 2009). Since tacit knowledge is by definition not quantifiable, attempts to measure it with education indicators completely miss the mark.

Nevertheless, tacit knowledge as observed and encouraged in education may reveal important truths that help governments and investors better understand the nature of a country's ICT readiness. Most studies show that the behavior and attitudes of children and teachers in a classroom – the "nurture" side of the nurture vs. nature argument – significantly influences an individual child's learning and future

development. This holds particularly true when the differences between how children learn begins to become more obvious in the classroom; as some children gravitate toward math and others struggle with it, the interplay between tacit and learned knowledge grows. Differences in both learning and tacit knowledge are magnified in the classroom as student personalities clash or mesh with teachers' and some believe that the inherent de-socialization that increased technology brings to education may help balance out children's various comprehension styles. However, computerizing education alone has not yet been shown to eliminate these problems (Nelson, 2003).

Incorporation of the internet and various computerized learning and instructional aids in the classroom have helped raise tacit knowledge in technology. Through learning the new technology by working with it, playing with it, and using it with other children to explore how they might view the mechanics of the system, children exposed to ICTs in the classroom develop a tacit understanding of how to think with the technology. This cannot be taught to a student who encounters a computer for the first time in university. When considering the example of typing instruction those who gain exposure to computers when older can certainly learn to type and even become quite quick and capable on a keyboard. But children who grow up with computers as everyday tools in the classroom think of a keyboard as almost an extension of their fingers (D. Archibugi, personal communication, August 6, 2013).

Of course, since this tacit knowledge cannot be quantified, indices struggle to incorporate it in meaningful ways. Learning by doing does not replace or diminish the importance of technical instruction, but, it is worth noting that children may receive a similar tacit benefit from one low-cost computer in the community as they do from high-

cost individual computers or even integrated, computerized educational environments (Nelson, 2003; Mitra, 2010). The basic exposure that stimulates the tacit learning may be enough to begin helping children bridge the digital divide (Mitra, 2010).

2.2.3.3 Infrastructure

Nearly all indices include infrastructure. This may be a measurement of fixed telephone mainlines, traditional power lines, electricity consumption, mobile phones per population, or wireless dissemination; currently, each index differs in its definition of infrastructure. Many studies show that telecommunications infrastructure in particular carries great importance in ICT productivity and therefore capability. Since lower costs mean mobile versus fixed telephony reins in developing countries, infrastructure measurements that focus on wired capabilities may unfairly paint developed countries in a more ICT-ready light (Dedrick, Kraemer & Shih, 2011). For example, through a non-profit project in Nepal, many unwired mountain villages now have WiFi; indices that only take wired technologies into account do not properly evaluate the readiness levels of these villages (Thapa & Sæbø, 2012).

An entire third of the ArCo index comprises infrastructure indicators that consider percent of internet users, telephone users, and electricity consumption. There is less of a focus on computer or internet access in homes – number of houses with a computer is a common indicator in many readiness measurements – and more room for different interpretations of infrastructure to allow developed and developing country comparisons (Archibugi & Coco, 2004). In a study of ICT productivity, measurements of telecommunications infrastructure considered investment rather than mainlines density in order to specifically capture mobile telephony and internet usage. Mobile and wireless

technologies, with their low-cost, quick-growing, complementary diffusion, catch on more quickly than traditional technology in developing countries, and indices that design indicators that can consider both traditional and new telecommunications infrastructure provide a more thorough and accurate view of current readiness comparisons (Dedrick, Kraemer & Shih, 2011).

2.2.3.4 Availability/Affordability of ICT

The two main questions regarding programs aimed at increasing ICT availability in developing countries are whether targeted individuals will be able to afford the devices to use the new technology and, if so, whether they will know how to use the new technology. Telecommunications providers and others interested in boosting ICT in developing countries now work with plans that specifically create technology solutions at affordable rates for that market; in fact, some organizations are finding that the "paying less for less" strategies boost their global reach in developed countries as well (Bilbao-Osorio & Dutta, 2012). The recent focus on pre-paid phone models and similar data plans, as well as increased government support, have made affordable ICT connections possible, though these are not always considered in developed countries as "real" advances (Bilbao-Osorio & Dutta, 2012). Not surprisingly, studies from the World Bank (2012) show that "direct correlations can be made between the affordability of broadband connectivity and an individual's or country's ability to successfully transform itself through the utilization of ICT capabilities;" if you make the technology reasonably affordable, developing countries will find a way to use it (Bilbao-Osorio & Dutta, 2012, p. xv).

Since telecommunications costs heavily influence access to the internet,

particularly in developing countries, their measurement in indices helps give an idea of future diffusion and usage. To balance the differences between developed and developing countries in these indicators, many indices consider business rather than consumer telecoms costs, since so few individual consumers exist in developing countries that their marginal operational costs still soar over those in developed countries (Dedrick, Kraemer & Shih, 2011). Harvard University's Center for International Development (CID) expanded the criteria even further to consider availability, cost, and quality of networks, services and equipment, and accounting for developing countries' tendencies to engage in public access through telecenters, internet cafes, and community centers (CID, 2006). The CID specifically cites wireless telecommunications and mobile devices as development catalysts for poor countries, with their tide of low costs, short deployment time (as compared to fixed lines), accelerated rollout potential, increasing power, convenience, and the trend for extremely inexpensive disposable devices with pay-as-you-go plans (CID, 2006).

2.2.3.5 Usage

Usage indicators attempt to determine what percentage of the population employs ICTs. Sometimes these indicators break measurements down into societal versus business usage, or even further into firm and government usage; other indices, however, simply compare gross usage (CID, 2006). Gross usage may distort true data reading of ICT readiness in the same ways that misclassification of infrastructure capabilities might – indices that measure usage based off of households with computers or households with internet plans are clearly biased toward developed countries (Bilbao-Osorio, Dutta & Lanvin, 2013). In developing countries, where widespread use of internet cafes and

kiosks or even the sharing of email accounts significantly increases percentage of the population accessing ICTs, usage can be tough to quantify. Poor communities increasingly share network infrastructure in public areas and sometimes even share mobile phones, so even the most cautious indicators mapping usage should be taken with a grain of salt (CID, 2006).

2.2.3.6 Additional Factors

Depending on the index, indicators may also measure the regulatory environment, openness to the global economy, and technology creation. Though these indicators appear less frequently than those considering skills and infrastructure, they tell an important story about a country's ICT potentiality in the long run. In the CID's Readiness Guide (2006), they consider the regulatory environment as part of the state's "Networked Policy," and question whether policies and legislation help or hurt ICT dissemination and usage. Notably, many developing countries – including Mauritius and India (see "Positive Examples of ICT Investment," Section 2.5.7) – with pro-ICT policies have reaped significant gains as a result (Bilbao-Osorio & Dutta, 2012; Krishna & Walsham, 2005). Openness to the global economy is often a precursor to improved policy or other ICT advances (Dedrick, Kraemer & Shih, 2011). Technology creation, often left off of indices that consider developing countries, which tend to use rather than create ICT, makes up an entire third of the ArCo index. Often, indices specific to technology creation are simply compared alongside other ICT readiness measurements (Archibugi & Coco, 2004).

2.2.4 ICT Indices and Country Rankings

Each index calculates its indicators' scores differently, but at the end of the day,

countries tend to appear in roughly similar places in various ICT readiness rankings (Archibugi & Coco, 2005). Archibugi & Coco (2004) group countries into leaders (1-25); potential leaders (26-50), characterized by investment in human skills and basic infrastructure, but lack innovation; latecomers (51-111), which work to stimulate technology growth while simultaneously pushing for additional development; and marginalized (112-162), lacking telephony and electricity and without the capability to even begin technology creation. Filippetti & Peyrache (2011), in a more recent study, take a slightly different view of the similar four groups of countries. They refer to them as composition improving, which includes some traditional European leaders and emerging growth countries like the Asian Tigers; losing momentum, as characterized by low growth and slow performance loss from previous leaders; balanced catch-up, with good performance in growth from China, Mexico, Turkey, Estonia, and Lithuania; and unbalanced catch-up, composed mainly of transition economies and including most of the same countries as Archibugi & Coco's (2004) marginalized group. The results from Filippetti & Peyrache (2011) when compared against those from Archibugi & Coco (2004), or those from many studies around 2004 with more recent studies from today, show that North America, Western Europe, and Japan no longer run the gamut in ICT capability. Though the marginalized or unbalanced "catch-up" countries may still struggle far behind, the safe lead previously held by developed countries has already begun to dissolve.

Countries with top positions in ICT capability rankings usually score highly in infrastructure, human skills, education, and low telecommunications prices (Archibugi & Coco, 2004; Dedrick, Kraemer & Shih, 2011). Recently, Nordic countries have

dominated ICT readiness indices; in the 2013 Networked Readiness Index, Finland, Sweden, Norway, and Denmark placed in the top ten, and Iceland, the fifth Nordic country, ranked seventeenth (World Economic Forum, 2013; Bilbao-Osorio, Dutta, & Lanvin, 2013). Exemplary education and human skills are featured prominently in each of the top ten countries on the list, and the Asian Tigers crept forward with business-friendly approaches and infrastructure investments complementing their highly-skilled populations (Bilbao-Osorio, Dutta, & Lanvin, 2013; World Economic Forum, 2013). Finland, which stole the top spot on most indices away from Sweden in recent years, boasts one of the world's best educational systems with the highest number of ICT patent applications per capita, an extremely connected population (90% of Fins are online, as compared to only 70% of Americans), and a major digital innovator (World Economic Forum, 2013). Interestingly, when asked why Nordic countries do so well at ICT readiness, Archibugi responds, "it's because it's so cold! What else are you going to do? Try to go shopping in Finland in the winter. Certain conditions force countries to develop cooperation and social development" (D. Archibugi, personal communication, August 6, 2013). While a bit tongue-in-cheek, Archibugi's evaluation certainly makes sense.

Traditionally, higher education and technology rates seem to boost rankings for advanced economies, whereas increased basic education and institutions have helped developing economies. However, with the tide of wireless networking and mobile telephony, low-cost technology can more easily be made available to marginalized or lagging-behind countries. While rich countries still dominate the top quarter of any index, ICT readiness rankings are slowly beginning to show that these technological

transitions might have the chance to change the balance of power and help narrow the

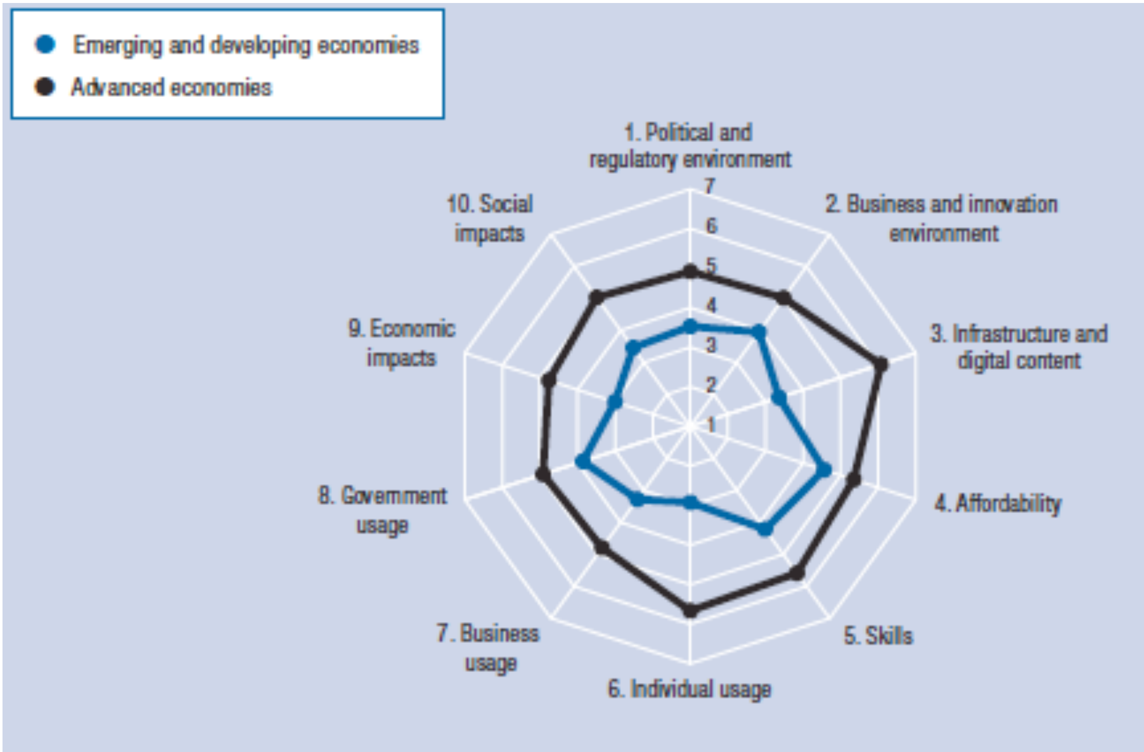

Figure 3: ICT Readiness in Developed and Developing Countries. Bilbao-Osorio, Dutta & Lanvin, 2013, p. 17.

digital divide (Filippetti & Peyrache, 2011).

Around half of the measurable countries usually fit in the middle two categories – potential leaders and latecomers for Archibugi & Coco (2004). Many emerging economies, such as some of the Asian Tigers and the BRICs, typically end up in these categories. They have recently invested in business and innovation and worked hard to improve infrastructure and education, and ICT's impact on their societies stands out as an important factor in future development (Bilbao-Osorio, Dutta, & Lanvin, 2013). However, their investments are recent and many benefits have yet to surface. Russia, which hovers in the 50s in the Networked Readiness Index rankings, leads the BRICs, followed by China and India in the low 50s and high 60s respectively, Brazil in the low 60s, and South Africa closer to 70 (World Economic Forum, 2013). Though the

importance of BRIC economies and investment in ICTs have exploded over the last decade, their technological capabilities are catching up more slowly than those of many Asian and Eastern European countries (Archibugi et al, 2009).

The marginalized countries, which make up at least a fourth of measurable countries and likely would hold countries not included in indices due to problems of accessing data (for example, Sudan and South Sudan), lack basic infrastructure, electricity, and often any formal educational system at all. These are the low-income countries in The World Bank's classification system (The World Bank, 2013a). Many of these countries have extremely low literacy rates, and all measurable Sub-Saharan African countries aside from Mauritius and South Africa fall into the bottom (Bilbao-Osorio, Dutta, & Lanvin, 2013). These countries still have a very long way to go before most financiers, international foreign investors and governments consider them ICT ready enough for significant investments. In a 2009 study, Archibugi et al (2009) noted that five years after the creation of the ArCo index, countries remained relatively stable in their ranks across various indices. However, the recent advances in wireless and mobile technology may yet help these marginalized countries to leap forward far enough in capability to catch investors' attention.

2.2.4.1 The Problems with ICT Indices

Helpful though synthetic indices for ICT capability may be, assigning one numerical value to a country is tenuous work (Archibugi & Coco, 2005). Altering weights and selections of indicators even slightly transforms scores and rankings appreciably, casting doubt on the results of any one index if not considered alongside others. Rankings aside, indices themselves pose several concerns. Differences in

definitions of indicators and readiness, variations in methodologies, imbalances between micro and macro indicators, and problems of multicollinearity complicate even the best-researched and most thoroughly worked indices. Despite these issues, indices remain the preeminent mechanisms for measuring ICT capability; however, it is important to remember their common limitations when analyzing rankings, especially before an investment or policy change (D. Archibugi, personal communication, August 6, 2013).

2.2.4.1.1 Rankings and Cross-Country Comparisons

Though advantageous in their ability to give a quick snapshot of the overall relative status of a country, by simplifying such a complex process, ICT capability rankings fail to provide the complete picture. These indices are so aggregate that an attempt to glean conceptual intelligence to shape policy may be misplaced (Archibugi et al, 2009). Furthermore, rankings give only a limited account of the actual gaps between countries; though Poland and Bulgaria may only be separated by one ranking in the list, the true differences between their capabilities may be much greater than the differences between Finland and Sweden (Grupp & Mogee, 2004; Archibugi & Coco, 2005). Perhaps most discouragingly, Archibugi laments that for many, “The purpose of the data is not to develop academic work, but to appear in the press. The press likes the rankings. If you produce a new ranking, you can be almost certain it will go to the press, but that doesn’t mean it is helpful” (D. Archibugi, personal communication, August 6, 2013).

Jeff Sachs, speaking about Harvard’s “Readiness for the Networked World” (2006), also interprets rankings with caution. He guards against using the Center for International Development’s proposed guide to compare countries, noting that the guide is not meant for ranking or setting down fixed steps for a state to follow, but meant to

help a community decide which indicators it should focus on to improve networked readiness (CID, 2006). Nonetheless, composite indices currently provide the only reasonable measurement of ICT readiness. When methodologies remain stable over several years, country groupings become relevant, as their spots are relative. Analysis of an index with a consistent methods, indicators, and data sources results in an understanding of how countries have increased their ICT capabilities compared to each other (Archibugi et al, 2009).

If rankings must tell the story, policymakers must understand their shortcomings. For a general overview of how a country fares in comparison to the rest of the world – whether it is in the top quarter, middle half, or at the bottom – rankings from composite indices provide a quick and easy starting point. To mold strategy, though, policymakers need to go beyond these synthesized indicators for a comprehensive comprehension of ICT readiness. Any policy based off rankings alone could easily magnify these indices' shortcomings at the cost of global negative implications (Grupp & Mogee, 2004).

The first assumption of the theory of indices of technological capability – that it makes sense to compare countries – also inherently generates problems. Countries differ in their abilities to create, accept, diffuse, and alter technology; otherwise there would be no need to make any comparison of their ICT capabilities (Filippetti & Peyrache, 2011). However, these variations also muddle analysis. Along with differences in ICT indicators like education, skills, and infrastructure, diversity of size (geographical and population), GDP, development stage, and currency strength – among others – influence results. For example, former second-world countries had no business sector at all until recently, a factor that clearly affected their technology innovation and creation in later

years; yet such dynamics fall out of consideration in most synthesized indices (Archibugi et al, 2009). Perhaps most importantly, finding uniform data across countries is nearly impossible, and for certain indicators developing countries keep no data at all; for this reason many indices only attempt to cover small groups of countries, such as OECD members (Pohjola, 2002).

Indices that endeavor to provide full cross-country comparisons do best to use only a few macro indicators, thus eliminating many differences specific only to certain groups of countries (Archibugi & Coco, 2004). Such indices need also to present clear questions not open to interpretation. Lall (2001) suggests setting up surveys with answers in numeric or yes-no form, and warns against repetitive or redundant questions unless researchers can weight them appropriately (Lall, 2001). When comparing countries, the simpler the index, the better. When ranking countries, the focus should be on a general grouping, not a country's exact position or literal score (D. Archibugi, personal communication, August 6, 2013).

2.2.4.1.2 Index Issues

On a base level, no uniform definition of indicators and readiness themselves yet exists. ICT readiness, ICT capability, networked readiness, and e-readiness all generally refer to a state at which a country reaches "robust foundations of readiness," but no agreed-upon outline of those foundations guides researchers or policymakers to understand what exactly readiness requires (Maugis et al, 2005, p. 2). Some believe that capability can best be described by dissemination and diffusion; others, infrastructure or education, or both (Álvarez & Magaña, 2007). Still others hail innovation as the leading factor. As a result of these erratic designations, indices become almost incomparable

unless comparing one index against itself across years (Archibugi & Coco, 2005).

Even when considering the same index over multiple years, legitimate analysis requires a constant methodology. When an index's authors switch up the indicators significantly, it no longer becomes relevant to follow scores from year to year (D. Archibugi, personal communication, August 6, 2013). Methodological haziness obfuscates results; without a clear process, meaningful analysis becomes almost impossible. Certainly, if an index addresses a different question, its methodology should differ as well. For example, an ICT capability study of Africa may aim to determine whether the population would benefit from subsidized mobile phones, while one focused on Nordic countries may probe preparedness of children to innovate in technology fields. In this case, what both researchers and interpreters of these indices must ask themselves is, as Maugis et al (2005) put it, "*e- Readiness for what*?" (Maugis et al, 2005, p. 3).

Determining the scope of the study leads the data, the indicators, and the index itself. The first question is whether the index is macro, across countries, or micro, at the industry level within a country. Many of the more well-known indices purport to provide macro information. Archibugi notes that macro studies between countries need only very basic indicators, since the countries themselves differ so widely as to render micro data irrelevant (D. Archibugi, personal communication, August 6, 2013). His ArCo Index contains a mere 36 indicators to the Networked Readiness Index's 54 and the Knowledge Assessment Index's 147 (Archibugi & Coco, 2005; Bilbao-Osorio, Dutta & Lanvin, 2013; The World Bank, 2013c). Achibugi's goal, he quips, is to "get the difference across countries over issues so you can be so foolish as to try to summarize everything into a single number" (D. Archibugi, personal communication, August 6, 2013).

Since the purpose of the index shapes its methodology, Dada (2006) diverges from Archibugi and argues for evaluating the micro level in addition to the macro environment. Performing e-readiness assessments costs significant time and money but infrequently results in identification of specific ways in which developing countries can better themselves, so Dada (2006) believes that a careful breakdown of firms and industries provides a more helpful output. Countries that are not ready, he notes, know they are not ready; what they need is an index to tell them what specifically, where specifically, and how specifically they should attack the issue (Dada, 2006). Archibugi does not discount this theory, but cannot imagine the amount of time and money such an effort would cost. He also admits that one factor in his studies has been that the macro data was available – a major consideration for building indices (D. Archibugi, personal communication, August 6, 2013).

A related problem with adding on more indicators becomes multicollinearity. The more indicators a study employs, the more likely those indicators will represent inseparable characteristics contributing to a country's ICT readiness. Though many assume that the basic categories of creation, diffusion, infrastructure, and human skills are somewhat interchangeable, those factors are in fact highly correlated – the improvement of one tends to spike the progress of others. Infrastructures and human skills have a particularly robust complementarity, as they both add to the capability of a country to accept and disseminate technology (Filippetti & Peyrache, 2011; Castellacci & Archibugi, 2008).

Foreign capital, qualified labor markets, and human resources training also impact or indicate ICT development, and scientific publications are highly correlated with

internet users (Álvarez & Magaña, 2007). Unsurprisingly, PCs and internet usage are also extremely complementary (Dewan, Ganley & Kraemer, 2009). Interestingly, though, internet use is not as strongly correlated with traditional infrastructures such as phone and electric lines (Archibugi & Coco, 2004). This may result from the recent surge in wireless technologies and alternative energy sources in developing.

The issue with multicollinearity, Archibugi notes, is one of double counting. He gives an example of computers and computer mice. When a country has many computers, he notes, it will have many mice; of course, the fewer computers a country has, the fewer mice. By counting both computers and mice as indicators, an incorrect picture forms. However, while he stresses the importance of guarding against multicollinearity whenever possible and frets over the problems inherent with indices and indicators, Archibugi concludes that ICT readiness indices exist to further development, and disagreements on methodology aside, “at the end of the day we are required to rely on indicators that we can find” (D. Archibugi, personal communication, August 6, 2013).

2.3 Leapfrogging the Digital Divide: The Relevance of ICT Indices

"The developing world is now more mobile than the developed world."

- The World Bank: InfoDev, 2012a.

As discussed in Section 2.2, many of today's ICT measurements still contain indicators that are more common in developed countries than developing ones, such as fixed-line electricity and telephony. However, in the past few years developing countries have embraced mobile services at a shocking pace. Not only are the majority of mobile phones owned by users in developing countries; those users also drive applications for mobile health, mobile agriculture, and mobile money (The World Bank: InfoDev, 2012a). This section considers the argument that developing countries are employing mobile and wireless technologies to leapfrog traditional ICT infrastructure and capability requirements, thus beginning to bridge the digital divide. After mapping the upsurge in mobile and wireless use in poor areas, a project that has successfully provided internet access to the mountainous regions of Nepal is given as an example. This section next assesses the different methods of mobile and internet usage in developing countries, including public access centers and high incidences of sharing devices. Finally, the implications of leapfrogging are discussed in terms of ICT for development.

2.3.1 What Is Leapfrogging?

Economist Joseph Schumpeter predicted that large monopolistic firms, feeling secure in their prominence, would fail to innovate – an idea he modified from Karl Marx's creative destruction and commonly known today as "Schumpeter's Gale." When this occurred, Schumpeter warned, smaller companies willing to take risks as pioneers in new technology would "leapfrog" over the established firms (Schumpeter, 1942).

Speaking of this phenomenon in the context of mammoth transportation companies, Schumpeter once remarked, "add as many mail-coaches as you please, you will never get a railroad by doing so" (as cited in Archibugi & Coco, 2004, p. 670). Long after history validated Schumpeter's theories, Steve Jobs popularized them. In a *Harvard Business Review* article published shortly after Jobs' death, his biographer noted that one of the Apple mogul's top lessons to innovators is simply, "When behind, leapfrog" (Isaacson, 2012). Time and again, Jobs leapfrogged over well-known competitors like Microsoft and IBM by looking forward rather than stagnating in success; he even pushed his company to build products that would overtake his old best-sellers, essentially making the groundbreaking iPod obsolete with the release of the iPhone, because he knew that otherwise another young tech firm would be able to leapfrog over Apple (Isaacson, 2012).

Recently the concept of leapfrogging has been adopted by the ICT development community, which sees possibilities for low-tech countries to skip over intermediate infrastructures and technologies. Developing countries are not expected to surpass developed ones in this appropriation of the term, but the new generation of wireless networking and mobile devices may allow these countries to develop technology much more rapidly and cheaply than if they needed to build upon traditional wired technology. Maugis et al (2003) give the example of Ghana in 2003, where many of the 20 million people still lacked common banking services; if evaluated in terms of traditional developed-world e-banking, Ghana would rank very poorly. However, Ghana became one of many developing countries to utilize mobile banking, and in leapfrogging over the construction of significant numbers of physical banks and ATMs Ghana began the long

process of narrowing the digital divide through an original pathway better-suited to a developing country (Maugis et al, 2003).

2.3.2 The Digital Divide

The "digital divide" refers to the expansive difference in current ICT capability between developed and developing countries. Seventy-seven percent of the developed world is online, compared to only 31% of developing populations; Europe's penetration rate is 75%, whereas Africa's is only 16%. Internet usage in developed countries is nearly equal between men and women, but in developing areas 16% fewer women than men are online (ITU, 2013).

Advanced countries continue to make significant progress in technology, but many developing countries struggle to innovate at all. Asian Tigers have combated this divide to some extent, capitalizing on the electronics market successfully. However, there remains a clear segregation between developed and developing countries in ICT diffusion, innovation, and overall capabilities, augmented by the complementary factors of education, GDP per capita, and infrastructure (Fagerberg, Srholec & Knell, 2007).

African countries in particular fall behind, lacking even the most basic infrastructure considered by many as absolute prerequisites for ICT development (Ifinedo, 2005). Geography, nature, and climate also negatively affect Sub-Saharan Africa in particular, as well as Latin America; special care must be taken of ICT devices when they are exposed to much more dust and humidity than those typically produced for the developed world (Fagerberg, Srholec & Knell, 2007). However, recent advances in WiFi and mobile technology may transform possibilities for Africa and other developing states; Jeff Sachs foresees that ICT, when applied correctly, could "improve the lives of

the 80% of the world's population that lives in the developing world…there now exists a unique opportunity for many of these communities to join global information networks to propel them to greater wealth and prosperity" (CID, 2006, p. 3).

Some argue that ICT diffusion is exponential in nature; the further along a country's technological capability, the more quickly it can diffuse new technology. If true, this could point to a widening of the digital divide (Fagerberg, Srholec & Knell, 2007). However, it seems more likely that advances in ICT specifically for developing countries will lead to leapfrogging possibilities that will allow nations currently behind to narrow and eventually bridge the divide. Technology diffusion in developed countries may actually provide great opportunities for developing nations, as they can easily imitate the existing advanced technology rather than needing to home-grow the capability to innovate it, which takes much more time, effort, and capital (Fagerberg, Srholec & Knell, 2007).

Jeff Sachs, who certainly believes in the potential of developing countries to leapfrog their way across the digital divide, does warn that those governments and populations must engage in a rigorous effort to ready their countries as much as possible for the opportunities ICT diffusion might create. Without the proper strategic planning and preparation, he believes, the digital divide will continue to widen (CID, 2006). The Global Information Technology Report 2013 from the World Economic Forum applauds developing countries on their high cell phone penetration rates, but notes that "Mobile telephony alone will not allow developing countries to bridge the digital divide" and encourages an extrapolation of the innovation and effort put into cell phone development and diffusion so that other technologies might spread in a similar manner (Bilbao-Osorio,

Dutta, & Lanvin, 2013, p. 17-18). Though these may seem like obvious observations, they in fact highlight serious problems. Many in rural areas of developing countries focus foremost on access to clean water, sufficient food, and sewage. It is only after those basic needs are attained that priority shifts to healthcare, education, roads, and general infrastructure – all before ICT development (Pun, 2012). Lack of investment and concentration on technology dooms those areas to fall even further behind without substantial aid from others.

In an analysis that sheds light on the current nature of the digital divide, Archibugi and his colleague Castellacci (2008) group countries into three “technology clubs.” The advanced club is characterized by high infrastructure, skills, and innovation, and comprises roughly 15-21 technologically advanced countries, including the US, Japan, and many European countries; in 2000 a few of the Asian Tigers joined the group, but otherwise it is extremely stable. The Advanced club accounts for only 15% of the world’s population but 40% of GDP. The Followers club holds 70 countries – 27% of the world’s population and 36% of its GDP – and boasts medium-high infrastructures and skills but low innovation. In the 1990s, the sudden investments and improvements in ICTs in a few countries in Asia, the Middle East, Central America, and even Africa pushed those states into the Followers club. The Marginalized club holds developing countries with low infrastructures, skills, and innovation; with 60% of the world’s population and 23% of GDP, this group suffers the most from the digital divide (Castellacci & Archibugi, 2008).

Castellacci & Archibugi (2008) track the movements in the technology clubs between 1990 and 2000, the first period of uptakes in ICT investments and efforts by

developing countries (see Figure 3 below). In every type of indicator except Tertiary Science and Engineering Enrollment, Followers narrowed the gap to the Advanced club – often quite aggressively. Marginalized countries made significant progress in terms of Internet users and phone dissemination, with close to a 100% change in the Internet User ratio, and they closed the literacy rate and Science and Engineering Enrollment gaps notably better than the Followers club. In many of the categories, though, the Marginalized group fell behind or only made small improvements. The failure of Marginalized countries to make more progress in such areas indicates the widening disparity in innovation capabilities between many of the most and least developed nations (Castellacci & Archibugi, 2008).

Table 3
The technology gap between the three clubs, and its change over the 1990s

	Advanced vs. Followers			Followers vs. Marginalized		
	1990	2000	%Change	1990	2000	%Change
Patents	16.18	14.29	−11.6	190.3	237.4	+24.7
Scientific articles	9.15	7.40	−19.0	13.87	16.09	+16.0
Internet users (1994 and 2000)	10.77	5.05	−53.0	270.6	16.32	−94.0
Fixed and mobile telephones	3.17	2.61	−17.7	12.20	8.58	−29.6
Electricity consumption	3.64	3.50	−4.0	9.72	9.39	−3.4
Tertiary S&E enrolment ratio	1.63	1.85	+13.8	5.21	4.54	−12.9
Mean years of schooling	1.51	1.48	−2.1	1.92	1.79	−6.4
Literacy rate	1.08	1.05	−2.6	1.57	1.39	−11.7

Source: As for Table 1a. The first and second columns report the ratio between technological capabilities in the advanced and followers clusters in 1990 and 2000, and the third indicates the rate of change of the technology gap in the period. Similarly, the fourth and fifth columns report the ratio between technological capabilities in the followers and marginalized clusters in 1990 and 2000, and the sixth shows the rate of change of the technology gap over the 1990s.

Figure 4: The Technology Clubs. Castellacci & Archibugi, 2008, p. 1665.

The concern at this lack of advancement in the highly innovation-focused indicators is that it will contribute to a deepening of the digital divide, despite the improvements in literacy rates and internet usage. The ten years of analysis, though, may not span enough time to effectively foretell the future of the developing world, particularly since most agree that a certain level of groundwork is necessary before results become measurable. Further progress in the thirteen years since 2000 may point to even more rapid ICT diffusion. The best explanation, the authors posit, may be that "inequality is widening in this phase of rapid technological change but will later narrow

when the international diffusion of advanced technologies will eventually benefit less developed countries as well" (Castellacci & Archibugi, 2008, p. 1670). Notably, despite data showing the potential for a widening of the digital divide, no country moved backward into a lower-innovation club and a total of twenty countries actually improved their standing by one level (six from followers to advanced and fourteen from marginalized to followers) (Castellacci & Archibugi, 2008).

2.3.2.1 Developing Countries Leapfrogging Across the Digital Divide

It is widely understood that technological development cuts costs and aids in economic development. In addition to driving growth by increasing efficiency of communication, ICTs paved the way for mobile money systems (The World Bank, 2011). The mobile money industry, which allows for individuals without access to banking institutions (mostly those living in poverty or developed countries) to use currency more easily, grows as quickly as the rest of the ICT sector – if not more so. This "unbanked" population currently has access to more than 150 services in 72 countries, an increase of almost 38% from 2012, with 109 new deployments in the works for 2013 (Penicaud, 2013). To put the mobile money industry into perspective, as many of these outlets exist for the "unbanked" as do Western Unions (Penicaud, 2013).

Mobile phones, low-cost PCs, public internet kiosks, and wireless internet are such new technologies that they are only just beginning to be featured in studies. However, what little is known about their effects in developing countries points to a possibility to leapfrog across traditional methods with cheaper, faster dissemination of ICTs. In Bangladesh, solar-powered cell phones replace the need for electric wires; in Zambia, mobile banking has grown so popular that Coca-Cola distributors text payment

orders to banks rather than relying on cash (Dewan, Ganley & Kraemer, 2009). Though adoption has previously been slower in poorer countries, such recent changes are now helping them ramp up connectivity much more rapidly (Bilbao-Osorio & Dutta, 2012).

By some estimates, digitization could result in half a billion people rising out of poverty by 2023 (World Economic Forum, 2013). Many independent studies find that diffusion in developing countries is beginning to pick up as complementary effects slowly come into play; installed PCs in public areas, for example, have accustomed many to the idea of technology development and created a desire in poor countries for internet access (Filippetti & Peyrache, 2011; Dewan, Ganley & Kraemer, 2009). Though higher GDP per capita appears to correlate to the rate of ICT dissemination more than many other factors, ICT adoption in developing countries is currently growing at a vastly faster rate, resulting in the beginnings of a reduction in the digital divide. Interestingly, GDP per capita matters less in countries with low ICT saturation, meaning that those countries now working to catch up may not be penalized as heavily for their lack of resources. Countries with higher years of schooling, lower telephone costs, and significant international trade may lead toward more impressive adoption rates when compared with countries boasting high GDP per capita alone (Dewan, Ganley & Kraemer, 2005).

Certainly, newer technologies alleviate traditionally prohibitive prices and provide alternatives to the old infrastructure-first, internet-later model (Álvarez & Magaña, 2007, p. 7). Sudden accessibility due to wireless network advances and scaling of devices specifically for poor countries empowers these states to begin leapfrogging, and falling ICT costs have increased opportunities for even remote areas of developing countries (CID, 2006; Thapa, Sein & Sæbø, 2012b). These “inefficient” countries have

more to gain if they work now to make the investments and implement technology as quickly as possible (Pohjola, 2002; Álvarez & Magaña, 2007). The advantages for developed countries are shrinking, but without initiative from developing countries to pick up the slack and capitalize on the leapfrog window, the digital divide cannot narrow (Ruth, 2012; Álvarez & Magaña, 2007).

Technological advances continue to offer never-before-imagined opportunities for developing countries. Cloud computing has exponentially increased availability of new tools to those online; wireless networks have grown in capability and fallen in price. A new class of entrepreneurs in poor regions demonstrates that reduced barriers have the potential not only to narrow the digital divide – but also to reduce economic inequalities and potentially ameliorate poverty. (Bilbao-Osorio, Dutta, & Lanvin, 2013).

2.3.2.2 What Makes Leapfrogging More Possible Today?

"The spread of mobile phone technology to the hands of billions of individuals may be the single most significant innovation that has affected developing countries in the past decade…Mobile technology is used as a substitute for weak telecommunications and transport infrastructures as well as underdeveloped financial and banking systems"
- Global Pulse, 2013, p. 2.

2.3.2.2.1 Upsurge in Mobile and WiFi Use

ICTs are increasingly pervasive in daily life. In 2012, the World Economic Forum's Global Information Technology Report revealed that individuals today are more likely to have a mobile device – usually a cell phone – than electricity, a statistic that

Table A: Penetration of various technologies, 2011

Population-weighted rates	Developing economies (109)	Advanced economies (35)	All economies (144)	Ratio of advanced to developing economies
Mobile cellular telephone subscriptions per 100 pop.	81.3	110.7	85.7	1.4
Fixed (wired) broadband subscriptions per 100 pop.	5.1	28.7	8.7	5.7
Active mobile broadband subscriptions per 100 pop.	8.8	64.8	17.0	7.3
Percentage of individuals using the Internet	25.0	77.3	32.8	3.1
Percentage of households with a computer	22.2	77.7	31.2	3.5

Source: Authors' calculation, based on ITU's *World Telecommunication/ICT Indicators Database* 2012 (December 2012 edition).
Note: See Table 1 for country classification. Penetration rates are based on the sample of 144 economies included in the NRI. For each technology, economies for which no data are available for 2011 are excluded from the calculation.

Figure 5: Technology Penetration. Bilbao-Osorio, Dutta & Lanvin, 2013, p. 18.

points to the increasing usage of data generation and technological capabilities for individuals (Bilbao-Osorio & Dutta, 2012). Furthermore, the vast majority of individuals using and relying upon ICT now live in developing countries. In 2000, 29% of the 0.7 billion mobile subscriptions came from low-income regions; by 2010, 77% of the 5.9 billion mobile subscriptions came from low-income regions (The World Bank: InfoDev, 2012a). Literature and recent data suggest that this transition creates an environment in which developing countries find greater government transparency, higher economic returns and better economic stability, all of which help to close the gap between developed and developing nations. Most predict that ICT and increased interconnectivity will continue to exponentially enhance globalization and resulting transparency and economic success (Bilbao-Osorio & Dutta, 2012).

Belief in technology's ability to combat poverty and aid development is no longer relegated to NGOs. The CEO of Booz & Company, Cesare Mainardi, remains staunchly committed to the company's conviction "in the power and potential of digitization to help solve the economic and societal challenges of tomorrow;" Huawei Technologies Chairwoman Sun Yafang affirms that "ICT and relevant technological innovations will propel global economic growth further than ever before" (Bilbao-Osorio & Dutta, 2012, p. vii; p. ix). The available data clearly show that ICT positively affects growth by enough to be measured by gains in GDP per capita. Recent studies by Deloitte and the Global System for Mobile Communications (GSM) Association found that improving a population's mobile access from 2G to 3G by 10% leads to a 0.15% growth in per capita GDP; doubling data usage on mobile devices results in a 0.5% growth in per capita GDP; and increasing overall mobile penetration by 10% also results in an increase in Total

Factor Productivity of 4.2% (Deloitte & GSMA, 2011).

From 2007 to 2013, mobile-broadband subscriptions grew annually at 40%, with developing countries more than doubling their subscriptions to exceed those in developed ones. In Africa alone, mobile-broadband penetration rose from 2% in 2010 to 11% in 2013, the highest growth rate in the world. The lower cost of mobile-broadband in developing countries likely explains these incredible figures. Developing countries also prefer the cheapest plans, which tend to be postpaid handset-based services such as pay-as-you-go models that do not punish the plan holder for late payments or periods of inactivity (ITU, 2013).

Brahima Sanou, Director of the International Telecommunications Union Telecommunication Development Bureau, rejoices in these statistics:

> Every day we are moving closer to having almost as many mobile- cellular subscriptions as people on earth. This is exciting news. The mobile revolution is m-powering people in developing countries by delivering ICT applications in education, health, government, banking, environment and business. Let us all celebrate this mobile miracle that I have no doubt will hasten our pace towards sustainable development (ITU, 2013, p. 1).

Indeed, all signals point to this generation of ICTs to narrow the digital divide – and finally give developing countries the boost toward a level playing field.

2.3.2.2.2 ICT Diffusion in Developing Countries

In 1991 there were 376,000 computer hosts on the internet; by 2001 there were 110 million. This is a huge amount of progress, but even then online access was considered an even more explicit indication of socioeconomic divides than GDP per capita. Concerns about expanding internet access to rural areas were much louder in 2001, as propositions to make the internet free and available worldwide were a near-impossibility at a time when wired access remained the norm and alternative electricity

measures were science fiction (Kiiski & Pohjola, 2001).

In March 1949, Andrew Hamilton in *Popular Mechanics* envisioned a time when computers “perhaps weigh only 1½ tons” (Meigs, 2012). Though often the brunt of the joke today, Hamilton wrote at a time when the ENIAC calculator weighed a staggering 30 tons. Even eight years after his prediction, when IBM developed a 1.2 ton computer, today’s featherweight laptops and handheld smartphones remained absolutely unimaginable (Meigs, 2012). Forecasts about ICT dissemination in developing countries stem from data and technologies that transform at exponentially greater speeds. From 110 million in 2001, the United States Central Intelligence Agency’s 2012 estimates put the number of internet hosts at over 900 million (CIA, 2013). More recent statistics from the Internet Systems Consortium (2013) note that by the end of July 2013, the world had 996,230,757 internet hosts (ISC, 2013). If the current trend continues, within a few years today’s calculations may look as outdated as Andrew Hamilton’s did.

While every country needs different elements to increase ICT diffusion, developing countries require particularly distinctive factors for successful saturation, and as a result it becomes useful to compare rich and poor nations in this manner (Shih, Kraemer & Dedrick, 2008). As with any technology, statistics on use and diffusion arise only after enough time has passed for relevant studies to arise. Information on telephone operation took twenty-five years to be tracked and published (Comin & Hobijn, 2003, as cited in Cuberes et al, 2008). Today’s studies on internet adoption and diffusion are preliminary and cover only a short period of time by default; however, their results tend to confirm other theories in ICT penetration for developing countries.

In developing countries, availability of loans and foreign aid, openness to foreign

investment, and complementary technology diffusion play a large role in ICT diffusion; many of these elements never play in developed countries (Shih, Kraemer & Dedrick, 2008). Interestingly, some of the most imperative factors unique to developing countries include sharing a common language and network effects. For example, the more Portuguese-speaking members of Mozambique use the internet in 2013, the more they will convince friends and family to get online and on email, and the more Portuguese-speaking Mozambicans will use the internet in 2014, and so on. Increasing numbers of users speaking the same language adds value to email services and websites, making the networking effect particularly important to internet adoption (Cuberes et al, 2008).

2.3.2.2.3 Traditional Infrastructure: Telecoms and Electricity

Internet adoption falls into the "leader-follower" mold; for followers – developing countries – adoption costs plummet. These low costs have significant effects on the measurement of potential users of the internet; as far as technology diffusion is concerned, costs pose smaller barriers for poor communities as potential users, since they are predicted to continue dropping at a scale that will allow for extremely inexpensive usage in the near future. The recent decline in infrastructure costs, partially due to a decreased need for wired infrastructures for both networked connectivity and electricity, improves the chances for ICT dissemination to reach poor rural areas and aid in general development for essential services (Thapa & Sæbø, 2012). The telecommunications industry has successfully employed wireless, microwave, and satellite technologies that cut costs and increase effectiveness in difficult-to-reach areas (Dewan, Ganley & Kraemer, 2009). Recent innovations that enhance electricity generation, consumption, storing, and transmitting now allow households with no access to traditional power

structures the opportunity to connect to the electric grid, so that mobile device diffusion is no longer restricted to areas with developed power lines (Heeks, 2008).

2.3.2.2.4 Wired and Wireless Networks

Wireless networks in particular catch the attention of investors and policymakers looking to effect change in developing countries. In a 2002 challenge to Silicon Valley, former United Nations Secretary General Kofi Annan wrote that "We need to think of ways to bring Wireless Fidelity (Wi-Fi) applications to the developing world, so as to make use of unlicensed radio spectrum to deliver cheap and fast Internet access" (Annan, 2002). In the intervening decade, Silicon Valley and others have risen to the challenge. Wireless networks exploit low costs, increasing technological advances, and unlicensed radio bands to help provide internet access to previously isolated regions of the world (Best, 2003).

2.3.2.2.4.1 WiFi, WiMAX, WLANs, WMANs, and 3G: What's in a Wireless Network?

Different types of wireless networks exist for different ranges of use. Wireless Fidelity (WiFi) uses unlicensed radio frequencies to power Wireless Local Area Networks (WLANs), which connect devices in small areas, such as homes or offices, and typically work best inside rather than to blanket outdoor spaces. Worldwide Interoperability for Microwave Access (WiMAX) may use licensed or unlicensed spectrums that run Wireless Metropolitan Area Networks (WMANs) over large distances, sometimes spanning multiple kilometers, and typically focuses less on in-office coverage (Bhardwaj, 2013). Recently, those working on ICT diffusion in developing countries have become enamored with WiMAX for its low-cost, easily-implemented technology that can reach rural areas with little trouble and insignificant infrastructure development.

This "last-mile" internet coverage, as it is known, finds WiMAX a potential solution to isolation for many small villages in impoverished regions (Kim, 2009).

Another option for difficult-to-wire areas is 3G, which refers to the third-generation of mobile communications technology. Notably, 3G does not offer a wireless network in the sense of WiFi or WiMAX; rather, it is a top-down telecommunications provider method to distribute wireless access to the internet from a mobile device. 3G mobile services may offer broader and more continuous service than WiMAX for a user who moves throughout villages; however, plans tend to be more expensive and not as conducive to sharing connectivity, which is popular in many developing countries as a cost-saving method (Lehr & McKnight, 2003). Interestingly, recent studies show that, among countries with similar mobile diffusion rates, those with more 3G connections also experience greater relative GDP per capita growth (Bilbao-Osorio, Dutta, & Lanvin, 2013).

The differences between WiFi, WiMAX, and 3G may cause arguments among some, but matter little to most users. In developing countries, often only one choice is available; even in developed ones, many do not know the difference between these technologies. It is not the kind of technology the user cares about – it is simply whether he can get online (Lehr & McKnight, 2003).

2.3.2.2.4.2 Wireless Applications and Benefits

Historically, the evolution of new telecommunications technologies revolves around the environment created by the old ones; networks typically grow in haphazard paths rather than spinning out from centralized plans, and user preferences and inputs help mold systems to their needs. Wireless networks have taken these norms to a new

level. “Learning by doing” has been such a common theme among WiFi users that many know more about the network functionalities than some of the large firms that started out trying to hold traditional telecommunications monopolies, and the unlicensed nature of WLANs only contributes to the user-driven model growing today (Bar & Galperin, 2004).

Wireless networks became an obvious application for developing countries as early as the 1990s, since it was obvious that wired connections would be nearly impossible to implement, and by the mid-2000s attention had focused around WiMAX innovation (Heeks, 2008). WiMAX’s lower costs and higher flexibility – particularly for rural regions difficult to access physically and challenging to wire due to geography – reduce necessary capital and present opportunities more palatable for potential investors looking to help developing countries leapfrog over fixed-wire networks (Pentland, Fletcher & Hassan, 2004; Galperin, 2005). These advances have “extended the reach of wireless services to (literally) the man on the street” (Agarwal, Norman & Gupta, 2004, p. 1-2).

Since WiFi networks work on unlicensed radio frequencies, any interested party can build one without regulatory delays (Bar & Galperin, 2004). Galperin (2005) explains the difference between wired and wireless infrastructure construction by relating the laying of telecom wires to paving roads; like paving roads, laying wires necessitates much larger investments, a longer time frame, and careful planning; as a result rural, remote, or difficult to access areas are even less likely to get telecom wires than paved roads. Wireless, on the other hand, presents with low sunk costs and scales up with increased usage easily (Lehr & McKnight, 2003). Eliminating wires cuts costs in

installation and maintenance, as does removing the need for building local distribution plants for wired networks (Bar & Galperin, 2004; Lehr & McKnight, 2003). With the expansion of WiMAX, wireless networking provides the "last-mile" connectivity for many developing countries, as ever more remote areas can be reached with ever fewer costs (Galperin, 2005). Even the example of wireless hotspots at fast food restaurants demonstrates the capabilities of wireless networks; in a metropolis like New York City, one can connect almost constantly through the free WiFi offered by various restaurants and coffee shops (Best, 2003).

Free wireless hotspots also create disincentives for selling WiFi, as they exist for the aim of providing WiFi to the general public, a particularly effective dissemination policy in countries where mobile devices are more popular than home computers and Internet usage can spread at no cost (Bar & Galperin, 2004). The user-modifiable structure of wireless networks has led to a class of small entrepreneurs transmitting WiFi for their communities for very small fees, or sometimes for free, pushing firms like those that have traditionally ruled telecommunications with prices and regulations prohibitive to developing countries. In fact, many technology enthusiasts enjoy disrupting established telecommunications companies and "overturning the corporate apple cart" by ensuring universal access at little to no cost – even though that may mean no profit for those independent providers (Sawhney, 2003, p. 32). As more independent providers pop up their networks begin overlapping coverage areas, so that traveling past shops in rural villages may become much like hopping around fast food hotspots in New York City – in terms of WiFi connectivity, at least. These networks are open to innovation from the community and spark social and economic development (Best, 2003).

2.3.2.2.4.3 An Example: The Nepal Wireless Networking Project

In 2001, Mahabir Pun set out on what many of his friends called a crazy mission: he wanted to bring wireless internet to the small village of Nangi in Nepal. Nangi lacked electricity and villagers needed to walk to the nearest city – between five and eight hours away – just to make a telephone call; most communication remained word-of-mouth. Nepal was also caught in a Maoist insurgency, and both importing and installing any sort of wireless equipment was illegal. Pun ignored the regulations and the people who told him his “pipe dream” could never work; after all, he said, “It’s better to be crazy than to die” (Thapa, Sein & Sæbø, 2012a, p. 3). He built a computer from donated parts and started transmitting a wireless connection, hoping just to bring basic communication services to Nangi and a few nearby villages. The school possessed two computers that were donated in 1997, but without phone lines or even mobile coverage the villagers had yet to see the internet, and Pun believed WiFi technology to be the only option due to cost and infrastructure impossibilities (ITU, 2009). Pun linked his makeshift computer and the two 1997 devices to a wireless signal originating at the nearest provider in Pokhara, 25 miles away by air but a seven-hour bus ride by land (Pun, 2013). With solar power and wind generators to power two repeating stations and several smaller relay stations – necessary because of the harsh conditions and difficulty of receiving signal over Nepal’s mountains – Pun finally got his devices online in early 2002 (ITU, 2009; Pun, 2013).

Within two years, Nepal had 180,000 email subscribers; by 2011, it had more than 2,940,623 across 160 villages (Pun, 2012; Thapa, Sein & Sæbø, 2012a; Pun, 2013). By May 2002 Pun’s Nepal Wireless Networking Project (NWNP) began receiving donations and started a “one dollar a month” campaign to raise additional money (Pun, 2012; ITU,

2009). The success of Nangi allowed NWNP to expand its mission from simply connecting a few people to bridging the digital divide by creating a network for villagers across the country to achieve advances in health, education, social development, trade, and entrepreneurship (Pun, 2012; Thapa, Sein & Sæbø, 2012a). Today, the NWNP also runs training programs to help local communities manage their wireless connections and holds computer training to raise the level of ICT literacy (Pun, 2012). As one village put it, the NWNP has given them more than just wireless internet access: "The dimension of communication has been altered" (Thapa, Sein & Sæbø, 2012b, p. 12).

The Nepal Wireless Networking Project has faced challenges that run the gambit of typical ICT problems in developing countries, like power outages, poor literacy, no knowledge of English on an internet that does not cater to their less-widely-spoken languages, and – most importantly for sustainability, according to Pun – a lack of technical expertise (Thapa, Sein & Sæbø, 2012b; Pun, 2012). None of these challenges deterred Pun; he did not hold with the belief that uneducated or illiterate villagers would not appreciate or be capable of using internet, but instead trusted that providing wireless networks would help rural areas bridge the digital divide. However, Pun did recognize the importance of creating a sustainable program. He needed the local community to become involved in their wireless technology so that maintenance and repairs would not require the expense and difficulties of sending in an outsider (Pun, 2012). By connecting with the local community, Pun not only created a sustainable system, but he also encouraged even faster and greater ICT diffusion in a way that the International Telecommunications Union praises "has greatly contributed to social and human development in Himalayan mountain villages" (ITU, 2009). Notably, in addition to all

the expected ICT challenges, Pun and a small team also worried constantly about being found out by either the government or insurgent forces, and Pun sometimes confides he feels they were lucky to make it past the first several years alive (Pun, 2013).

Pun's Nepal Wireless Networking Project shines as an example of ICT working toward development. With simple, low-cost solutions, Pun connected villagers to the world and encouraged community-run programs to improve quality of life at every possible intersection with ICT: health, communication, education, and business. By building up local demand, involving village entrepreneurs in development, and giving ownership to the people by training them in maintenance, Pun created the framework for a reliable, sustainable service that could answer the problem of the digital divide elsewhere (Ruth, 2012).

2.3.2.2.5 Mobile Devices and PCs

The upsurge in wireless networks has been paralleled by incredible growth in the mobile device sector, and in developing countries mobile telecommunication sales and usage dwarf that of computers or other fixed devices. Mobile telephony ushered in the dawn of ICT and has thus far been the largest driver of ICT development, connecting four times as many people as landlines and keeping costs low so that network availability remains unrestricted across countries. Today, the increased availability of low-cost mobile broadband helps provide high-speed Internet on mobile networks (Bilbao-Osorio & Dutta, 2012).

Mobile telephony attracts users in developing countries by taking advantage of wireless networks; scalable, low-cost devices; and flexible services, from unlimited monthly data plans to pay-as-you-go ones that offer minutes or amounts of data. Even

the least expensive computers and computer-based services cost significantly more, limiting the ability of cash-strapped governments and individuals to fully adopt PC technology. However, as demonstrated by the information that developing countries more than doubled mobile subscriptions between 2007-2013, mobile telephony can and does offer realistic opportunities for impoverished nations to connect with the world and become ICT literate (ITU, 2013).

In both developed and developing countries, mobile phones are credited for positively affecting productivity and growth in nearly every sector, from agriculture to finance, “by transforming the way in which consumers and businesses operate and communicate” (Bilbao-Osorio, Dutta, & Lanvin, 2013, p. 79). Many studies such as The World Economic Forum’s Global Information Technology Report 2013 find that mobile penetration affects GDP per capita significantly and measurably (Bilbao-Osorio, Dutta, & Lanvin, 2013).

2.3.2.2.5.1 Multifaceted Mobile Device Usage

Heeks (2008) considers the factors that make mobile devices attractive to developing countries and provide huge possibilities for ICT for development (ICT4D). Since computers and other larger devices require infrastructure minimums that mobiles do not, he believes that capitalizing off mobile phone preferences established and working to extend 3G and 4G networks may be the simplest, cheapest, and best way to help poor nations. The global poor have “voted with their wallets” for mobile devices, he says, so rather than try to create and diffuse more expensive or complicated instruments that better suit the ICT4D needs as developed countries view them, organizations and governments hoping to truly aid in development will find a way to use calls, SMS, and

other mobile phone technologies to further their goals (Heeks, 2008, p. 28).

ICT4D programs following this advice often see incredible results. The Pocket School gave illiterate, impoverished indigenous Latin American children small mobile devices – that would fit in their pockets – with simple applications to teach them how to read and write in Spanish. Despite protests that illiterate children could not possibly become ICT literate, these children quickly and easily used the devices to begin reading, familiarizing themselves in the process with the new technology. Many computer-based studies with children in developing countries have shown similar results, but the study's authors note that the unique function of the Pocket School is that its use extends far past children. Most of the children in the study lived in tiny houses with many family members, and few households owned televisions or even radios, much less phones or computers. The entire family could interact with the mobile device, learning how to read; other applications could help family members' educations in health, the environment, math, entrepreneurship, microloans, market prices for agriculture, and many more subjects. A computer in the home could certainly perform these functions and many more, but the cheapest computer yet available still costs almost ten times more than the $20 Pocket School device – and most of the families in the study could not even afford that (Kim, 2009).

2.3.2.2.5.2 Internet Cafes and Device Sharing

The concept of sharing devices is extremely popular in developing countries. Where many in richer nations think of mobile phones or computers as personal items, making ICT diffusion measurable by individual numbers of those devices sold or distributed, in developing countries one device could create value for eight or ten family

members. In the case of internet cafes or computer kiosks, that number could be much larger. This diminishes adoption costs for new types of technology, as one unit produces significant diffusion results (Dewan, Ganley & Kraemer, 2009).

Internet cafes and kiosks play a crucial role in developing economies. Farmers use these public internet facilities to check market prices, villagers stay connected to friends and family members who have moved away, and individuals learn more about the outside world and begin to demand more information and better living conditions. However, these internet cafes have taken on other functions as well: since many villagers have no credit cards, they can act as collection agencies for e-commerce funds sparked by entrepreneurs who run their businesses out of the cafes; often they are pick-up points for merchandise sold online, since the buyers and sellers must be at the cafes to perform their transactions. Internet cafes and kiosks have become social hubs for learning and development in completely unexpected ways, and exemplify the “creativity to find alternate pathways that makes it possible for opportunities to exist and even flourish under widely different circumstances” (Maugis et al, 2003, p. 319).

Individuals in impoverished areas with very few devices for the entire community not only cut costs by sharing – they also help each other with the ICT literacy learning process. In a situation where only one person possesses the means for a device, that member becomes a makeshift teacher for the rest of the community (Pentland, Fletcher & Hassan, 2004; Mitra, 2013). In some studies on ICT dissemination, incidental results have shown that individuals compete to be the teacher, trying to show that they know more than others and placing high value on ICT literacy (Kim, 2009). Whether at internet cafes, kiosks, or huddled around a small mobile phone, members of developing

countries accustomed to sharing ICT devices treat the learning process as a social endeavor rather than the personal or individual one it is considered in rich nations.

2.3.3 ICT4D

The Arab Spring proved to the world that ICT makes a difference in political and social change. Data from less precarious situations confirms that hypothesis: access to information via networked communications, whether through Internet services and applications or peer-to-peer texts, has led to a huge increase in transparency and a marked effect on governance. ICT networks act now as citizen participatory platforms, helping common people play a role in the government of their countries without wading through time-draining or costly bureaucratic maneuvers (The World Bank, 2011).

ICT as a transformative factor for social change has given credibility to those who emphasize ICT4D. The revolution of relatively inexpensive mobile devices and WiFi developments have paved the way for SMS messages to remind people with AIDS to take their antiretroviral medications, for the global unbanked to engage in e-banking, and for previously uninformed masses to take part in government – whether informally, as with the Arab Spring, or through e-government systems (Heeks, 2008). The Nepal Wireless Networking Project (NWNP) is an example of a successful implementation of a *para-poor* ICT4D program, or one in which a person or organization works with the community to involve people in their own development. In the case of the NWNP, Pun engaged other community members to a point at which the project nearly became *per-poor*, or one in which ICT4D comes from and is implemented by the community it serves (Thapa & Sæbø, 2012; Heeks, 2008). *Per-poor* ICT4D initiatives tend to be the most successful, as the people designing the projects understand their own needs and wants

better than most outsiders (Heeks, 2008; Blattman, Jensen & Roman, 2002). *Pro-poor* ICT4D efforts, which account for many of the initial programs in extremely isolated areas, are ones that take place on behalf of poor communities but mainly germinate outside of them: Telecenters and prepaid mobile plans are two examples (Heeks, 2008). *Pro-poor* programs often work well, but local communities sometimes resist new technologies if seen as imposed by outsiders. For example, Blattman, Jensen & Roman (2002) found that farmers in rural areas infrequently used the telephone to check market prices before selling their goods, despite voicing an interest in the ability to do so; rather, they usually relied on the television or informal methods like word of mouth – if they checked prices at all. Further ICT development in the form of telecenters, kiosks, or mobile telephony could potentially help those farmers achieve higher profits by permitting them additional opportunities to connect with the market, but such measures would need to be rolled out in a way that considers their previous resistance to newer technology use. Short trainings or programs that take a *para-poor* route to more heavily involve the community in developing, implementing, and diffusing ICT4D projects might be more effective (Blattman, Jensen & Roman, 2002).

2.3.4 What's e-Government Got To Do With It?

Several studies examine the relation between e-government and ICT capability of a country's citizens. Interestingly, in considering Latin American countries, Altman (2002) found no direct proportional relationship between e-government use and ICT capabilities. As most e-readiness indices do, Altman (2002) includes education and computer skills as indicators to determine whether the population in various Latin American countries could effectively use e-government; he calls these "the minimum

conditions necessary for achieving this goal" and believes that without them the implementation of "e-government could simply be an additional resource for perpetuating the power of the already powerful people or, more specifically, increasing the digital gap" (Altman, 2002, p. 9). He notes that minimum conditions are necessary but not sufficient for the development of e-government, and concludes that the discrepancy between e-readiness and e-governance in Latin America exists since citizens already satisfied with the status quo do not request greater accountability through increased e-governance possibilities. In fact, he found that countries whose citizens rated their satisfaction with the democratic process more highly employed e-government less than those in turmoil (Altman, 2002).

While e-government may not make a difference, government support certainly does. The evidence thus far points to adults in poor and rural areas as able and often willing to learn new technologies even given low ICT skill sets and low literacy rates. However, individuals in developing countries may be significantly helped or hindered from increased ICT access by their governments' ICT policies and regulations. Governments who take steps to encourage ICT see positive results in economic, social, and political development; Mauritius, for example, has spent 15 years building a friendly environment for ICT, and profits handsomely from its ICT regulatory and policy work (For more on this, please see section 2.5.7.5 on Mauritius) (Bilbao-Osorio & Dutta, 2012). On the other hand, governments that fail to consider appropriate ICT regulations or that restrict subsidies, international trade, or national funding for education or ICT development may hamper their citizens' opportunities to bridge the digital divide.

2.4 ICT in Education

In addition to providing significant opportunities for general development, ICT advocates have long argued that advancements might help transform education around the world. This section evaluates ICT as a new tool for the classroom. After giving a history of education and concluding that teaching must change to accommodate today's professions and needs, the importance of ICT in education is laid out alongside an update of the current state of classroom technology. Though many difficulties exist for implementation of ICT in education for developing (and developed) countries, a survey of several projects provides a framework for policymakers going forward. Finally, this section questions the ingrained belief that significant training must come before ICT in education can be useful.

2.4.1 History of Education

In ancient Greece, Sophocles, Aristotle, and Plato serve as exemplars of the educated man; celebrated philosophers, they led their communities in spirited debates and elevated reflections. Education existed to nurture the mind and soul. Then came the industrial revolution in the late 18th century. As the changing face of industry required more children with specific skills to work to support their families, the educational system adapted and began to produce a large, employable workforce. At the time, that meant an emphasis on the rigid, cookie-cutter environment of the scores of new factories, and children were educated in a manner that prepared them for factory life and little else (Mitra, 2013).

The industrial revolution contributed to the expanse of the difference between the higher and lower socio-economic classes, and led worldwide to a deepening of the

educational divide between developing and developed countries (the digital divide remained a century and a half away) (Gulati, 2008). Government action – or lack thereof – in developing countries further crippled their educational possibilities; leaders of these countries either shunned the ways of the first world or tried to copy exactly the examples set by developed states, with no modifications to suit their own poorer and culturally distinctive populations (Lewins and Stuart, 1991, as cited in Gulati, 2008). The state of today's education demonstrates the scale of those failures while highlighting the problems behind the inflexible lecturing piled upon even the richest children in the world.

The educational system adapted to teach children workplace skills during the industrial revolution; yet in the 21st century we maintain a system modeled after factories rather than updating schooling to encourage the workplace skills necessary today. Children in the United States graduate from high school with a vague liberal arts background but often receive no training on how to use the technologies or management methods necessary for the jobs they seek; at best, they are prepared to enter a liberal arts college, and at worst they end up floating between low-paying positions until technologies or more skilled and less expensive employees render them irrelevant. Prospects are even worse in developing countries, where the lack of education or skills – and sometimes illiteracy – confines children to the same poverty-stricken social order of their forbearers.

Part of the problem in first-world countries, many educators warn, is that children are not motivated to learn. If taught in a manner that directly relates class work to the real world (as opposed to threatening students to memorize times tables *because I said*

so), or if taught to stimulate creativity and thought rather than to regurgitate facts, children might emerge better-prepared to grow into careers. Kim et al (2009) note that even in developing countries, both parents and children become more excited about the learning process when it clearly aids in relevant skill development.

2.4.2 ICT: A New Tool for Education

Numerous studies demonstrate the effectiveness of appropriately applied ICT in education to increased capacity of students in the professional workforce. When used correctly, the presence of ICTs in schools does not just help children learn basic computer skills; it provides teachers with a tool for simulating real-life situations (Lowther, et al., 2008 and Weert & Tatnall, 2005, as cited in Fu, 2013). The ideal ICT-infused environment would center on students, encouraging learners to engage more actively in their educations and interact with the technology and programs they will encounter in their careers while teachers act as guides rather than lecturers (Castro Sánchez & Alemán, 2011 and Lu, Hou & Huang, 2010, as cited in Fu, 2013). Outside of school, those with access to computers or mobile devices frequently continue to learn informally, the way many academics and sociologists believe should be applied to the classroom (Fu, 2013, p. 112). For example, Dr. Stephen Ehrmann, a pioneer in the study of technology in education, encourages teachers to employ email or videoconferences for language courses and correspondence; he, too, believes that collaborative learning often succeeds over lectures, and he cautions against heralding the use of technology to simply make one-sided lectures available to more people (Ehrmann, 1995b).

2.4.2.1 Educational Revolution: The Rationale

Unfortunately, bemoans Dr. Seymour Papert, “before the computer could change

School, School changed the computer" (Papert, 1995b). Papert, renowned for his work in artificial intelligence and his rousing speeches to the US House of Representatives on overhauling the education system, also invented the Logo programming language and applied a theory he calls "constructionism" to education, but despite his efforts few of his suggestions have been widely adopted. In fact, nearly twenty years after Papert's lament, much of the software used for learning in schools was not even designed as such; "worldware" like the Microsoft Office package more commonly serves students than specialized programs that might better stimulate learning. While tech-savvy academics like Papert and Ehrmann still push for the computer to change School, they recognize that at least the use of worldware actually aids students in learning programs and skills they will need in their futures – a huge step toward a system that will teach students more practical and relevant life skills (Ehrmann, 1995a).

From country to country educational programs seem oddly resistant to the changes made possible by ICT diffusion in schools. Some adversaries cite concerns about student attention in the classroom or reach for more lofty worries about the marriage of the educational and digital divides (Anderson, 2007, p. 33). Others talk about the high cost of computers or the impossibility of training all teachers on cutting-edge technologies (Papert, 1995a). Even the grading of ICT-enhanced classrooms comes under attack as traditional teaching lacks a good way to evaluate the development of social media or database management skills – particularly if the teachers are not trained (Brittain, 2011, p. 1). The underlying issue with these complaints is that their emphasis on ICTs in schools is the requirement that education change. In fact, notes Papert (1995b), technology is simply a tool in what he views as a necessary revolution in

education. Ehrmann, too, shrugs off the idea of some "magic level of technology that an institution needs before such changes can begin," reminding readers that leadership in an educational revolution centers around faculty, alumni, and mostly students – not computers (Ehrmann, 2004).

The academic's push for technology in education positions it not as a method of augmenting traditional teaching, but as an impetus to move toward a student-centered learning environment in which teachers focus on supporting creativity and knowledge development so that every student enjoys an enhanced learning experience, no matter his or her current level in any given subject. In such a system, teachers encourage children who are slower to learn as well as those who are quicker, and reward productive learning across the board (Tezci, 2011a, Birch & Irvine, 2009, and Honan, 2008, as cited in Fu, 2013). Technology makes the necessary changes easier, but it neither creates nor dictates them. As theologist-cum-tech educator Richard Clark says, "the medium is not the message" (as cited in Ehrmann, 1995a). Past failures show that a simple change of the medium to teach the old way – for example, requiring children to do their times tables on computers rather than paper – makes little difference in educational results and serves only to augment costs and frustration (Ehrmann, 1995a). Ehrmann (1995a) emphasizes that he and his pro-tech education colleagues do not believe that technology is the answer to the problem with education; he quips, "If you're headed in the wrong direction, technology won't help you get to the right place," but determining which technologies might best facilitate educational improvements and implementing them thoughtfully might (Ehrmann, 1995a).

2.4.2.2 Constructivism, Minimally Invasive Education, and Self-

Organized Learning Environments

The plea for a movement away from the current model of one teacher lecturing to a group of children – known as “frontal presentation” – and determining the amount of knowledge absorbed through the grading of basic repetition and regurgitation can be achieved with computer assisted learning. However, it is the individual needs of students - and studies that demonstrate that encouraging children to learn as individuals, in the way that best suits each one, rather than as a single classroom unit - that drives the call for change in education. Academics have proposed several alternatives to traditional education. Learning by doing and active engagement in learning appear to stimulate knowledge and skill creation better than either traditional methods or traditional methods augmented by computers (in the “medium-only” sense) (Osin, 1998). Constructionism, advocated by Papert, provides one option; Sugata Mitra’s newly-famous minimally invasive education conducted in self-organized learning environments is another. The common thread in the methods described below is their unity against the traditional form, dubbed ominously by Papert as “Instructionism.”

Papert defines his Constructionism as a sort of kickback to the transmission and acquisition of knowledge that philosophers and revolutionaries embrace – “the right not only to think what they please, but to think it in their own ways” (Papert & Harel, 1991). This model of thinking and learning encourages building rather than reciting; it encourages students to “tinker” to decide what learning methods work best for them, extends to academics who prefer different routes for research, and has consequences far beyond the reach of transformative technologies. Constructionism, in the vein of many alternative recommendations to traditional teaching, has no base in computers; in fact, when Papert began tossing the idea around personal computers were in their infancy, and

Papert & Harel (1991) note that they only discuss the technology at all because it is so applicable as a tool in implementing their technique. When teachers embrace Constructionism and technology in education together, students are uniquely engaged. Anderson (2007) gives an example of one educator who had trouble convincing her students to use an interface her school required, which provided an online environment for homework assignments and discussion groups, among other tools. Frustrated and confused as to why they would not use the technology, she spoke to some of the students and discovered that they were already using Facebook to share materials and have discussions about class. In the constructionist style, she said, “I thought I might as well join them and ask them questions in their preferred space” (Anderson, 2007, p. 33-34). For her to be able to communicate with her students on their turf, with their rules, allowed for a fuller engagement for everyone.

In his recent review of ICT in education, Fu (2013) finds Constructionism supported by numerous experts in the field, and cites Koc (2005), Vannatta and Beyerbach (2000), Abbott and Faris (2000), Whelan (2008), Palak and Walls (2009), and Tezci (2011a), agreeing that this approach vastly outperforms traditional teaching – and that without new methods such as Constructionism, technology in the classroom falls flat. Yet despite widespread academic support and rousing speeches to Congress, Papert (1995b) recognizes the improbability of the US government implementing his ideas on a large scale. Over time, his hope begins to lie more in the constructionist use of technology by children outside of the classroom – and in the transfer of that knowledge acquired to the classroom in ways that affect both the children with access to computers and those without (Papert, 1995b). This “evolution” effectively fans the revolutionary

flames as children begin to question what they are learning, how they are learning, and why they are learning it.

Professor Sugata Mitra took Papert's Constructionism one step further in his own studies on Minimally Invasive Education (MIE). Mitra, who derived the MIE name from "minimally invasive surgery," concurs with Papert that "We have never lived in a world where one standard educated everyone," and wonders if we should simply "do away with standard education. Maybe the convergence of technology and curiosity will solve this problem" (Kluge, 2013, p. 1). In 1999, Mitra set off to test his theory. He began his now-renowned "Hole in the Wall" study by installing a basic PC in a hole in a wall in a Delhi slum. Over a period of a few months, he observed the local children as they taught themselves how to use the new technology (Mitra et. al., 2005). Impressed by the results, he repeated the experiment worldwide, and over ten years discovered that children from any environment, from any language, background, socioeconomic group, or education, can and will learn how to use computers on their own (Fildes, 2010). In Mitra's most extreme test, he left a program on biotechnology in English on a computer accessed by a group of Tamil-speaking 12-year-olds in India; when he returned two months later, one of the girls using the program told him that "apart from the fact that improper replication of the DNA contributes to genetic disease – we've understood nothing else" (Fildes, 2010).

Mitra's work has evolved to include what he calls a "Self-Organized Learning Environment" (SOLE) and, since winning the TED Prize in 2013, the development of a "School in the Cloud." He refers to the SOLE, which is just an extension of the MIE from a hole in a wall to a regulated environment, as a "cybercafé" in which children can

learn (Mitra, 2010a, p. 4). These efforts, which are slowly being recognized as legitimate alternatives to traditional education, and as particularly relevant and necessary in developing countries or impoverished areas, are a far cry from the attempts Papert (1995b) scorns as making "a camel in the sense of a horse designed by a committee. Nobody is satisfied with the camel and the system snaps back to the old equilibrium" (Papert, 1995b). Twenty years later, perhaps we are finally ready to begin to help the computer change schooling.

2.4.2.3 Education Needs ICT

No matter its method or type, education has always intended to impart knowledge or skills that are valued once a child leaves school. In Athens, Sophocles learned to debate and became a great orator; during the Industrial Revolution, children emerged from the classroom prepared to support themselves and their families in the skilled labor of the day; medical colleges require significant prerequisites in science so their students understand physical and biological processes. Twenty-first century careers increasingly necessitate the use of computers and related technology, and if ICTs are not incorporated into education, the system will fail to meet its goals of preparing children for value-added knowledge and skills (Brittain, 2011; Callaghan, 2012). Today's debaters research their topics on LexisNexis; factory workers must function alongside ever-evolving machines; doctors operate with automated instruments and microscopic cameras display their progress on giant computer screens. Even professionals in disciplines as time-tested as statistics now employ technology to an extent that the ability to calculate averages by hand no longer matters as much as knowing which command performs that function in Microsoft Excel, or how to program with software like R (Ehrmann, 2004).

In addition to providing substantial future career advantages, studies show that the implementation of various technologies such as wireless networks add value to the learning environment itself by promoting communication and collaboration between students and professors, easing students' abilities to work together on group projects, and connecting students to other regions of the world, thus broadening their horizons at a fraction of the cost of travel (Barker et al, 2005, p. 1). These advantages prove even more valuable to children in developing countries who have even extremely limited access to such technologies. Children in remote areas with no schools in walking distance and no infrastructure for wired connections might still be able to learn if just one device can be acquired for the whole community, such as in the case of Mitra's Hole-in-the-Wall or in the Pocket Schools described earlier. In instances where children can attend school but must leave at odd intervals to help families with harvests or in other labor, wireless networks and one device can help them stay connected to the classroom. Whether as a supplement to learning or as a replacement for school, the inclusion of ICTs in education significantly increases opportunities for children in both developed and developing countries (Kim, Miranda & Olaciregui, 2008, p. 438).

2.4.2.4 The Current Status of ICT in Education

Despite the literature urging ICT in education, many developed countries with funds to invest in education have dragged their feet. For example, many public school systems in the United States fare poorly in ICT implementation – perhaps one of the reasons Papert grew so animated in his addresses to Congress. After United States President George W. Bush enacted the No Child Left Behind Act in 2001, several US states executed complementary technology programs. Unfortunately, not all programs

were fully funded nor realized. One study of schools in Tennessee investigated whether the use of technology in education, when the appropriate infrastructure is provided, influences the quality of instruction. The study, which compared the realized programs to a control group, found that any grade performance improvements were too mixed to be statistically significant, which the study's authors believe could be due to the limited time the program had been in place. Statistical significance aside, the "tech group" used computers notably more than the control children, both in and out of the classroom, and the authors conclude it is likely the use of technology will transfer to workplace skills. Furthermore, teachers in the schools with fully-realized programs reflected higher technical skill levels and more positive attitudes toward including technology in their classrooms (Lowther et al, 2008).

Of course, experiments and studies of ICTs in education in developed countries tell a much different story than in developing ones. Whatever challenges are faced by developed countries in terms of teacher preparation, appropriate resources, and healthy learning environments are often worse in the developing world, where educational resources are far scarcer (Osin, 1998). Along with different standards of living and job expectations, developing countries have different motives for wanting to incorporate ICT into education. For example, where developed countries hope to use e-learning initiatives to reach literate, non-traditional learners to expand upon their educations – often at a university or graduate level – developing countries' interests in distance learning revolve around literacy and basic, "survivalist" education (Gulati, 2008). As with any indicator, there exists some danger in attempting to compare the level of and motivations for advancing ICT in education across all developing countries. However, in spite of the

wide-spanning diversity of these countries, they do share similar challenges created by extreme poverty and rural isolation (Gulati, 2008).

2.4.2.5 Challenges to Implementing ICT in Education in Developing Countries

E-learning has not yet become a viable alternative for developing countries, but many academics are hopeful that with recent strides in the creation of culture- and environment-specific devices and software, its potential may soon be realized. For the moment, the majority of governments still divert all investments and energies into the improvement of basic sanitation (Gulati, 2008). Sharp criticisms follow academics and non-profits such as Mitra and his foundation who suggest that ICT and education investments should be made alongside investments for basic development; still, when investments for technology in the classroom are paired against investments for basic education needs, such as schoolhouses or textbooks, resistance to ICT remains (Malakooty, 2007).

Fu (2013) describes two types of difficulties for the implementation of ICT in education in developing countries: internal and external. External factors include poor access to technologies and electricity as well as lack of technical or administrative support. Internal factors, such as teachers' cultural biases[1] or beliefs and problems understanding technology, can also have a negative impact (Fu, 2013).

Even in situations where an educational system in a developing country does support efforts to incorporate ICT into the classroom, external factors can derail initiatives. Sife et al (2007) discuss the situation of universities in Tanzania, which, with governmental backing, attempted to implement ICT in higher learning. Their study

[1] Cultural issues are discussed in the later section on policy recommendations.

defines several causes the universities still had not begun using such technologies widely by 2007: the absence of any systemic approach to ICT implementation, which aids in the development of the complex process; poor administrative support, which is necessary for the success of most programs in any educational system; poor technical support, crucial to maintain and operate the new technologies; failure to adapt their methods to the new technology, the way Papert and Ehrmann suggest (Sife et al (2007) call this "transforming higher education"); lack of staff development, resulting in untrained teachers who are unable to instruct their students; lack of ownership, which allows stakeholders, teachers, students, and administrators to brush off new technologies rather than inspiring motivation and participation in the new plans; and, perhaps most obviously, inadequate funds (Sife et al, 2007).

Non-profit initiatives such as Pocket School and One Laptop Per Child (OLPC) expend significant efforts to create affordable technologies for developing countries. OLPC produces sturdy, dust- and fall-proof laptops for around $200, and Pocket School recently came out with mobile devices for around $20 (Malakooty, 2007; Kim, 2009). Unfortunately, many of the rural families in studies done on the Pocket School could not even afford one $20 mobile device, much less a laptop for ten times that much (Kim, 2009). In a review of mobile learning in India, Indonesia, Pakistan, Kenya, and South Africa, multiple studies found that the major worry among students in such programs was the cost of devices (Imtinan, Chang, & Issa, 2012).

In order to make ICTs in education affordable for rural students in developing countries, subsidies from the government or private organizations are imperative. However, Kim (2009) cautions against initiatives to fully fund mobile devices or issue

them freely to anyone, noting that the act of paying even a fraction of the total cost instills a grander sense of value for the devices, encouraging a higher level of care and upkeep. The notion of ownership mentioned by Sife et al (2007) comes into play more literally: when an individual feels as if he owns something, he looks after it and looks for ways to use it.

The Pocket School group argues that although rural children in developing countries cannot afford cheap mobile devices, it should not discourage their development. While subsidies may be required for these projects, their price is much lower than the cost of building and maintaining a school and finding, training, and paying teachers (Kim, Miranda & Olaciregui, 2008). In areas of developing countries that already have schools and lack technology, Osin (1998) finds that an annual per-student cost of one computer per student, including maintenance and software, equates to roughly $84. However, he stipulates that given the likelihood that students and their families will treat their computers as community resources to be used for more than simply in-school educational tools, and employed to increase skill levels among non-students as well, the hourly cost drops to $0.34. Cost, he argues, is a poor excuse for failing to implement ICT initiatives in education in developing countries, since “there is no alternative system known that may provide the benefits possible by integrating computers in the educational system, while at the same time serving the whole community, at a cost of 34 cents per hour of interaction” (Osin, 1998, p. 9).

2.4.2.6 ICT in Education: Initiatives

2.4.2.6.1 Logo

In the late 1960s, Dr. Seymour Papert worked with a group of colleagues to create

Logo, one of the most celebrated educational programming languages of the time. His hope was to empower children to program computers so that they could participate in the burgeoning ICT process. During Logo's first years, Papert remembers walking by an art room on his way to teach a math class in Logo; he says he was so fascinated by the creative environment it inspired that he wanted his math class to emulate it. He termed the concept "soap-sculpture math" and set about teaching Logo the same way, encouraging students to build figures with mathematics. "Fantasy and science and math were coming together," he marvels, and so formed the roots of his theory of Constructionism (Papert & Harel, 1991).

2.4.2.6.2 Hole in the Wall

By the time Sugata Mitra began his Hole-in-the-Wall experiments in 1999, Papert's Logo classes for children in developed countries had long since made way for popular games like the eponymous Oregon Trail – though, notably, ICTs still barely entered the realm of education in the developed world, particularly in public schooling. Mitra was less concerned about the place of ICTs in education and more interested in the lack of any education whatsoever in the slums of India; where Papert viewed computers as a possible tool to further his educational agenda, Mitra saw it as the only tool that could make education a reality for millions of impoverished children. When interviewed about his philosophy in 2010, Mitra reflected,

> There are, and always will be, even in the developed world, places where good teachers do not want to go. How will learners in such areas get an equal opportunity? These areas are not necessarily geographically remote. They may be remote in other ways, for instance, areas in big cities that are socio-economically remote, areas that are religiously or ethnically remote. This is where computers come in…I decided to modify and develop technology and take it to some of the remotest locations I could find (Mitra, 2010a, p.2).

Mitra believed computers could inspire learning in areas where teachers refused to go, where a large portion of the population remained illiterate, and where children faced an extreme lack of educational opportunities. The children in his experiments not only learned how to use computers and the Internet – they learned English, science, or whatever the program Mitra would install in each test (Mitra, 2010a). Mitra's hypothesis that "All humans have the potential to learn, formally or informally" was quickly proven (Kluge, 2013, p. 2).

Since the children in Mitra's studies had no previous knowledge of English or computers, what computer users consider common terminology – words such as "keyboard," "icon," and "mouse" – had never entered their vocabulary. Unconcerned with whether formal jargon might exist, the children simply assigned their own words to the functions or devices, sometimes based on sounds or processes and other times made up (Dangwal et al, 2005). In 2004, Inamdar decided to test the computer skills developed by children in villages with Hole-in-the-Wall kiosks against children who had received computer skills training in school. Inamdar (2004) found the performance of children in villages with kiosks in official computer exams to reach a comparable level as children with training in the subject, terminology notwithstanding (Inamdar, 2004).

HiWEL began building on Inamdar's (2004) gamble by considering formal testing comparisons in many more of their experiments. In one of Mitra's most successful tests, children as young as 8 were able to answer questions in English about molecular biology after only a few months with the computer (Mitra & Dangwal, 2010). Though the group previously knew nothing about molecular biology and was unfamiliar with English, in standardized biology exams taken 75 days after their introduction to the

computer program, the 10-14 year old children in the molecular biology study performed better than children enrolled in public schools and almost as well as those of their own age in the elite private schools; after another 75 days, the children in the study achieved scores better than many 16-year-olds in the public schools and at the 7^{th} standard learners in the elite private schools (Mitra & Dangwal, 2010).

2.4.2.6.2.1.1 Further Applications for the Hole-in-the-Wall

After the success of the Hole-in-the-Wall experiment, Mitra expanded his MIE work to women in shelter homes and juveniles in government homes. Hole-in-the-Wall Education Limited, or HiWEL, defines as its "guiding philosophy" the goal of "[bridging] the "Digital Divide" by offering learning experiences through minimal invasion into the learning realm" (Dangwal & Sharma, 2013, p. E26). By reaching out to bring access to technology to the marginalized populations of India, HiWEL aims to significantly increase the future opportunities for groups who previously had none (Dangwal & Sharma, 2013).

2.4.2.6.2.1.1.1 HiWEL Study on Women in Shelter Homes

Curiously, in the initial Hole-in-the-Wall studies, adult women avoided approaching the computer, which may be a sign of a culturally pervasive sexism issue in developing countries (Mitra & Rana, 2001, p. 229). The objective of the women's shelter study was to apply Hole-in-the-Wall experiment to homeless women; in addition to living in extreme poverty on their own, 60% of these women are illiterate and only 13-15% are considered truly literate. To limit the sample for the first test, only the "truly literate" were studied (Dangwal & Sharma, 2013).

Despite observed reluctance to approach computers in previous Hole-in-the-Wall studies directed toward children, within six months of the beginning of the shelter study

initial results showed that the women were using the computer every chance they had free time. One of the shelter's superintendents noted that the computer was available at all hours of the day – and that the women took full advantage of the opportunity to use it around the clock. The same superintendent also expressed hope that the women would improve their computer literacy to a point of being able to obtain jobs in the sector, a sentiment embraced by HiWEL; the study's authors do believe that access to a computer in a non-threatening environment helped "shape the interest of the women towards computer usage as not just a recreational activity but also as an opportunity to learn and grow beyond the restricted environment of the shelter home" (Dangwal & Sharma, 2013, p. E30).

2.4.2.6.2.1.1.2 HiWEL on Juveniles

Similar success was found in the HiWEL experiments performed on children in government homes. Children in these homes are either juveniles in conflict with the law or ones considered "street children," who are orphaned or have run away from home, usually as a result of severe mistreatment. In recognizing that juveniles need educational and vocational training if they are to break the cycle of arrest and future detention, the Indian government supports the development of these homes to help prepare juveniles for their lives post-incarceration. IT literacy has been marked as a valuable skill, and HiWEL began setting up MIE environments in detention homes. Dangwal & Gupta (2012) performed a case study of five juveniles in the homes exposed to the HiWEL program – and found that all five used their IT skills to find jobs (Dangwal & Gupta, 2012).

2.4.2.6.2.1.1.3 School in the Cloud

In 2013 Mitra won a $1 million TED Prize to build what he calls a "School in the

Cloud." Building off his MIE experiences with HiWEL, Mitra is constructing a physical space in India where children can learn through his Self-Organized Learning Environment (SOLE) adapted to utilize cloud computing. "In the networked age," Mitra reminds unbelievers, "we need schools, not structured like factories, but like clouds. Join us up there" (Mitra, 2013).

2.4.2.6.3 El Plan Ceibal

Mitra's ideas focused around a change in educational styles, with ICT as a necessary tool for the process; perhaps more common is the attitude that a focus on ICT will help classrooms transform. One of the most-cited successful projects for implementing ICT in education began in Latin America. In 2007, the Uruguayan government began sponsoring a program to provide a laptop for every child and teacher in primary school. "El Plan Ceibal" has been the material for several studies, not least one by Mitra and the HiWEL team, who looked to the program for lessons to apply to the Hole-in-the-Wall experiments. Interestingly, Mitra & Quiroga (2012) found that collaborative learners blossom under online learning conditions, while individual learning practices do not necessarily fare as well.

2.4.2.6.4 One Laptop Per Child

David Cavallo also believed in the importance of providing children with laptops, and started a non-profit to reach countries that did not follow initiatives like Uruguay's. One Laptop Per Child (OLPC) aimed to create a $100 laptop, the XO, designed to withstand harsh conditions and with screen shields to ease reading in bright sunlight. Although a noble vision, OLPC has failed on several levels. The PC industry saw the OLPC call to build $100 laptops as the threat of competition, and while OLPC struggled

to lower the cost of its XO – which never got far below a $200 price tag – high-end PC companies raced to build models that were not significantly more expensive and did perform better. Additionally, though OLPC put a good deal of thought into creating computers that would work in rural areas, they equipped the XO with the Linux open-source operating system and interface. While this may have been a good idea from a cost perspective, Linux requires additional teacher training, which OLPC neglected to offer – along with maintenance and further software development (Kraemer, Dedrick & Sharma, 2009).

OLPC pilot studies in countries the laptops have reached do show positive results, but the non-profit overestimated their potential impact on the developing world market. Governments who initially contracted OLPC for thousands of computers quickly pulled out as costs rose from the promised $100 per device, and several years after the initiative's debut the company still struggles to sell their products. OLPC's incredible innovations in designing a laptop to withstand the conditions of rural life were off-balanced by the organization's lack of understanding of their customers. Though they understood that the laptops would have to be bought by subsidized or partially-funded programs, they made the mistake of not catering to developing governments at an individual level. In thinking that all developing governments would have the same interests based simply on the poverty levels of their populations, and in naively believing that initial support absolutely guaranteed future contracts, OLPC failed to consider local issues that might affect their product's dissemination and success (Kraemer, Dedrick & Sharma, 2009).

2.4.2.6.5 Mobile Learning

Other initiatives to bring technology to developing countries have taken a slightly different tack from Mitra's – the mobile one. Mobile learning, or "m-learning," provides ICT-based educational alternatives for rural areas by eliminating some of the most common hurdles for technology dissemination: slow dial-up internet connections, or, more often, no wired network possibilities at all; exorbitant costs; and the physical and human capital typically necessary for large-scale, high-maintenance computers (Imtinan, Chang, & Issa, 2012). Their portability and versatility better match the needs of economies still based around agriculture, and many trials to date have demonstrated the potential of m-learning to truly revolutionize educational opportunities in the developing world (Kim, Miranda & Olaciregui, 2008; Imtinan, Chang, & Issa, 2012).

2.4.2.6.5.1 Pocket School

Some of the more successful experiments with m-learning have been done at a much smaller level with mobile phones. Mobile phone penetration in the developing world vastly overpowers PC penetration; in Africa, for example, the extremely rapid growth of cell phones and the overwhelming comparison to the few fixed-line connections points to a possible niche market (Barker et al, 2005). If innovative technology must consider the customer to succeed, mobile phones seem like the best avenue for disseminating m-learning; in terms of flexibility, versatility, culture, and cost, simple mobile devices may have the highest potential for a transformative impact (Kim, Miranda & Olaciregui, 2008).

Heeks (2008) suggests that the OLPC failures point to the necessity of "adapting or applying existing technologies" to either m-learning or any other development-focused technology program; products that countries already feel vaguely familiar with may be an

easier sell, and often cost less (Heeks, 2008, p. 29). Kim, Miranda & Olaciregui (2008) agreed. They set off on a mission to bring m-learning to indigenous children in remote areas with no access to formal education – due to a lack of teachers, schools, family funds, or a combination of all three. They brought education made possible by ICTs through simple, $20 devices, and named their program the "Pocket School," since the little mobiles slipped easily into standard children's pockets. Unlike in most m-learning experiments, though, the children in the Pocket School were not being taught ICT skills, math, biology, or any of a number of advanced subjects. They were illiterate children being taught to read (Kim, Miranda & Olaciregui, 2008).

One of the common barriers mentioned to bringing technology to developing countries is illiteracy. In fact, some even argue that previous failures may be due in part to researchers overlooking what they categorize as basic literacy requirements necessary to the effective use of ICTs (Gulati, 2008). The Pocket School founders disagreed – strongly. Through a variety of audio and visual games that allowed children to use a basic arrow keyboard to select letters, words, stories, or other functions, the Pocket School aims to provide a teacher for children who had none. Incredibly, in studies of 3-13 year old indigenous children, participants immediately adopted the device, which they viewed as a fun game, quickly learned how to operate it, and within minutes observers saw older children helping younger ones learn (Kim, 2009).

Like the OLPC laptops, the Pocket School paid special attention to designing a device that could stand up to the elements, poor networked services, sporadic maintenance (if at all), and a lack of electricity for charging. Solar panels and cranks could power the mobiles, and in next rounds of development the founders plan to

enhance resistance to dust and scratches and elongate the battery lives. Upon realizing the potential scale of their project's success, the Pocket School program began working to develop two more specialized games for the devices: a storytelling application directed toward slightly older, literate children, and a basic education and business game based around farming solutions for adults. They hope that encouraging children to work with digital creation will help them build skills for today's world, and believe that providing adults with entrepreneurship development programs will increase their positions and possibilities in both rural and urban areas – particularly given the popularity of micro lending as a growing industry in developing countries (Kim et al, 2009, p. 3).

The Pocket School's success in teaching children to read should send a message to those who deny technology opportunities to developing countries about learning possibilities; but another note on the issue should also be made here. In fact, associating illiteracy so strongly with the poor in rural areas of developing countries does them a great disservice. At least one literate person is almost certain to live in each of these communities, and it takes only one reader to aid the rest of the community in accessing, interpreting, and learning the written word. As seen in all of the studies mentioned thus far, such community members were happy to help in such an effort (Heeks, 2008).

2.4.2.7 How Important is ICT Training?

As discussed earlier, many worry that the absence of ICT literacy will hinder developing populations from appreciating and fully utilizing any technology advances that might be offered them (Mitra & Rana, 2001). From this come the indicators that measure human skills for ICT readiness. Yet the current generation of programmers, software developers, and computer scientists in the developed world mostly learned their

way around new technologies by experimenting with technology as children. With the exception of a few schools that taught specialized programs – such as Papert's Logo – in the 1980s computer science and ICT skills were infrequently taught in the classroom (O'Donohoe, 2012). Like the children in Mitra's studies, hackers from developed countries learned their skills by doing, as a result of simple access to a device with many fewer capabilities than those today possible to offer to rural children, and almost entirely without any sort of instruction, supervision, or intervention by adults (Mitra & Rana, 2001). Basic access to technology provided today's top programmers with all they needed to become ICT literate.

2.4.2.7.1 Example: The Raspberry Pi

There is a growing movement originating in the UK and US to refocus ICT courses in schools that offer them around programming and coding, rather than around basic computer skills such as how to use the Microsoft Office package, which some argue does no more than create "passive users of specific software" (Hope, 2011). In the spirit of fostering the creativity and passion for ICT development of the 1980s, Eben Upton created the Raspberry Pi, a small, cheap ($25), programmable machine to encourage children to return to learning the most basic computer skills. The Raspberry Pi is designed specifically with children and classrooms in mind; it cannot be "bricked" (destroyed) and is made to be explored, dropped, taken apart, and used well

Figure 6: The Raspberry Pi. Williams, 2011, p. 2.

(Moorhead, 2012). Computer scientists and programmers herald the Raspberry Pi as the device that will save ICT education (Williams, 2011). Though it is currently marketed more toward school administrators in the UK and US, with its low price and durable structure the Raspberry Pi might soon be an applicable tool for children in developing nations as well.

2.5 Investment in ICT in Developing Countries

The widespread recognition that ICT has major implications for the social, economic, and political development of a country – and particularly for developing countries – gives credence to the search for factors that contribute to higher levels of ICT capability (for more on this connection, please see section 2.1). Policy analysts and academic researchers share an interest in defining and utilizing measures of ICT capability, which they compare against country development; governments, too, look for performance indicators for their countries and data that gives suggestions for improvements in ICT and elsewhere (Archibugi & Coco, 2005). Furthermore, everyone connected to the global network – any member of a known civilization – will be affected by the future of ICT development and policy. Many also have an investment in that future, either through payments for usage of ICT networks or devices, private investments, charitable contributions, or government-levied taxes. These individuals want to know whether their money is well spent.

This section attempts to answer that question. After providing background information on ICT investments and potential investors in developing countries, it investigates the downsides and impacts of financing further ICT advances. Short country studies demonstrate marked successes for governments who have encouraged or funded ICT development. Finally, policy recommendations for aiding investment are given, with focuses on both the indicator measurement system and on project action.

2.5.1 Where's the Money?

Even if policymakers worldwide agreed on the merits of immediately expanding efforts such as the Pocket School and Hole-in-the-Wall, a major question remains: How

will you pay for it? This inquiry haunts academics, researchers, sociologists, educators, and tech junkies alike. No matter how innovative or spot-on a proposal, someone still has to find the money to put it into action.

Investment in ICT differs widely in developed and developing countries. In every sector – education, infrastructure, business – both investment itself and the factors driving ICT investment vary from the first world to the third. As with any indicator, comparing across countries raises issues; but most studies show that developed countries feel more impact on investment due to interest rate fluctuations, intellectual property regulations, saturation of telecommunications infrastructure, and the size of the finance sector. In developing countries, on the other hand, openness to foreign trade, the size of the government sector, and human skills – particularly years of education – seem to have a greater impact (Shih, Kraemer & Dedrick, 2001).

For a variety of reasons, many policymakers and investors in the developed world hesitate to provide funding for technology projects in developing countries. They worry about the adequacy of the skills of the people receiving the devices or say that their grants will not do enough to narrow the digital divide. It is time to address those concerns and start down the path to investments in ICT worldwide – if not for moral reasons, then for economic ones. The populations of the developing world are growing, and those of the developed world are dwindling; meanwhile, ease of travel and speed of quickly-spreading internet connections are shrinking the globe. In December 1940, when US President Franklin D. Roosevelt introduced the historical Lend-Lease agreement, he was met with an uproar against supporting the Allies at the cost of billions of dollars of munitions and wartime material. Roosevelt responded to the protests with an allegory:

> Suppose my neighbor's home catches fire, and I have a length of garden hose four or five hundred feet away. If he can take my garden hose and connect it up with his hydrant, I may help him to put out his fire. Now, what do I do? I don't say to him before that operation, "Neighbor, my garden hose cost me $15; you have to pay me $15 for it." What is the transaction that goes on? I don't want $15—I want my garden hose back after the fire is over. All right. If it goes through the fire all right, intact, without any damage to it, he gives it back to me and thanks me very much for the use of it. But suppose it gets smashed up—holes in it—during the fire; we don't have to have too much formality about it, but I say to him, "I was glad to lend you that hose; I see I can't use it any more, it's all smashed up." He says, "How many feet of it were there?" I tell him, "There were 150 feet of it." He says, "All right, I will replace it." Now, if I get a nice garden hose back, I am in pretty good shape (Roosevelt, 1940, as cited in Peters & Wooley).

Soon, the US, UK and Nordic countries must realize that Eritrea, Zimbabwe, and the Democratic Republic of the Congo have become close neighbors. Developed countries can lend out their garden hoses – or haggle over the money and risk their own houses catching fire.

2.5.2 Investment Arguments: For and Against

In typical business ventures, backers like to gain some idea of the risks and potential payoffs of their investments; they prefer to settle the price of the hose before a fire ever breaks out, just to be safe. ICT4D initiatives infrequently have the luxury either of reaching investors pre-fire or of being able to demonstrate the future value for any of the parties involved. Most developing countries only began seeing investments in ICT in the 1990s, and as many of those either relied upon or directly treated human skills development, the germination period for results – positive or otherwise – is somewhat longer than normal. Such investments time to pay off and time to show up, and we may only be at the verge of discovering their outcome today (Dedrick, Kraemer & Shih, 2011).

Another factor in ICT investment results is ICT capital stock, which depreciates

rapidly. In developing countries, which tend to use ICT more than create it, struggle to replace retired stock without additional loans or subsidies. Until those countries are able to replace their own capital stock, the positive growth generated by the initial ICT investments may slow acutely (Shih, Kraemer & Dedrick, 2001).

Payoffs aside, perhaps the concern most often raised regarding technology investments in poverty-stricken areas is that money should be put toward attaining clean water, proper sewage systems, and ensuring basic physical needs, not whiled away on fancy technology for villages that do not even have electricity in many houses. ICT4D activists respond that development requires water, but it also requires access to information and the ability to learn employable skills, and in today's world that means digital technologies are increasingly important. Social, economic, and political life in developed countries revolves around digitized media and devices, and rural populations playing catch-up cannot hope to attain a similar level of well-being without access to new technologies (Heeks, 2008).

On a micro level, the argument resonates that much stronger. Mitra, in his observations of thousands of severely impoverished Indians, notes that even those who cannot afford food or clean water gravitate toward whatever entertainment technology they find, whether that be public televisions, HiWEL kiosks streaming videos and news, or games on mobile phones. A bit sadly, he writes that "the virtual world…is sometimes the only relief that the poor have from a harsh, and often unbearable reality" (Mitra & Rana, 2001, p. 222).

A study in India known as the Sustainable Access in Rural India (SARI) project, found that even in extremely impoverished rural areas, ICT markets are sustainable by

community members who learn to use the new technology and quickly embrace it in every aspect of their lives. These rural people are not only willing to spend small portions of their meager incomes for entertainment provided by ICT – as Mitra & Rana (2001) noted – they actually invested significant amounts in order to gain access to ICT in the hope of community, communications, and career development. SARI concluded that the research thus far speaks to increasing opportunities for similar projects' economic sustainability, and also noted that the addition of affordable public telecenter services like the kiosks in Mitra's (2013) Hole-in-the-Wall experiments might spur ICT development even further (Blattman, Jensen & Roman, 2002).

2.5.3 What Impacts ICT Investment in Developing Countries?

If developed countries are to help provide that relief and stimulate ICT development in those economies, policymakers need to better understand where and how to invest. In 2000, a study limited to 50 countries – including some developing countries, though not much data was available for their ICT investments at the time – found a strong correlation between ICT spending and country income level. At the time, developed countries spent a much larger percentage of their GDP on ICT (Pohjola, 2002). Investment in ICTs for developing countries only began in the 1990s, and did not pick up until much more recently. Due to the aforementioned demands of replenishing capital stock and the time required to nurture human capital, many of those economies have likely not yet arrived at a cumulative level of ICT spending that would reveal significant gains in productivity. Given that enough investments in ICT will eventually result in positive social and economic results, the lack of measurable data on gains to date increases the importance of what drives a country's ICT investments (Shih, Kraemer &

Dedrick, 2008).

Recent studies highlight the magnitude of monetary resources – potential capital – in investment decisions. In developed countries, these would be calculated by available bank loans; in developing ones, foreign aid plays a large role, along with currency valuation and lines of credit on international debts. Informal capital creation and foreign aid aside, interest rates are negatively correlated with investments. Economies based around finance tend to invest more readily, particularly in ICT, whereas traditionally agricultural systems remain wary of bank processes (Shih, Kraemer & Dedrick, 2008). Some machinery and genetic advances in technology that have spurred agricultural success, for example, in India, may help alleviate these specific concerns.

Many believe that international dealings have a huge impact upon investments in any sort of technology. Openness to external influences – whether through trade, educational exchanges, or even tourism – spark technology diffusion and create an environment in which governments and citizens begin considering ICT progress and forward-reaching endeavors as desirable. The spread of knowledge leads to the transmission of ideas (Dedrick, Kraemer & Shih, 2011). Both Mexico and Brazil saw increases in trade openness stimulate ICT investment by multinational companies (MNCs), which led in turn to the growth of the countries' ICT sectors as the MNCs employed suppliers on the ground and stoked domestic competition (Shih, Kraemer & Dedrick, 2008).

Predictably, two of the most important factors remain infrastructure and human skills. Educated workers as well as highly-performing professionals in management positions encourage ICT development; rural villagers with no knowledge of computers or

the internet who also lack electricity and networked connections are much less likely to support such investments (Shih, Kraemer & Dedrick, 2008; Dedrick, Kraemer & Shih, 2011). Even investment of human capital, without its preexistence, correlates strongly to ICT investments (Pohjola, 2002, p. 12).

2.5.4 Current Investments

Currently, governments spend heavily on three areas to promote ICT in order to meet market demand within their countries: policy and regulation reform, financial incentives to private firms, and direct ICT investment (Bilbao-Osorio & Dutta, 2012, p. xiv). Given that ICT tweaks can significantly affect GDP per capita, it is perhaps unsurprising that so much money flows into the ICT sector. Governments are not the only heavy spenders, either. In addition to private investments and business ventures, other public organizations have begun to put money in ICT development. Along with policy loans, technical assistance project components, fee-based service, and policy dialogue, the World Bank has invested more than $1.3 billion in ICT projects worldwide since 2003; they have lent an additional $7.3 billion to IT segments of other projects, such as in education or health, and are also helping finance broadband infrastructure in developing countries (The World Bank, 2011).

Unfortunately, a recent report by the GSMA shows that many of the funds raised to increase mobile access for poor and rural areas are “inefficient and ineffective,” with fewer than 12.5% reaching targeted results and fully one third of the funds not even spending the money they raised (Ladcomm Corporation & GSMA, 2013b, p. 7). This unspent money amounts to $11 billion that could be used to aid in ITC development in poverty-stricken regions (Ladcomm Corporation & GSMA, 2013b). In an extended

commentary, Tom Phillips, Chief Regulatory and Government Affairs Officer of GSMA, stated solemnly,

> The situation needs urgent government review and attention, as the money collected to date far exceeds the amount that is needed to ensure universal access…The reality is that these funds have become a convenient form of taxation on the telecommunications industry and in the majority of cases, they should be closed down and the balance of moneys held used to extend access to mobile services to those unable to afford them, or those groups that live in particularly remote areas (GSMA, 2013).

GSMA lists the worst offenders as Brazil, the Czech Republic, Ecuador, France, and Italy; Colombia, on the other hand, stood out as an example of good governance, having recently reduced taxes and increased transparency to promote ICT in the country (GSMA, 2013).

Developing countries are also changing the way ICT funding tilts. Though fixed telecommunications continues to be the most heavily funded ICT segment worldwide, Gartner predicts that within five years spending will center on mobile phones, storage, cloud computing, and mobile networks, all of which hold particular appeal to developing countries (Gartner, 2013). This points to the move toward global data and completely integrated Information and Communications Technology.

Data on ICT expenditures by country is freely available on The World Bank's data website, which allows organizations and individuals to access and analyze it. The Gartner Worldwide IT Spending Forecast compiles the World Bank and other data to produce a well-respected prediction of ICT spending for the years to come, used by governments and private organizations for their own considerations. According to the Gartner Worldwide IT Spending Forecast for 2013, this year will net around $3.8 trillion in ICT expenditures, up 4.1% from $3.6 trillion in 2012 (Gartner, 2013). To put those numbers in perspective, global military expenditures in 2012 added up to $1.7 trillion;

more than twice as much money was spent on ICT than on all countries' militaries combined (Sipri, 2013).

2.5.5 Public Investment

The organizations successfully providing technologies to samples of the poorer portions of the populace in developing countries recognize the importance that government subsidies play in technology dissemination. Just as government participation in and support of ICT4D projects may make or break them, government funding in these projects is absolutely a necessary evil. Compare the results achieved by the Pocket School, a program that courted government and private-sector support for their cause, against the litany of problems experienced by the One Laptop Per Child initiative, which halfheartedly secured vocal support from various governments but failed to follow up and secure the essential funds and contracts. Even when private investments could potentially cover the costs, the crucial role of governments in developing countries – especially in new democracies, where the people remain sharply cognizant of their freedoms and often engage heavily with politics – cannot be understated. A government endorsement means more than simply a monetary contribution; legislation to enable proper use of the new technology, aid in setting standards and ensuring proper enforcement mechanisms, and sometimes even propaganda and implementation fall under the purview of potential government support functions (World Economic Forum, 2013).

Certainly, the importance of private and non-governmental investments should not be glossed over; Sugata Mitra's recent $1,000,000 TED Prize makes that abundantly clear (Mitra, 2013). However, in the age of crowd sourcing, public funding is ever more

significant – particularly for projects that benefit the public good. McKinsey & Company worked with the World Economic Forum (2013) to produce four suggestions for stimulating public investment:

- Permit consolidation to promote efficient resource use and network operation;
- Encourage pricing flexibility to address the a wide-ranging socio-economic base of customers who desire diverse levels of access and service;
- Manage access regulation carefully, and only allow wholesale access regulation for a select set of basic services; and
- Allow operators to function in multiple theaters, thus broadening their options (World Economic Forum, 2013).

2.5.6 Does Investment in ICT in Developing Countries Pay?

Though the realization of ICT investment in developing countries may only just be beginning, the limited effects showing inspire hope. Studies hint at the same creeping productivity growth that the developed world saw when their initial investments in ICT started to pay off (Dedrick, Kraemer & Shih, 2011). Still, Professor Archibugi cautions that to truly understand the course of those effects, one must allow them to run the course of time; "if you think we can say that investment grew into something useful in China and Japan," he rebukes, just consider that,

> there are cases in which things have not turned out to work as expected – for example, the enormous investment in the Soviet Union in the 50s and 60s which worried the Americans in the State Department and which never turned into something economically and socially challenging. Education was much higher, but that is a case where inputs did not necessarily turn into outputs (D. Archibugi, personal communication, August 6, 2013).

In his work on indicators, Archibugi pays special attention to which inputs effectively produce the desired outputs. He does point out that more recent regression analyses of

ICT investments and technological readiness, or capability, suddenly show slightly negative correlations where experts in the field previously saw a strong positive ones; this he attributes to the incredible influx of ICT investments in poor countries not yet reaching the "ready" status (Archibugi & Coco, 2004).

Some academics reason that in addition to time, countries may need certain levels of ICT capital stock or human capital before generating positive productivity gains (Dedrick, Kraemer & Shih, 2011). Those inputs seemed to produce the right outputs for developed countries, and if developing countries follow their model, perhaps in another forty years they may reach the "readiness" status deemed acceptable in 2013. A more prudent tactic may be complementary investment, as suggested by the World Economic Forum in their Global Information Technology Report (2013). In their correlation analysis, they found a predicted cumulative effect of ICT investment upon ICT capability or readiness, but they also uncovered a strong relationship between investments made directly in ICT-related skills and human capital (Bilbao-Osorio, Dutta, & Lanvin, 2013). The development of one multiplies the development of the other.

2.5.7 Positive Examples of ICT Investment

The past several years have seen sharp hikes in ICT investment in Southeast Asia, Eastern Europe, Latin America, India, and even parts of Africa, piquing the curiosity of additional financiers (Dedrick, Kraemer & Shih, 2011). Google just announced a plan to help get an additional billion people from developing countries online by financing, building, and aiding in the operation of wireless networks across the globe, which they propose to do through high-altitude balloons and blimps. Google's initiative may appear almost science-fiction, but their rejection of the costs and difficulties involved in erecting

traditional infrastructure to meet such a challenge demonstrates the lengths to which developing countries are paving the way in leapfrogging technology (Geere, 2013). These countries may be paving the way in leapfrogging technology that aids developing countries in significantly narrowing the digital divide. Through advances in telecommunications, legislation, trade openness, and human skills development, these new investors are blowing past the typical paths of the current "most ready" or "most capable" countries to significantly narrow the digital divide. For Networked Readiness Index reports on Azerbaijan, Brazil, India, Mauritius, and Rwanda please reference the Appendix (Section 6.3).

2.5.7.1 South Korea

In mid-2013, South Korea began offering the world's fastest 4G data speeds with a new LTE-Advanced network that can download files at 150 megabits per second (Mbps) – twice as fast as the top capacity of 4G in the UK. The UK has responded in kind with a plan to launch "double-speed 4G," but critics note that most phones in the country will actually limit download rates to about 100 Mbps (BBC.com, 2013c). This enormous step from South Korea gives credence to the stories of the rise of the Asian Tigers in ICT capabilities.

2.5.7.2 Rwanda

Rwanda, called out by the World Economic Forum's Global Information Technology Report (2013) as an example in ICT development, recently began work to provide fiber-optic coverage across the entire country. The government plans to install fiber in a few key areas, and use the cheaper and more flexible wireless broadband connectivity for the "last mile". In concert with these efforts, a variety of public

telecommunications centers to increase access to information and the internet have sprung up, as have kiosks where Rwandans can easily perform quick queries and even ICT buses. These public resources increase ICT awareness and literacy training, helping "[provide] an ecosystem in which startups combine innovation and entrepreneurship to produce homegrown solutions for local challenges along with globally scalable knowledge" (Bilbao-Osorio, Dutta, & Lanvin, 2013, p. 120).

2.5.7.3 Angola

Ten years after the end of a devastating civil war, Angola has invested 100 million US dollars in a project with the international telecommunications company Movicel to provide the country with high-speed 4G service (Cossou, 2012). Project leaders expect 1 million 4G users by the end of 2013 – which would put Angola ahead of the European Union in terms of connectivity and technological advances in ICT (Cossou, 2012). Angola and Movicel are leaping forward even while they cannot manufacture the equipment or phones necessary for the project within Angola; as a result of the lingering effects of the not-so-distant civil war, the level of education is still too low to produce qualified employees (Cossou, 2012). Nonetheless, the hope is that Angolans will learn to use this new technology as soon as they have access to it – and, as amply demonstrated in this paper, such a goal seems easily attainable. Movicel CEO Yon Junior admits, "we are playing a game of the future…We are building an elegant network to speed up the growth of this country. But it's not just a question of technology. It has to be affordable according to the country's needs and capacity to pay" (Cossou, 2012). If Junior succeeds, he will not only move Angola to the forefront of the world's ICT stage by providing affordable mobile connections to a poverty-ridden country; he will also fulfill

his hope to employ and empower the local people in Angola (Cossou, 2012).

2.5.7.4 Azerbaijan

An emerging oil and gas giant with a focus on increasing ICT to enhance transparency and financial stability, Azerbaijan is notable not for its current level of development, but for its stated goals. A flurry of domestic and regional ICT projects is in the works, and with private organizations contributing as well, some projections put the country's ICT sector revenues reaching oil and gas revenues by 2025 (Bilbao-Osorio & Dutta, 2012). This would give Azerbaijan a new claim to fame as the region's ICT hub – a diversification that may put the country in a better position than reliance on oil and gas income. Experts believe Azerbaijan can accomplish this because it has already levied domestic compliance with international standards, created a stable and competitive market that has brought in new telecommunications providers, demonstrated efficiency and fairness in its relevant resource usage, and regulated interconnection and advanced licensing issues – all necessary steps for continuous ICT implementation (Bilbao-Osorio & Dutta, 2012).

2.5.7.5 Mauritius

One of the greatest challenges developing countries must overcome is that of outdated policies and regulations that fail to adequately cover ICT issues. Mauritius stands out as a shining example to all countries – developed or not – of how to implement effective policies and regulations so that ICT is encouraged. The country's commitment to a strong ICT infrastructure has paid off over the past fifteen years. In the most recent Global Technology Report, the World Bank's recommendations mirror policy moves Mauritius has taken to great fiscal, economic, and social benefits (Bilbao-Osorio & Dutta,

2012).

2.5.7.6 Burma

Burma and Brazil have focused on opening up bidding on telecom licenses to promote healthy competition. In Burma, one of the few markets without full saturation of mobile phones, the possibilities for growth are staggering; estimates show that only about 9% of Burmese currently have cell phones. With contracts to companies from Norway and Qatar newly awarded, Burma looks to tap this mobile market immediately. The contracts stipulate that within five years, firms winning bids must provide 75% of the country with voice services and at least 50% of the country with data – a particularly impressive goal, since studies speculate that only a very small percentage of the population could afford a mobile device, much less the services to complement it. In this ambitious endeavor, Burma could learn quite a bit from the examples of Azerbaijan and Mauritius; legislation to open the telecommunications sector lags behind the contract grants, and is essential to forward progress at this point (BBC.com, 2013a).

2.5.7.7 Brazil

Brazil, in an attempt to bulk up for the World Cup in 2014 and the Summer Olympics in 2016, also opened ICT bids for auction. Unfortunately, the process has not turned out as well as hoped, and only a fraction of the lots up for auction have been sold. Efforts to ensure that every host city for the upcoming games runs on 4G also lag behind (Duran, 2013). Where Burma falls short on legislation, though, Brazil does not; several incentive programs in infrastructure development and government subsidies help along such projects, even despite large-scale street protests during the summer of 2013 (Verotti, 2013).

2.5.7.8 India

In India, Chief Minister Chandrababu Naidu of Andhra Pradesh faced similar opposition when he began implementing ICT programs in 1995. As mentioned in the beginning of this section, many harbor concerns about addressing basic needs before considering ICT investments. Many in Andhra Pradesh slandered the Chief Minister's policy of tinkering with technology rather than addressing the sanitation or starvation problems of some of the world's most impoverished citizens. Recognizing the potential of ICT initiatives in India, a burgeoning hub for technology outsourcing and production, Naidu defied his critics and built an incredibly successful system for ICT development, implementing roughly a dozen programs between 1995 and 2002 and bringing India to its current level of capability – higher than many other developing countries (Krishna & Walsham, 2005).

India is a bit of a special case when it comes to ICT investments and payoffs. Given the extreme growth of its software export industry, Naidu saw major possibilities for quality of life improvements for his citizens if he could convince them to take the necessary steps to make ICT education available. Naidu's leadership, knowledge, and enthusiasm pushed ICT programs far beyond where they might otherwise be today in India, and have aided the province in sustained ICT and standard of living improvements. By making a long-term commitment to ICT development, involving himself heavily in the innovation and implementation processes, displaying and encouraging a willingness to learn from others and from his mistakes, and by using his political skills to convince other government leaders of his ideas and construct public-private partnership, Naidu painstakingly laid the groundwork for a public information system to support his people and increase their access to technology (Krishna & Walsham, 2005). Few other countries

have seen leaders with the same combination of commitment, drive, and involvement it takes to accomplish such a monumental task.

2.5.8 Policy Recommendations

As the steps described by the countries above demonstrate, simple investment in ICT without additional action is not enough to bridge the digital divide and solve the problems of the developing world (Pohjola, 2002, p. 17). Acting together, the development of human skills, proper legislation, ICT investment, and plans for dissemination hasten measurable positive productivity gains and also stimulate further investment. In light of the corollary effects of these various factors, many experts in the field suggest promoting packages of technologies rather than attempting to diffuse them individually. For a private company looking to enter the mobile market in a developing country, for example, bundling a mobile device with access plans, additional software possibilities, or even training – the way Apple does for its developed-country customers – may resonate more with emerging businesses looking to bump their ICT capabilities. In public programs, governments may respond better to requests for subsidies if they understand that new technology will not simply be hoisted on its ICT-illiterate and left to break down; offering maintenance possibilities and working with local businesses to create a network of village suppliers that could stimulate further economic growth might appeal more to leaders under pressure to attend to other needs for an impoverished population (Dedrick, Kraemer & Shih, 2011).

Utilizing this “systems approach,” which plays off the co-diffusive effects of various technological advances, may not only net additional ICT investment but also hasten the narrowing of the digital divide as underprivileged communities gain exposure

to multiple new technologies simultaneously. The rate at which ICT literacy and economic opportunities increase skyrockets, and ICT penetration snowballs. This holds particularly true for communications technologies in developing countries, as newer, easier methods of communicating with family members or friends quickly spread in cultures placing strong value on personal relationships (Dewan, Ganley & Kraemer, 2009).

2.5.8.1 Cultural Considerations

Cultural considerations should not be taken lightly. Particularly when it comes to bringing "Western" technology to marginalized populations, cultural objections to devices or networks that impact traditional relationships and ways of life may create additional barriers to dissemination. Again, incredible importance lies in helping local communities develop – locally, in manners that they appreciate, understand, and with projects that inspire them to take ownership. Occasions of offending the very people the initiatives purport to help may not be numerous, but failure to understand the consumer often negatively impacts ICT programs. Whether implementing information systems or trying to provide laptops for children, policymakers and organizations on the ground must focus on the cultural context of their target population – and design the initiative around that population's desires and needs rather than attempt to push a generic "developed country" device upon them (Krishna & Walsham, 2005).

Even among developed countries today a blanket focus on one aspect of ICT development for a group of countries obviously contributes to causing problems rather than fixing them. Europe, in addition to failing to consider factors that might influence each other, thereby limiting the effects of any "unpackaged" initiative, has applied the

same metrics and goals to its entire region. The sudden and alarming emergence of a digital divide between Nordic economies and those in Southern, Central, and Eastern Europe highlights the importance of developing ICT strategies for individual countries (Bilbao-Osorio, Dutta, & Lanvin, 2013).

2.5.8.1.1 Timid with Tech

A study of college students in South Africa brings to light certain cultural challenges infrequently contemplated by the policymakers and organizations often helping to disseminate ICTs and create programs to aid in ICT literacy. Brown (2002) investigated perceived ease of use of the interactive program “WebCT” for the students, many of whom were not accustomed to working on computers full-time (if at all) and few of whom shared a mother language with the language of instruction. In such cases, ease of understanding stands out as particularly important, as implementation and dissemination success hinge on actual adoptability (Brown, 2002).

As a result of his study, Brown (2002) believes that at the university level students from developing countries will shy away from technologies they perceive as too complex, and that such technologies will actually distract them from their work and impede their ability to learn. When students must spend more time trying to grasp new technologies than focusing on the content of a course, productivity drops – especially when those students are too shy or embarrassed to ask for help, as many of those in Brown’s (2002) study were. Self-efficacy played a strong role in these students, and many developed strong computer anxiety. The problem was not that the students could not learn the technology; it lay in the stress created by their unnecessary embarrassment and nervousness. Brown (2002) suggests that ICT illiterate university students from

developing countries be provided an opportunity to learn about how to use computers and the internet in a relaxed and friendly environment – much like those provided by such initiatives as Mitra's kiosks and School in the Cloud or by Pocket School. Here, again, offering package deals or promotions that include a week of ICT training for adults entering careers or schooling molded around computers might contribute to increased speed of adoption and diffusion.

2.5.8.1.2 Syria and the Problems with Western Technology

When the cultural issue at stake does have to do with the "invasion" of Western innovation, as sometimes happens in Arabic countries, many such Westerners are quick to scorn concerned societies as backward or radical. In fact, as Damarin (1998) notes, little has been written about the non-neutrality of computers; though webpages online now exist in many languages, the Internet certainly began as an English-leaning resource, and most software and code is still based in English, as well (as cited in Albirini, 2006). Software and hardware design were created with social and cultural Western biases, as well, with Arabic values rarely – if ever – considered (Albirini, 2006).

In a study done in Syria, Albirini (2006) found both teachers and students excited about the possibilities of the internet and other ICTs in the classroom. However, most of them cited apprehension about social barriers to using those technologies, including moral and religious concerns, worry about outside influence, and fear of changes in manners of communication. While they yearned for the opportunities the ICTs could provide, they hesitated to compromise their cultural values and norms (Albirini, 2006).

As before, these results point to the conclusion that simply dropping computers into a classroom will not effect the changes necessary for social and economic

development in poor areas. Teachers in the study in Syria expressed desires for Arab-made computers and software to help them educate their students without ignoring their ethical systems. They also noted that the engineering devices and software did not match the way they thought, and so processes intuitive to many Westerners made little sense in the Arabic schoolroom. A focus on local applications for individual communities could easily overcome these cultural issues and offer Arabic children the possibility of ICT literacy without value conflicts (Krishna & Walsham, 2005; Albirini, 2006).

2.5.8.2 Measurement and Indices for Investment

Important though cultural considerations are at the investment level, measurements of ICT readiness and capability are unlikely to capture them. However, several additional factors come into play when considering indices. As Archibugi (2013) cautions, macro indicators do more to create indices that allow for comparison across many heterogeneous countries; the more micro the indicator, the less relevant the comparison for large variances. In the case of education, for example, the ArCo index's macro indicators – basic literacy rates, average years of schooling, and number of students in advanced education for science and technology – give only a general idea of a country's educational situation (Archibugi & Coco, 2004). Indices like the Networked Readiness Index (NRI), on the other hand, include multiple complicated indicators that may not make sense across all the countries contained in the index (World Economic Forum, 2013). The NRI may give an investor for one country more specific information about that country, which can be incredibly useful; however, in a comparison to other countries, simpler indices provide a more balanced picture of the true environment (D. Archibugi, personal communication, August 6, 2013).

Additionally, ICT capability measurements would be well-advised to make sure they evaluate potential skills rather than focusing on current ICT literacy. As work by both Mitra (2013) and Kim et al (2009) shows, even children who lack basic literacy possess the abilities to quickly become versed in ICT, if given access. Though trainings may speed up the process, the Hole-in-the-Wall and the Pocket School examples demonstrate that ICT readiness may not need to rely upon trainings or previous ICT experience (Mitra, 2003; Kim et al, 2009).

2.5.8.3 Customer-based Actions

Perhaps the most important recommendation from most of the studies done on ICT implementation is that projects must be customer-focused to succeed. In order for an investment to pay off, devices and programs should be designed with the customer in mind; for example, if targeting a community with low literacy rates, basic cell phones may be disseminate better than personal computers (Kim et al, 2009). Additionally, it is important to invest in local solutions for locals. This means not only ensuring that projects address the community's needs, but also helping community members to set up supporting businesses so that they can sustain an ICT-ready environment and even begin to innovate themselves (Bilbao-Osorio, Dutta, & Lanvin, 2013).

Getting locals involved with ICT development leads to quicker diffusion and adoption of technologies, and aids in overall economic development as entrepreneurs and business leaders take advantage of the new opportunities and markets growing in their communities. Mahabir Pun of the Nepal Wireless Networking Project (2012) says that the most vital thing he learned from his experience is that only by involving local private partners and organizations can an ICT4D project flourish long-term. Working with local

stakeholders, Pun (2012) believes that programs like his can help bridge the digital divide, but "without community involvement, an ICT4D project will survive for the project period only, and then may flounder" (Pun, 2012, p. 12).

Government initiative and support also helps, and while under-the-radar ICT development is possible without approval for a time, for long-term sustainable ICT readiness the government needs to be on board. Basic infrastructure construction for many developing countries is simply too expensive for outside organizations or even generous investors to take on, and restrictive legislation can strangle the efforts of entrepreneurs attempting to work with the community. Rural areas in particular require government support, as few commercial companies are likely to invest in last-mile infrastructure without additional incentives (Pun, 2012).

On a product level, many customers in developing countries – especially in rural areas with low literacy rates – prefer packaged solutions that include maintenance and training. This may not always be the case, but offering such options may increase dissemination and make an ICT possibility friendlier to these consumers. If an individual is afraid he will be unable to benefit from an ICT product, he is much less likely to try to use it (Dedrick, Kraemer & Shih, 2011).

The examples given here highlight only a few community-specific issues that may arise during ICT development projects. The most important policy recommendation is a general one: consider the customer. If a region is properly studied and catered to, investment in ICT should result in significantly positive results.

3 Implications for Policy Making

Investments in mobile and wireless technologies will allow organizations and governments to leapfrog traditional infrastructure, narrowing the digital divide and resulting in attainable education, skyrocketing literacy rates, and sustainable solutions for development in impoverished states. ICT readiness and capability measurements are quickly becoming outdated and need to be reworked to accurately reflect the potential of ICT projects in even extremely rural or illiterate communities. To take advantage of this revolution, policymakers and financiers for developing countries should fully consider the leapfrogging effects on education and development when evaluating new ICT programs.

This paper presented evidence that the leapfrogging phenomenon for ICTs should lead to a revamped method of measuring ICT capability and readiness. Studies such as Mitra's (2005) Hole-in-the-Wall and Kim et al's (2009) Pocket School prove that poor, illiterate children can not only learn to use technology with minimal or no instruction, but can also use that technology to teach themselves how to read in local languages and in English. With the falling prices in mobile and wireless tools, governments and organizations can now reasonably invest in connecting poor countries and subsidizing internet-enabled devices, cafes, or kiosks for their citizens. Education in particular benefits from these changes, as children in areas without teachers can now access the means to learn without traveling long distances.

After discussing the positive returns on ICT investments in various states, this paper laid out several policy recommendations for improving and increasing ICT project financing in developing countries. Moving forward, such advancements as big data, the

cloud, and the bring-your-own-device (BYOD) movement will provide even more opportunities for growth for marginalized countries, allowing them to harness the power to take charge of their own development and opening up local ICT markets worldwide. After providing an overview of these "game-changers," this paper concludes that development spurred by ICT can be sustainable and successful with the right investments and support even when current measurements of ICT readiness indicate that an area is not yet prepared for such an undertaking.

3.1 Game-changers: Big Data, The Cloud, and BYOD

Castellacci & Archibugi (2008) write that "countries differ, first and foremost, in terms of their ability to innovate and to imitate advanced technologies" (Castellacci & Archibugi, 2008, p. 1669). Generally speaking, developed countries tend to innovate, whereas developing countries at various levels imitate, adopt, or struggle to acquire at all. However, these differences in ability to innovate and imitate do more than set rich and poor countries apart – they also define the technology development and implementation processes in those areas. Pro-poor technology transfer projects, such as One Laptop Per Child, often fail to acknowledge the distinctions of the ICT environment in developing versus developed countries, and run the risk of attempting to replicate in poor areas a project that worked in a rich area (Osin, 1998). While students in the United States might quickly display the benefits of each having a laptop in a classroom, children in impoverished rural African communities might do better to begin their ICT educations by sharing a few simple devices that require less battery power and maintenance. As mentioned in the policy recommendations, knowing your customer goes a long way to sustaining success. Luckily for policymakers, investors, governments, entrepreneurs, and

private and public companies, the rise of "Big data" makes knowing your customer today more possible than ever before – especially in developing markets.

3.1.1 Big data

"Big data" refers to the incredible amount of information the world currently generates, much of which can be harvested through internet-capable devices. Every day, people worldwide use billions of mobile phones to transfer money, complete sales or purchases, check market prices or stock levels, vote, send test results, or even just communicate. These "mobile sensors of human behavior" – cell phones – generate data with each action (Lohr, 2013). Analysis of that data can help business owners identify and reach their customers, but it can also be used for international development by paving the way for early warnings, real-time awareness, and real-time feedback. With algorithms that run through and distill huge quantities of data, tracking health trends may allow disease centers to stock up sufficiently on necessary drugs a week before an epidemic hits an area; analysis of social media topics in Twitter or Facebook allows for an understanding of the political tension in an area, as during the Arab Spring in 2011; following movements in online news outlets can illuminate emerging concerns weeks before they might otherwise be obvious (Global Pulse, 2013).

Big data for development aims to use the new abilities and insights of data analysis to help poor countries navigate their problems and spur growth. For-profit organizations in developed countries have already begun using big data, and many non-profit organizations do already exist to harness big data for humanitarian needs. DataKind, Ushahidi, Crisis Mappers and InSTEDD all use big data for crisis response to natural disasters and other emergencies, such as for relief and coordination after

earthquakes and tsunamis. Recently, big data for development has found a more broadly-based partner in Global Pulse, a United Nations project that focuses on using big data to enhance typical development projects year-round (Lohr, 2013). In Figure 6, Global Pulse demonstrates that big data can aid developing countries improve financial systems, education, health, and agriculture (Global Pulse, 2013).

Global Pulse's goal is to use real-time monitoring to sniff out "digital smoke signals of distress," which give off early warning signs of potential spikes that could have significant effects on developing countries (Lohr, 2013). In addition, Global Pulse believes that the addition of big data to current development projects can help increase adaptability and speed, leading to faster and better results (Lohr,

Financial Services

Data gleaned from mobile money services can provide deep insight into spending and saving habits across sectors and regions. Digital payment histories can allow individuals to build credit histories, making them candidates for loans and other credit-based financial services.

Education

Data derived from the use of mobile value-added services can be used to improve public-sector understanding of educational needs and knowledge gaps, allowing more targeted and timely initiatives to disseminate critical information.

Health

Data collected through mobile devices, whether captured by health workers, submitted by individuals, or analysed in the form of data exhaust, can be a crucial tool in understanding population health trends or stopping outbreaks (see box on page 5). When collected in the context of individual electronic health records, this data not only improves continuity of care for the individual, but it can be used to create massive datasets with which treatments and outcomes can be compared in an efficient and cost effective manner.

Agriculture

Mobile payments for agricultural products, input purchases and subsidies may help governments better predict food production trends and incentives. This knowledge can be used to ensure the availability of proper crop storage, reduce waste and spoilage, and provide better information about what types of financial services are needed by farmers. Mobile use patterns may also help governments and development organisations identify regions in distress so that targeted assistance can be directed to them. Early detection can help prevent families from leaving their land and further decreasing agricultural production.

Figure 7: Big Data for Development. Global Pulse, 2013, p. 2.

2013). The World Economic Forum (2012) posits that “In a time of constrained government resources and reduced foreign aid, the insight produced by mining mobile data offers the possibility of preventing crises and targeting services to the populations that need them most” (World Economic Forum, 2012, p. 5). If Global Pulse and similar organizations can accomplish their goals, big data may be the next big break for countries trying to bridge the digital divide.

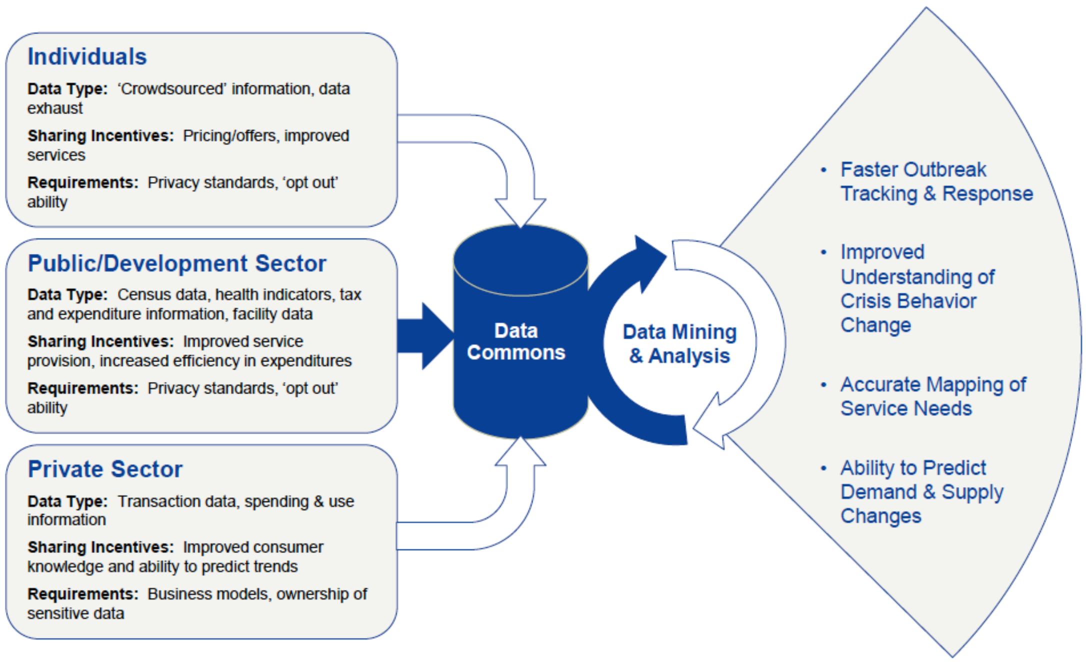

Figure 8. Big Data: How it Works. Global Pulse, 2013, p. 4.

3.1.2 The Cloud

Cloud computing provides additional internet-based opportunities for development. Sugata Mitra, the champion of the Hole-in-the-Wall internet kiosks for children’s educations, is using his 2013 TED Prize to build what he calls a “School in the Cloud” (Mitra, 2013). Mitra (2013) envisions a future in which children can use basic devices with internet connections to access the best educational opportunities available, no matter where they live or how few teachers exist in their areas. In the developed world, the banking, entertainment, and health sectors are already taking steps to exploit

the power of cloud computing and enhance output; Mitra believes that applying those methods to his minimally-invasive, self-guided education model will provide children worldwide with access to learning and knowledge sharing (Mitra, 2013). Using the cloud requires nothing more than internet access, and as such is a new technology that requires no additional infrastructure or training. Like WiFi and mobile phones, cloud computing may provide developing countries with an accessible platform to further connect and level the playing field.

3.1.3 BYOD

Mobility has led not only to the growth of mobile devices, but also to an expansion of mobile data plans. More mobile devices mean more connections, which ends in increased spending on ICT within an area. Increased mobility has recently helped spark the “Bring Your Own Device” (BYOD) movement, in which employees – with or without the approval of employers – bring their own mobile phones, computers, and tablets to work, using them rather than fixed devices or mobile ones supplied by a company (Lovelock, 2013). BYOD is popular for sensible reasons: people grow comfortable with their own devices, which they have already configured with their preferences, and having to carry both personal and work devices can be cumbersome and difficult to keep track of (Lohrmann, 2013). Consumers love using Apple’s iCloud on their iPhones because their contacts, emails, calendars, photos, entertainment, news, and maps are seamlessly integrated in one small mobile device – and can be accessed on any other iCloud enabled device. In a BYOD work environment, a smartphone can actually fulfill its design promise to handle all aspects of its owner’s life.

Though this may seem like a phenomenon biased toward developed countries,

where more people are able to afford mobile devices, BYOD is actually most common in emerging economies. In high-growth markets like Brazil, Russia, China, South Africa,

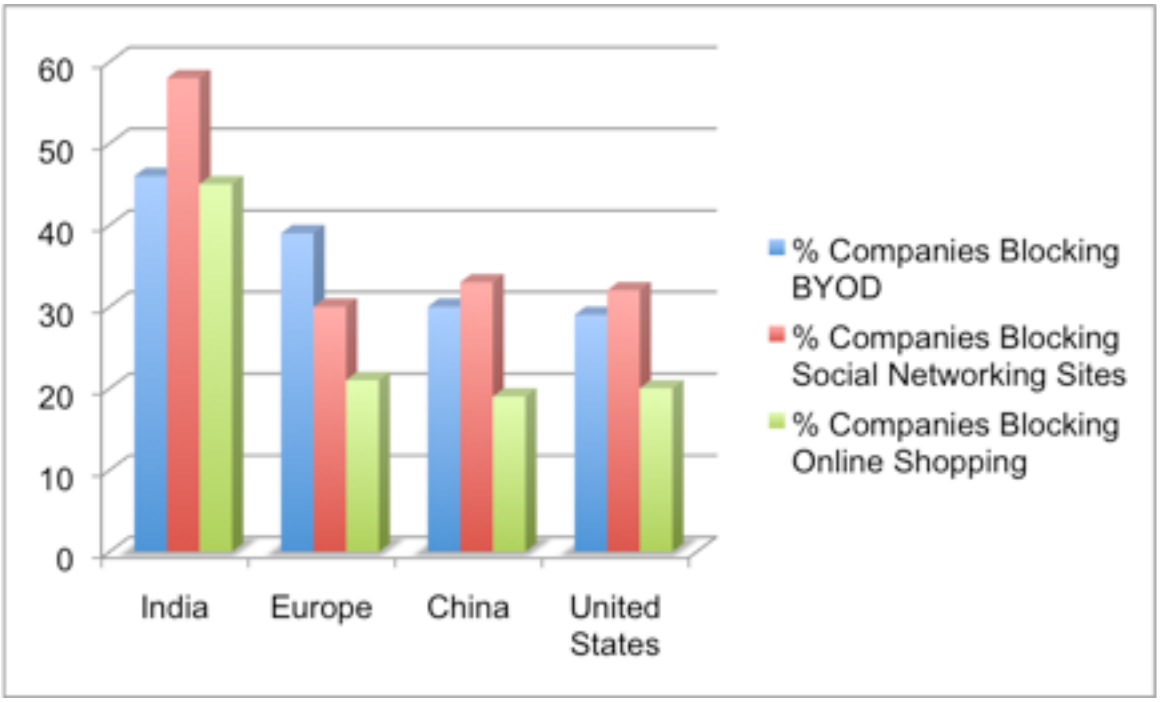

Figure 9: Features commonly blocked by companies. Ashford, 2013.

UAE, and Malaysia, nearly 75% of users engaged in BYOD; developed markets come in at only around 44%; employers in those countries are also much more likely to allow BYOD practices (Drury & Absalom, 2013; Lohrmann, 2013). Interestingly, India holds out against BYOD; almost half of India's companies prohibit the policy for security reasons. In Europe, 39% of companies block BYOD, in China, 30% do, and in the US, 29% share similar restrictions. As seen in Figure 8, India topped the charts for prohibiting access to social networking sites and online shopping on company devices (Ashford, 2013).

As compared with developed countries, emerging markets consist of many young "Generation Y" employees who are more likely to feel attached to their mobile devices (Ozores, 2012). Young professionals in fast-growth countries may face obstacles that drive them to work extremely hard, engaging in "live to work" attitudes and making sure

they are constantly reachable by their employees with whatever device will help them complete their projects (Drury & Absalom, 2013, p. 1). This contrasts with the outlook of developed markets, which more often draw hard lines between personal and work behavior; in France, for example, fewer than 31% of the workforce reports joining the BYOD movement. Additionally, companies in emerging markets are simply less prone to providing employees with devices, sometimes because they cannot afford to, which may account for the lax environment surrounding BYOD policies (Drury & Absalom, 2013). For more information on BYOD preferences, please see the Appendix (Section 6.4).

In fact, especially with the increasing penetration of smartphones, BYOD security should be considered by companies before BYOD is fully adopted as an acceptable practice (Ozores, 2012; Drury & Absalom, 2013; Lohrmann, 2013). Lohrmann (2013) calls BYOD "the new WiFi," noting that security and privacy are easily compromised when a company allows personal devices without antivirus or encryption software access to firm files and protected data (Lohrmann, 2013). As in policy recommendations that encourage governments to promote legislation and regulations to aid in ICT development, leaders of organizations in developing countries should ensure that they strike a balance between openness toward BYOD and safety measures to keep it a viable option.

4 Conclusion: Implications and Future Work

Every day new technologies crop up that enhance development opportunities in poor countries. Big data, the cloud, and the BYOD movement are only a few of the most promising. Policymakers, governments, and organizations that use the current measurement tools to understand their customers and then invest in local solutions sustainable for targeted areas will facilitate developing countries on their paths to leapfrog traditional infrastructure and bridge the digital divide. However, investors should not rely on ICT capability indices to define whether a country or area is "ready" for investments and development.

Indices calculating e-readiness, ICT readiness, ICT capability, networked readiness, and similar concepts should be understood as tools that provide information on a country's current measurable indicators for ICT development. When indices become important for their ranking systems alone, or when they are utilized as test scores to determine whether a country "passes" a certain readiness count for a project, every party involved loses. Because readiness indices comprise different definitions applicable to a variety of contexts and purposes, authored by multiple scholars with the use of data from assorted sources, one number for a country from a readiness index cannot possibly divulge sufficient information for proper decision-making on whether and how to invest (Dada, 2006).

Furthermore, as Sugata Mitra (2005) demonstrated through his novel teaching practices, "Learning is the new skill. Imagination, creation and asking new questions are at its core" (Kluge, 2013, p. 1). Mitra showed time and again that basic access to ICT is adequate for children and adults in compromised circumstances and impoverished

conditions to learn (Mitra, 2013). Consider Mitra's work alongside projects like that of Mahabir Pun (2012), who made it clear that WiFi can be provided in even the most remote poor villages that lack existing electric or telecommunications infrastructure as measured in readiness indices. In today's world, believing that ICT development projects can only occur in countries that already score as "capable" or "ready" is erroneous (Dada, 2006).

In fact, the question is not whether a country is ICT ready; the question is what kind of ICT devices and developments a community prefers. This paper does not aim to do away with or change readiness indices. The current indices, particularly the Networked Readiness Index (NRI), provides extensive, country-level information for much of the world, and if used correctly can greatly aid a policymaker with investment decisions. However, the NRI should be used as a reference tool rather than a "cutoff" ranking system. ICT development should not consist of an organization promoting a low-cost mobile learning device and deciding based on readiness rankings that Zambia will not benefit from the project, since its readiness is so much lower than that of South Africa. Rather, a developer should consider the opportunities the device might provide in each location and determine best ways to tailor it for a specific market. In South Africa, where the mobile market is already highly saturated, sleek designs and exciting learning applications might encourage dissemination and adoption; in Zambia, where electricity and telecommunications networks are scarcer, solar power, long battery lives, and pre-paid 3G or satellite plans would be more important in encouraging use.

This paper provides a starting point for further research on the best ways to continue successful, sustainable ICT development in impoverished communities. It

proscribes additional work on updating readiness indicators, increasing solutions for mobile designs and telecommunications plans, the effect of local answers on entrepreneurship and development, and education reform. As new technologies continue to offer opportunities for developing countries to leapfrog traditional infrastructure, policymakers, governments, organizations, and investors must also adapt. Future studies in those areas could lead to an end to the digital divide.

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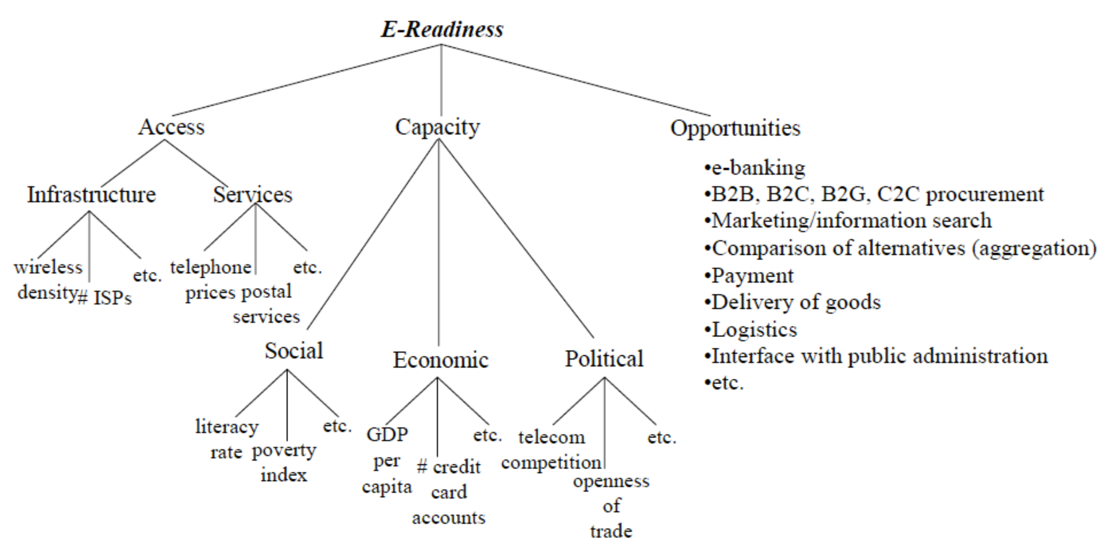
6 Appendix

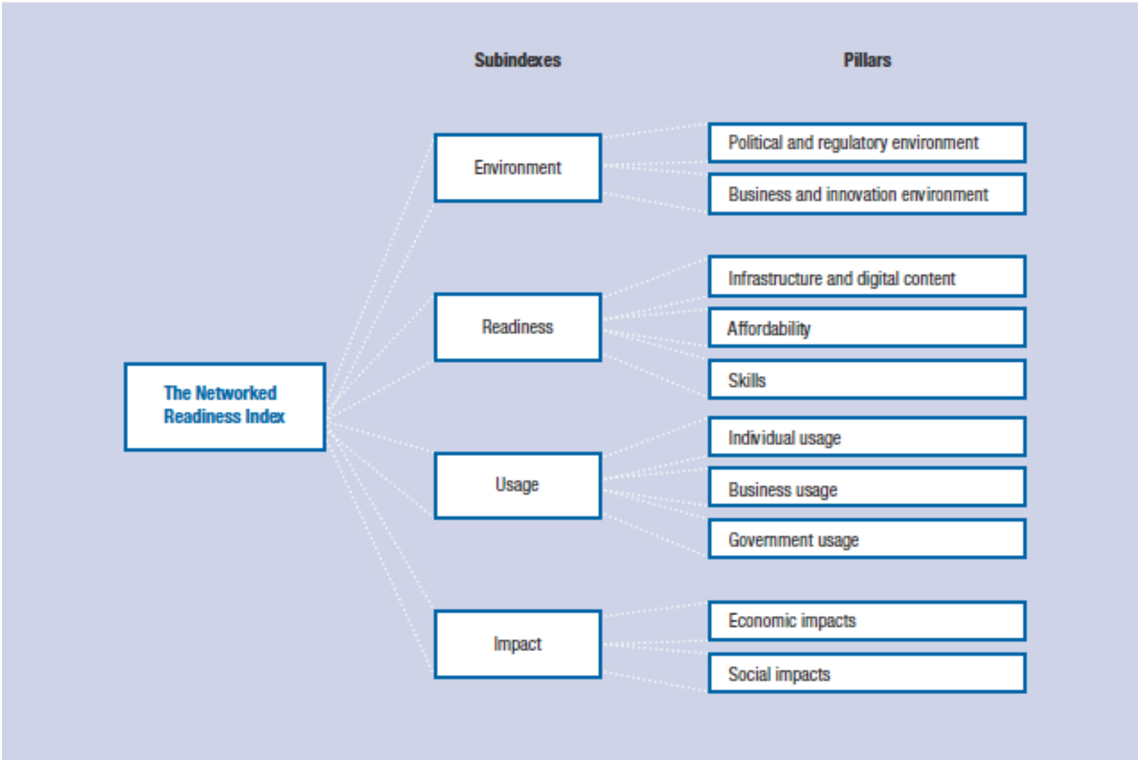
6.1 Index Structures and Rankings

Table 2
e-Readiness: Domains & Clusters

Domains	**Clusters**
1. Access	(a) infrastructure (b) services
2. Capacity	(a) social factors (b) economic factors (c) policy factors
3. Opportunities	(a) opportunity penetration (b) specific applications



Example of an index's structure. Maugis et al, 2005, p. 10.



Bilbao-Osorio, Dutta & Lanvin, 2013, p. 6.

Rank	Country/Economy	Score	2012 rank (out of 142)	Group*
1	Finland	5.98	3	ADV
2	Singapore	5.96	2	ADV
3	Sweden	5.91	1	ADV
4	Netherlands	5.81	6	ADV
5	Norway	5.66	7	ADV
6	Switzerland	5.66	5	ADV
7	United Kingdom	5.64	10	ADV
8	Denmark	5.58	4	ADV
9	United States	5.57	8	ADV
10	Taiwan, China	5.47	11	ADV
11	Korea, Rep.	5.46	12	ADV
12	Canada	5.44	9	ADV
13	Germany	5.43	16	ADV
14	Hong Kong SAR	5.40	13	ADV
15	Israel	5.39	20	ADV
16	Luxembourg	5.37	21	ADV
17	Iceland	5.31	15	ADV
18	Australia	5.26	17	ADV
19	Austria	5.25	19	ADV
20	New Zealand	5.25	14	ADV
21	Japan	5.24	18	ADV
22	Estonia	5.12	24	ADV
23	Qatar	5.10	28	MENA
24	Belgium	5.10	22	ADV
25	United Arab Emirates	5.07	30	MENA
26	France	5.06	23	ADV
27	Ireland	5.05	25	ADV
28	Malta	4.90	26	ADV
29	Bahrain	4.83	27	MENA
30	Malaysia	4.82	29	DEV ASIA
31	Saudi Arabia	4.82	34	MENA
32	Lithuania	4.72	31	CEE
33	Portugal	4.67	33	ADV
34	Chile	4.59	39	LATAM
35	Cyprus	4.59	32	ADV
36	Puerto Rico	4.55	36	ADV
37	Slovenia	4.53	37	ADV
38	Spain	4.51	38	ADV
39	Barbados	4.49	35	LATAM
40	Oman	4.48	40	MENA
41	Latvia	4.43	41	CEE
42	Czech Republic	4.38	42	ADV
43	Kazakhstan	4.32	55	CIS
44	Hungary	4.29	43	CEE
45	Turkey	4.22	52	CEE
46	Panama	4.22	57	LATAM
47	Jordan	4.20	47	MENA
48	Montenegro	4.20	46	CEE
49	Poland	4.19	49	CEE
50	Italy	4.18	48	ADV
51	Croatia	4.17	45	CEE
52	Uruguay	4.16	44	LATAM
53	Costa Rica	4.15	58	LATAM
54	Russian Federation	4.13	56	CIS
55	Mauritius	4.12	53	SSA
56	Azerbaijan	4.11	61	CIS
57	Brunei Darussalam	4.11	54	DEV ASIA
58	China	4.03	51	DEV ASIA
59	Mongolia	4.01	63	CIS
60	Brazil	3.97	65	LATAM
61	Slovak Republic	3.95	64	ADV
62	Kuwait	3.94	62	MENA
63	Mexico	3.93	76	LATAM
64	Greece	3.93	59	ADV
65	Georgia	3.93	88	CIS
66	Colombia	3.91	73	LATAM
67	Macedonia, FYR	3.89	66	CEE
68	India	3.88	69	DEV ASIA
69	Sri Lanka	3.88	71	DEV ASIA
70	South Africa	3.87	72	SSA
71	Bulgaria	3.87	70	CEE
72	Trinidad and Tobago	3.87	60	LATAM
73	Ukraine	3.87	75	CIS
74	Thailand	3.86	77	DEV ASIA
75	Romania	3.86	67	CEE
76	Indonesia	3.84	80	DEV ASIA
77	Moldova	3.84	78	CIS
78	Bosnia and Herzegovina	3.80	84	CEE
79	Seychelles	3.80	n/a	SSA
80	Egypt	3.78	79	MENA
81	Cape Verde	3.78	81	SSA
82	Armenia	3.76	94	CIS
83	Albania	3.75	68	CEE
84	Vietnam	3.74	83	DEV ASIA
85	Jamaica	3.74	74	LATAM
86	Philippines	3.73	86	DEV ASIA
87	Serbia	3.70	85	CEE
88	Rwanda	3.68	82	SSA
89	Morocco	3.64	91	MENA
90	Dominican Republic	3.62	87	LATAM
91	Ecuador	3.58	96	LATAM
92	Kenya	3.54	93	SSA
93	El Salvador	3.53	103	LATAM
94	Lebanon	3.53	95	MENA
95	Ghana	3.51	97	SSA
96	Botswana	3.50	89	SSA
97	Liberia	3.48	n/a	SSA
98	Gambia, The	3.47	101	SSA
99	Argentina	3.47	92	LATAM
100	Guyana	3.45	90	LATAM
101	Iran, Islamic Rep.	3.43	104	MENA
102	Guatemala	3.42	98	LATAM
103	Peru	3.39	106	LATAM
104	Paraguay	3.37	111	LATAM
105	Pakistan	3.35	102	DEV ASIA
106	Cambodia	3.34	108	DEV ASIA
107	Senegal	3.33	100	SSA
108	Venezuela	3.33	107	LATAM
109	Honduras	3.32	99	LATAM
110	Uganda	3.30	110	SSA
111	Namibia	3.29	105	SSA
112	Tajikistan	3.29	114	CIS
113	Nigeria	3.27	112	SSA
114	Bangladesh	3.22	113	DEV ASIA
115	Zambia	3.19	109	SSA
116	Zimbabwe	3.17	124	SSA
117	Suriname	3.13	121	LATAM
118	Kyrgyz Republic	3.09	115	CIS
119	Bolivia	3.01	127	LATAM
120	Côte d'Ivoire	3.00	122	SSA
121	Gabon	2.97	n/a	SSA
122	Mali	2.97	126	SSA
123	Benin	2.97	117	SSA
124	Cameroon	2.95	125	SSA
125	Nicaragua	2.93	131	LATAM
126	Nepal	2.93	128	DEV ASIA
127	Tanzania	2.92	123	SSA
128	Ethiopia	2.85	130	SSA
129	Malawi	2.83	116	SSA
130	Burkina Faso	2.80	135	SSA
131	Algeria	2.78	118	MENA
132	Libya	2.77	n/a	MENA
133	Mozambique	2.76	120	SSA
134	Timor-Leste	2.72	132	DEV ASIA
135	Mauritania	2.71	139	MENA
136	Swaziland	2.69	136	SSA
137	Madagascar	2.69	134	SSA
138	Lesotho	2.68	133	SSA
139	Yemen	2.63	141	MENA
140	Guinea	2.61	n/a	SSA
141	Haiti	2.58	142	LATAM
142	Chad	2.53	138	SSA
143	Sierra Leone	2.53	n/a	SSA
144	Burundi	2.30	137	SSA

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 11.

ENVIRONMENT SUBINDEX			Political and regulatory environment		Business and innovation environment	
Rank	Country/Economy	Score	Rank	Score	Rank	Score
1	Singapore	5.89	1	5.97	1	5.80
2	New Zealand	5.65	2	5.92	6	5.38
3	Finland	5.59	3	5.84	7	5.34
4	Netherlands	5.53	6	5.67	5	5.40
5	Sweden	5.48	5	5.67	11	5.30
6	United Kingdom	5.48	7	5.62	8	5.33
7	Switzerland	5.46	8	5.60	9	5.32
8	Hong Kong SAR	5.44	15	5.27	2	5.61
9	Norway	5.42	9	5.52	10	5.31
10	Canada	5.42	12	5.36	3	5.47
11	Australia	5.29	10	5.39	21	5.19
12	Denmark	5.27	14	5.30	19	5.23
13	Luxembourg	5.25	4	5.77	34	4.73
14	Qatar	5.19	18	5.10	12	5.29
15	Ireland	5.17	16	5.24	24	5.10
16	United States	5.11	22	4.94	13	5.29
17	Belgium	5.09	23	4.94	18	5.23
18	Malaysia	5.07	24	4.88	16	5.25
19	United Arab Emirates	5.05	26	4.84	17	5.25
20	Germany	5.05	11	5.38	36	4.71
21	Iceland	5.02	25	4.88	22	5.15
22	Austria	4.99	17	5.21	31	4.78
23	Israel	4.97	28	4.69	15	5.26
24	Taiwan, China	4.97	33	4.51	4	5.44
25	Saudi Arabia	4.87	29	4.68	25	5.07
26	Japan	4.86	19	5.04	37	4.68
27	France	4.84	20	5.02	39	4.66
28	Bahrain	4.83	40	4.39	14	5.27
29	Rwanda	4.81	13	5.30	59	4.32
30	Chile	4.80	38	4.40	20	5.20
31	Estonia	4.71	27	4.84	45	4.59
32	Korea, Rep.	4.70	42	4.25	23	5.14
33	South Africa	4.69	21	5.00	55	4.38
34	Cyprus	4.67	41	4.35	26	4.99
35	Puerto Rico	4.65	35	4.46	30	4.83
36	Barbados	4.63	32	4.59	38	4.67
37	Oman	4.61	34	4.47	33	4.75
38	Portugal	4.57	43	4.24	27	4.91
39	Malta	4.53	31	4.59	50	4.47
40	Spain	4.49	44	4.14	29	4.85
41	Mauritius	4.48	36	4.42	46	4.53
42	Jordan	4.35	48	4.05	40	4.65
43	Latvia	4.33	52	4.02	42	4.65
44	Slovenia	4.33	61	3.81	28	4.85
45	Lithuania	4.31	51	4.02	44	4.60
46	Turkey	4.31	54	3.97	43	4.64
47	Hungary	4.23	49	4.04	51	4.42
48	Panama	4.22	69	3.69	32	4.76
49	Czech Republic	4.21	46	4.06	56	4.36
50	Uruguay	4.20	58	3.91	47	4.50
51	Liberia	4.17	53	4.01	58	4.34
52	Montenegro	4.16	72	3.67	41	4.65
53	Seychelles	4.14	50	4.03	63	4.25
54	Gambia, The	4.13	30	4.68	116	3.58
55	Poland	4.10	62	3.80	53	4.41
56	Botswana	4.10	39	4.40	103	3.80
57	Brunei Darussalam	4.09	45	4.11	77	4.07
58	Namibia	4.04	37	4.41	112	3.67
59	Macedonia, FYR	4.04	80	3.59	49	4.48
60	Thailand	4.00	81	3.59	52	4.42
61	Zambia	3.99	64	3.77	65	4.22
62	Slovak Republic	3.99	70	3.68	61	4.30
63	Sri Lanka	3.95	68	3.70	67	4.21
64	Ghana	3.95	57	3.92	84	3.99
65	Cape Verde	3.94	55	3.97	92	3.91
66	Kazakhstan	3.93	77	3.63	64	4.23
67	Jamaica	3.93	59	3.87	82	4.00
68	Bulgaria	3.91	101	3.31	48	4.50
69	Kuwait	3.90	71	3.67	71	4.13
70	Croatia	3.90	90	3.48	60	4.32
71	China	3.88	56	3.97	105	3.78
72	Iran, Islamic Rep.	3.86	67	3.70	80	4.03
73	Georgia	3.86	100	3.34	54	4.39
74	Morocco	3.85	73	3.66	79	4.04
75	Mexico	3.85	79	3.60	74	4.09
76	Mongolia	3.84	93	3.41	62	4.28
77	Azerbaijan	3.84	66	3.72	86	3.96
78	Indonesia	3.83	82	3.57	73	4.10
79	Cambodia	3.83	65	3.75	91	3.92
80	Tajikistan	3.80	47	4.06	121	3.54
81	Guyana	3.79	84	3.55	81	4.02
82	Costa Rica	3.78	74	3.66	94	3.90
83	Italy	3.77	95	3.39	69	4.16
84	Albania	3.76	102	3.31	66	4.22
85	India	3.75	75	3.65	99	3.85
86	Lebanon	3.74	133	2.76	35	4.73
87	Greece	3.73	103	3.29	68	4.16
88	Uganda	3.71	60	3.83	115	3.59
89	Romania	3.70	106	3.25	70	4.14
90	Armenia	3.70	104	3.27	72	4.12
91	Peru	3.69	121	3.04	57	4.34
92	Bosnia and Herzegovina	3.68	97	3.36	83	3.99
93	Trinidad and Tobago	3.66	91	3.42	93	3.90
94	Nigeria	3.66	89	3.48	101	3.83
95	Dominican Republic	3.65	109	3.22	75	4.08
96	Colombia	3.64	92	3.41	95	3.87
97	Vietnam	3.63	85	3.51	108	3.75
98	Kenya	3.63	87	3.49	106	3.76
99	Egypt	3.62	96	3.39	98	3.85
100	Philippines	3.60	98	3.36	100	3.84
101	Senegal	3.60	114	3.11	76	4.08
102	Russian Federation	3.58	108	3.24	90	3.92
103	Malawi	3.56	63	3.80	131	3.36
104	Ethiopia	3.55	83	3.56	119	3.55
105	Ukraine	3.54	124	3.01	78	4.07
106	Serbia	3.54	115	3.10	85	3.98
107	Brazil	3.53	78	3.63	126	3.42
108	Tanzania	3.52	76	3.65	128	3.38
109	Moldova	3.52	117	3.09	88	3.94
110	Burkina Faso	3.49	88	3.49	122	3.49
111	Mali	3.47	99	3.35	114	3.59
112	Honduras	3.47	111	3.21	109	3.72
113	Ecuador	3.46	118	3.07	96	3.86
114	Sierra Leone	3.44	86	3.50	127	3.39
115	Benin	3.44	94	3.41	123	3.47
116	Pakistan	3.42	123	3.03	102	3.81
117	El Salvador	3.41	129	2.86	87	3.95
118	Guatemala	3.39	127	2.92	97	3.85
119	Cameroon	3.36	126	2.97	107	3.75
120	Mozambique	3.36	105	3.26	124	3.45
121	Lesotho	3.32	116	3.09	118	3.55
122	Nepal	3.31	119	3.05	117	3.57
123	Gabon	3.31	107	3.25	129	3.37
124	Paraguay	3.29	138	2.65	89	3.93
125	Madagascar	3.26	134	2.73	104	3.79
126	Argentina	3.25	131	2.82	110	3.68
127	Côte d'Ivoire	3.23	128	2.87	113	3.60
128	Bangladesh	3.19	137	2.71	111	3.68
129	Bolivia	3.19	110	3.22	137	3.17
130	Libya	3.18	130	2.83	120	3.54
131	Timor-Leste	3.18	125	3.00	130	3.36
132	Zimbabwe	3.13	120	3.05	135	3.22
133	Swaziland	3.12	112	3.21	138	3.03
134	Nicaragua	3.11	122	3.03	136	3.18
135	Suriname	3.08	135	2.73	125	3.43
136	Mauritania	3.07	113	3.18	140	2.95
137	Kyrgyz Republic	3.02	136	2.72	132	3.32
138	Yemen	2.91	140	2.51	133	3.30
139	Guinea	2.84	132	2.77	141	2.91
140	Venezuela	2.83	142	2.43	134	3.22
141	Haiti	2.65	143	2.40	142	2.89
142	Burundi	2.63	144	2.30	139	2.96
143	Algeria	2.60	141	2.46	143	2.74
144	Chad	2.59	139	2.59	144	2.58

Environment Subindex (Bilbao-Osorio, Dutta & Lanvin, 2013, p. 12).

READINESS SUBINDEX			Infrastructure and digital content		Affordability		Skills	
Rank	Country/Economy	Score	Rank	Score	Rank	Score	Rank	Score
1	Finland	6.51	2	6.87	19	6.22	1	6.45
2	Iceland	6.43	1	6.87	5	6.55	9	5.87
3	Sweden	6.38	4	6.83	7	6.48	10	5.84
4	United States	6.25	7	6.80	15	6.31	20	5.62
5	Canada	6.17	5	6.81	43	5.89	6	6.02
6	Norway	6.15	3	6.84	23	6.09	27	5.52
7	Denmark	6.04	14	6.40	22	6.09	18	5.63
8	Switzerland	6.02	8	6.71	68	5.25	4	6.10
9	Austria	6.01	9	6.60	37	5.89	24	5.55
10	United Kingdom	5.99	13	6.42	35	5.90	15	5.66
11	Singapore	5.96	19	6.20	55	5.50	2	6.18
12	Cyprus	5.92	21	6.08	28	6.02	16	5.66
13	Netherlands	5.92	11	6.48	60	5.39	8	5.89
14	Germany	5.88	10	6.50	53	5.52	19	5.62
15	Belgium	5.84	18	6.20	70	5.20	3	6.11
16	Ireland	5.80	16	6.24	61	5.38	12	5.78
17	Taiwan, China	5.80	22	5.99	54	5.50	7	5.91
18	Luxembourg	5.79	12	6.43	48	5.61	33	5.33
19	Hong Kong SAR	5.70	27	5.78	17	6.28	52	5.05
20	Lithuania	5.67	33	5.23	14	6.32	29	5.46
21	Malta	5.65	15	6.26	72	5.15	28	5.53
22	Israel	5.59	29	5.73	44	5.66	32	5.37
23	Korea, Rep.	5.56	20	6.13	83	4.88	14	5.67
24	Estonia	5.55	26	5.79	56	5.44	30	5.43
25	Australia	5.51	6	6.81	97	4.07	17	5.64
26	France	5.40	28	5.76	86	4.84	21	5.59
27	Latvia	5.38	41	4.83	16	6.30	54	5.01
28	Japan	5.36	24	5.84	92	4.50	13	5.73
29	Ukraine	5.34	74	3.85	2	6.88	35	5.30
30	New Zealand	5.33	17	6.22	100	3.96	11	5.81
31	Slovenia	5.33	25	5.82	85	4.86	36	5.30
32	Russian Federation	5.29	43	4.72	18	6.23	61	4.91
33	Costa Rica	5.28	76	3.77	6	6.52	23	5.56
34	Portugal	5.27	34	5.23	57	5.44	49	5.14
35	Bahrain	5.27	39	4.97	46	5.64	44	5.20
36	Turkey	5.27	48	4.56	4	6.59	81	4.65
37	Poland	5.26	38	5.00	47	5.63	47	5.15
38	Italy	5.25	40	4.94	49	5.61	45	5.16
39	Saudi Arabia	5.23	36	5.07	65	5.35	37	5.29
40	United Arab Emirates	5.23	30	5.46	89	4.70	25	5.54
41	Croatia	5.14	57	4.29	26	6.03	51	5.09
42	Mongolia	5.13	60	4.18	10	6.43	72	4.78
43	Bosnia and Herzegovina	5.08	64	4.13	31	5.99	49	5.11
44	Qatar	5.06	35	5.22	103	3.92	5	6.04
45	Trinidad and Tobago	5.02	53	4.41	58	5.40	39	5.25
46	Moldova	5.02	55	4.31	25	6.06	78	4.69
47	Greece	5.00	46	4.62	73	5.13	41	5.25
48	Georgia	4.99	68	4.03	11	6.39	83	4.56
49	Chile	4.99	61	4.18	33	5.94	66	4.85
50	Kazakhstan	4.98	63	4.14	36	5.90	62	4.91
51	Azerbaijan	4.98	75	3.82	20	6.16	57	4.96
52	Romania	4.98	47	4.62	62	5.36	58	4.95
53	Czech Republic	4.97	23	5.85	99	3.97	50	5.10
54	Mauritius	4.97	77	3.73	12	6.36	67	4.82
55	Jordan	4.97	81	3.55	27	6.03	34	5.33
56	Oman	4.92	66	4.05	34	5.90	68	4.81
57	Malaysia	4.87	73	3.85	50	5.58	43	5.20
58	Kuwait	4.87	45	4.64	71	5.18	71	4.79
59	Hungary	4.87	58	4.25	74	5.10	42	5.24
60	Panama	4.86	51	4.42	32	5.99	99	4.17
61	Spain	4.85	31	5.43	102	3.93	46	5.18
62	Montenegro	4.82	42	4.70	93	4.42	40	5.25
63	Thailand	4.78	71	3.95	45	5.64	76	4.75
64	Sri Lanka	4.78	101	3.05	29	6.02	38	5.26
65	Barbados	4.76	32	5.25	111	3.49	22	5.56
66	China	4.76	83	3.46	40	5.82	53	5.01
67	Serbia	4.71	54	4.39	84	4.87	65	4.86
68	India	4.70	111	2.80	1	7.00	95	4.31
69	Puerto Rico	4.70	52	4.42	n/a	n/a	55	4.97
70	Uruguay	4.66	49	4.50	80	4.94	85	4.53
71	Indonesia	4.66	89	3.28	39	5.82	63	4.88
72	Albania	4.62	79	3.60	66	5.29	56	4.96
73	Armenia	4.60	72	3.88	77	4.97	59	4.94
74	Brazil	4.53	62	4.16	76	5.01	91	4.42
75	Bulgaria	4.53	37	5.03	106	3.76	70	4.79
76	Mexico	4.47	82	3.53	63	5.36	87	4.51
77	Jamaica	4.46	65	4.10	87	4.81	88	4.48
78	Paraguay	4.44	67	4.04	52	5.53	107	3.74
79	Vietnam	4.43	114	2.76	38	5.86	79	4.68
80	Colombia	4.41	96	3.18	67	5.29	74	4.77
81	Venezuela	4.41	85	3.42	51	5.55	96	4.26
82	Egypt	4.41	93	3.19	8	6.47	115	3.56
83	Cape Verde	4.40	103	3.04	42	5.72	90	4.43
84	Macedonia, FYR	4.36	69	3.99	94	4.40	77	4.70
85	Philippines	4.36	84	3.42	82	4.89	73	4.77
86	Lebanon	4.29	88	3.27	95	4.12	26	5.49
87	Zimbabwe	4.28	129	2.16	9	6.47	98	4.18
88	Morocco	4.28	95	3.18	30	6.02	114	3.63
89	Ecuador	4.26	78	3.71	91	4.54	84	4.54
90	El Salvador	4.16	92	3.20	41	5.72	117	3.55
91	Bangladesh	4.14	109	2.84	13	6.34	128	3.24
92	Slovak Republic	4.12	56	4.29	113	3.32	75	4.75
93	Pakistan	4.11	104	3.00	21	6.15	129	3.19
94	Brunei Darussalam	4.06	50	4.47	135	2.33	31	5.38
95	South Africa	4.04	59	4.21	104	3.91	102	4.01
96	Algeria	4.00	119	2.62	64	5.35	101	4.02
97	Argentina	3.98	70	3.99	114	3.29	80	4.66
98	Dominican Republic	3.94	98	3.08	79	4.94	105	3.79
99	Liberia	3.93	142	1.57	3	6.78	122	3.42
100	Suriname	3.92	118	2.66	90	4.64	89	4.46
101	Ghana	3.89	121	2.51	59	5.40	106	3.77
102	Honduras	3.86	107	2.88	78	4.96	108	3.72
103	Kyrgyz Republic	3.78	90	3.26	107	3.67	92	4.40
104	Uganda	3.76	106	2.89	75	5.07	125	3.33
105	Guyana	3.75	94	3.19	110	3.50	82	4.56
106	Seychelles	3.73	44	4.67	139	1.61	60	4.92
107	Botswana	3.72	100	3.06	109	3.57	86	4.52
108	Guatemala	3.72	116	2.69	81	4.92	118	3.53
109	Iran, Islamic Rep.	3.69	97	3.15	115	3.13	69	4.79
110	Kenya	3.68	110	2.84	105	3.81	93	4.39
111	Cambodia	3.49	87	3.31	112	3.47	109	3.68
112	Nepal	3.33	140	1.62	69	5.20	131	3.17
113	Haiti	3.33	144	1.53	24	6.09	143	2.37
114	Gabon	3.33	125	2.32	96	4.11	116	3.55
115	Namibia	3.27	102	3.04	117	3.09	111	3.67
116	Rwanda	3.25	105	2.98	116	3.12	113	3.64
117	Yemen	3.24	123	2.43	88	4.75	138	2.54
118	Tajikistan	3.22	126	2.30	131	2.49	64	4.86
119	Peru	3.08	86	3.31	138	1.66	100	4.07
120	Senegal	3.07	108	2.86	118	3.07	126	3.30
121	Nicaragua	3.07	91	3.25	136	2.31	112	3.64
122	Côte d'Ivoire	3.07	99	3.07	119	2.96	130	3.17
123	Nigeria	3.02	115	2.70	120	2.96	123	3.40
124	Bolivia	3.01	138	1.74	122	2.89	94	4.39
125	Gambia, The	3.00	117	2.68	124	2.81	120	3.50
126	Libya	2.91	80	3.56	141	1.00	97	4.18
127	Chad	2.90	127	2.22	98	4.06	141	2.43
128	Benin	2.85	113	2.79	133	2.39	124	3.39
129	Zambia	2.85	133	2.02	127	2.69	104	3.84
130	Swaziland	2.84	112	2.80	137	2.03	110	3.68
131	Cameroon	2.80	137	1.75	125	2.79	103	3.87
132	Guinea	2.80	132	2.10	108	3.58	135	2.73
133	Mauritania	2.80	134	1.95	101	3.94	139	2.50
134	Timor-Leste	2.71	122	2.48	123	2.82	133	2.82
135	Tanzania	2.70	124	2.36	130	2.58	132	3.16
136	Lesotho	2.68	130	2.16	134	2.35	119	3.53
137	Madagascar	2.57	143	1.56	121	2.90	127	3.26
138	Burundi	2.50	128	2.20	n/a	n/a	134	2.79
139	Malawi	2.41	120	2.58	140	1.17	121	3.47
140	Ethiopia	2.34	141	1.62	126	2.78	137	2.61
141	Mali	2.32	139	1.65	128	2.67	136	2.63
142	Burkina Faso	2.27	136	1.79	129	2.59	142	2.43
143	Mozambique	2.22	135	1.81	132	2.42	140	2.44
144	Sierra Leone	1.74	131	2.11	141	1.00	144	2.10

Readiness Subindex (Bilbao-Osorio, Dutta & Lanvin, 2013, p. 13).

USAGE SUBINDEX			Individual usage		Business usage		Government usage	
Rank	Country/Economy	Score	Rank	Score	Rank	Score	Rank	Score
1	Sweden	6.00	3	6.53	4	5.89	8	5.56
2	Finland	5.97	6	6.40	3	5.97	10	5.55
3	Singapore	5.86	11	6.13	14	5.18	1	6.29
4	Korea, Rep.	5.86	7	6.39	11	5.31	3	5.89
5	Netherlands	5.78	5	6.42	8	5.53	15	5.39
6	Denmark	5.75	1	6.65	7	5.56	24	5.05
7	Norway	5.75	2	6.62	12	5.23	14	5.39
8	Switzerland	5.70	10	6.15	1	6.11	31	4.86
9	Japan	5.62	13	5.89	2	6.01	27	4.98
10	Luxembourg	5.62	4	6.47	16	4.97	13	5.41
11	United Kingdom	5.59	9	6.17	15	5.05	9	5.55
12	Germany	5.57	14	5.88	5	5.81	26	5.01
13	United States	5.51	18	5.66	10	5.37	11	5.49
14	Israel	5.45	28	5.43	6	5.67	20	5.23
15	Taiwan, China	5.45	20	5.66	13	5.19	12	5.49
16	Qatar	5.35	16	5.82	27	4.47	5	5.75
17	Austria	5.23	19	5.66	9	5.39	35	4.65
18	Australia	5.22	15	5.88	25	4.54	19	5.25
19	New Zealand	5.20	17	5.78	23	4.54	18	5.29
20	Hong Kong SAR	5.18	12	5.91	19	4.77	30	4.87
21	Iceland	5.15	8	6.35	20	4.77	50	4.32
22	France	5.13	24	5.52	18	4.86	25	5.02
23	United Arab Emirates	5.07	36	4.90	28	4.31	2	5.99
24	Canada	5.04	27	5.44	24	4.54	22	5.14
25	Estonia	5.01	23	5.53	29	4.13	17	5.36
26	Belgium	4.97	25	5.48	17	4.94	41	4.48
27	Malta	4.92	22	5.59	38	3.81	16	5.37
28	Ireland	4.87	21	5.59	22	4.58	43	4.44
29	Malaysia	4.83	46	4.44	26	4.49	7	5.57
30	Bahrain	4.83	30	5.15	56	3.59	4	5.78
31	Saudi Arabia	4.74	47	4.39	30	4.10	6	5.73
32	Portugal	4.50	41	4.71	36	3.86	28	4.93
33	Spain	4.46	31	5.12	41	3.80	42	4.46
34	Barbados	4.44	26	5.48	43	3.72	64	4.13
35	Slovenia	4.43	32	5.06	32	3.94	52	4.30
36	Lithuania	4.41	37	4.86	42	3.75	36	4.60
37	Oman	4.38	50	4.31	52	3.62	21	5.14
38	Czech Republic	4.35	29	5.16	31	4.06	93	3.79
39	Puerto Rico	4.31	59	3.94	21	4.59	46	4.40
40	Chile	4.24	53	4.12	44	3.71	29	4.90
41	Brunei Darussalam	4.21	49	4.32	59	3.56	33	4.75
42	Kazakhstan	4.18	54	4.06	85	3.34	23	5.13
43	Latvia	4.16	38	4.84	51	3.64	75	3.99
44	Brazil	4.08	58	3.97	34	3.90	48	4.38
45	Italy	4.08	34	4.93	46	3.68	108	3.62
46	Hungary	4.07	42	4.67	61	3.50	69	4.03
47	Croatia	4.06	39	4.83	81	3.36	73	3.99
48	Cyprus	4.05	44	4.52	60	3.51	65	4.13
49	Slovak Republic	4.04	35	4.92	65	3.47	100	3.71
50	Poland	4.01	33	5.00	74	3.41	107	3.62
51	Panama	4.00	65	3.59	39	3.81	37	4.60
52	Azerbaijan	3.99	64	3.68	58	3.57	34	4.71
53	Montenegro	3.95	56	4.01	71	3.43	47	4.39
54	Uruguay	3.94	51	4.17	72	3.43	55	4.22
55	Kuwait	3.94	40	4.83	83	3.35	105	3.63
56	Russian Federation	3.91	45	4.51	95	3.24	74	3.99
57	Seychelles	3.85	62	3.76	64	3.48	51	4.31
58	China	3.80	83	2.96	35	3.86	38	4.58
59	Costa Rica	3.79	71	3.37	37	3.84	61	4.17
60	Jordan	3.79	66	3.55	55	3.59	56	4.22
61	Macedonia, FYR	3.78	52	4.13	123	2.94	54	4.27
62	Turkey	3.78	68	3.51	48	3.65	60	4.18
63	Bulgaria	3.75	48	4.32	101	3.18	98	3.74
64	Colombia	3.75	76	3.09	77	3.39	32	4.77
65	Mauritius	3.71	70	3.38	73	3.42	49	4.34
66	Mexico	3.68	82	2.98	62	3.50	39	4.55
67	Trinidad and Tobago	3.67	61	3.77	97	3.23	70	4.01
68	Greece	3.66	43	4.53	107	3.11	118	3.34
69	Romania	3.66	57	3.97	94	3.24	96	3.76
70	Indonesia	3.58	92	2.74	40	3.81	58	4.20
71	Morocco	3.55	67	3.54	99	3.20	81	3.92
72	South Africa	3.53	81	2.99	33	3.91	102	3.70
73	Vietnam	3.52	78	3.08	88	3.30	62	4.16
74	Argentina	3.51	60	3.92	90	3.28	117	3.35
75	Egypt	3.49	69	3.43	106	3.11	80	3.92
76	Philippines	3.46	95	2.69	47	3.65	67	4.04
77	Georgia	3.46	75	3.16	112	3.07	63	4.14
78	Serbia	3.45	55	4.01	135	2.70	104	3.64
79	Armenia	3.44	77	3.08	89	3.30	78	3.94
80	Mongolia	3.41	90	2.79	78	3.39	66	4.06
81	India	3.41	121	1.97	45	3.70	40	4.55
82	Moldova	3.39	72	3.36	129	2.86	76	3.97
83	Thailand	3.39	88	2.84	63	3.50	86	3.84
84	Kenya	3.38	115	2.08	53	3.62	44	4.43
85	Albania	3.37	84	2.93	79	3.38	95	3.79
86	Dominican Republic	3.36	93	2.73	82	3.36	72	3.99
87	Bosnia and Herzegovina	3.34	73	3.32	104	3.15	111	3.55
88	Ecuador	3.33	85	2.92	92	3.27	94	3.79
89	Jamaica	3.32	86	2.89	86	3.32	97	3.76
90	Sri Lanka	3.32	110	2.19	57	3.57	57	4.20
91	Peru	3.32	87	2.89	93	3.26	90	3.81
92	Gambia, The	3.32	118	2.03	50	3.64	53	4.28
93	Guatemala	3.28	96	2.67	49	3.65	114	3.51
94	El Salvador	3.27	91	2.79	100	3.20	88	3.83
95	Ukraine	3.27	74	3.17	84	3.35	121	3.28
96	Cape Verde	3.25	103	2.37	122	2.96	45	4.41
97	Guyana	3.24	106	2.25	54	3.60	85	3.87
98	Lebanon	3.21	63	3.70	116	3.02	134	2.90
99	Botswana	3.20	98	2.57	96	3.23	91	3.80
100	Senegal	3.16	113	2.09	66	3.47	82	3.91
101	Namibia	3.12	99	2.53	76	3.40	116	3.43
102	Ghana	3.12	102	2.40	103	3.15	89	3.81
103	Tajikistan	3.12	107	2.20	87	3.32	87	3.83
104	Cambodia	3.09	112	2.14	70	3.44	103	3.69
105	Venezuela	3.07	80	3.02	120	2.97	126	3.21
106	Iran, Islamic Rep.	3.06	108	2.20	119	2.99	71	4.00
107	Rwanda	3.05	139	1.50	67	3.46	59	4.20
108	Nigeria	3.04	111	2.16	68	3.45	113	3.52
109	Zambia	3.04	122	1.84	80	3.36	79	3.92
110	Paraguay	3.01	97	2.66	110	3.09	123	3.27
111	Honduras	3.01	101	2.45	75	3.40	127	3.17
112	Suriname	2.97	79	3.07	113	3.06	138	2.78
113	Bolivia	2.96	104	2.34	109	3.09	115	3.45
114	Liberia	2.93	126	1.74	69	3.45	109	3.59
115	Mali	2.93	125	1.76	114	3.06	77	3.96
116	Côte d'Ivoire	2.92	117	2.07	105	3.14	112	3.54
117	Uganda	2.89	131	1.65	108	3.13	84	3.90
118	Pakistan	2.89	123	1.83	91	3.27	110	3.56
119	Cameroon	2.86	130	1.65	98	3.21	101	3.71
120	Tanzania	2.86	127	1.68	102	3.16	99	3.73
121	Bangladesh	2.83	128	1.65	132	2.81	68	4.03
122	Gabon	2.83	105	2.34	130	2.85	120	3.30
123	Kyrgyz Republic	2.81	94	2.70	138	2.65	130	3.08
124	Nicaragua	2.78	120	1.98	111	3.07	125	3.21
125	Zimbabwe	2.72	114	2.09	115	3.03	132	3.05
126	Burkina Faso	2.71	140	1.49	131	2.83	92	3.80
127	Benin	2.70	109	2.19	117	3.01	135	2.90
128	Mozambique	2.66	141	1.45	125	2.90	106	3.62
129	Libya	2.65	89	2.80	136	2.69	143	2.44
130	Ethiopia	2.62	143	1.34	140	2.62	83	3.91
131	Malawi	2.60	136	1.56	121	2.97	122	3.27
132	Mauritania	2.58	116	2.08	126	2.88	137	2.79
133	Madagascar	2.55	132	1.60	118	3.00	131	3.05
134	Nepal	2.54	137	1.54	127	2.87	124	3.21
135	Lesotho	2.52	129	1.65	133	2.79	128	3.12
136	Timor-Leste	2.51	124	1.80	139	2.63	129	3.11
137	Sierra Leone	2.50	133	1.59	141	2.59	119	3.33
138	Swaziland	2.49	119	1.98	124	2.90	140	2.58
139	Guinea	2.47	138	1.53	128	2.86	133	3.02
140	Algeria	2.42	100	2.46	144	2.15	139	2.65
141	Chad	2.34	142	1.35	134	2.79	136	2.89
142	Yemen	2.27	135	1.57	137	2.68	141	2.56
143	Haiti	2.17	134	1.58	142	2.56	144	2.36
144	Burundi	2.04	144	1.33	143	2.31	142	2.47

Usage Subindex (Bilbao-Osorio, Dutta & Lanvin, 2013, p. 14).

IMPACT SUBINDEX

Rank	Country/Economy	Score	Economic impacts Rank	Economic impacts Score	Social impacts Rank	Social impacts Score
1	Singapore	6.13	2	5.98	1	6.28
2	Netherlands	6.00	4	5.93	3	6.08
3	Finland	5.86	1	5.99	9	5.74
4	Sweden	5.77	3	5.93	10	5.62
5	Korea, Rep.	5.71	12	5.24	2	6.19
6	Taiwan, China	5.65	7	5.49	6	5.82
7	Israel	5.54	6	5.63	14	5.45
8	United Kingdom	5.48	14	5.09	4	5.86
9	Switzerland	5.44	5	5.80	24	5.08
10	United States	5.43	11	5.32	11	5.55
11	Norway	5.32	13	5.17	13	5.47
12	Hong Kong SAR	5.28	15	5.03	12	5.54
13	Denmark	5.25	9	5.33	19	5.18
14	Germany	5.22	10	5.32	22	5.12
15	Estonia	5.19	23	4.55	5	5.83
16	Canada	5.14	16	4.93	17	5.35
17	Japan	5.12	8	5.36	31	4.88
18	Australia	5.01	20	4.61	15	5.41
19	United Arab Emirates	4.94	28	4.13	7	5.75
20	France	4.86	17	4.92	32	4.79
21	Luxembourg	4.81	25	4.47	20	5.15
22	New Zealand	4.81	26	4.47	21	5.15
23	Qatar	4.80	33	3.85	8	5.75
24	Austria	4.76	22	4.57	29	4.95
25	Iceland	4.65	24	4.54	33	4.76
26	Puerto Rico	4.56	21	4.58	37	4.53
27	Malaysia	4.52	29	4.02	25	5.02
28	Belgium	4.51	19	4.67	41	4.34
29	Malta	4.50	31	4.00	26	5.01
30	Lithuania	4.49	30	4.01	28	4.96
31	Saudi Arabia	4.43	42	3.64	18	5.22
32	Bahrain	4.39	52	3.39	16	5.38
33	Ireland	4.36	18	4.77	56	3.96
34	Chile	4.35	35	3.73	27	4.97
35	Portugal	4.32	36	3.70	30	4.94
36	Spain	4.22	32	3.86	36	4.58
37	Kazakhstan	4.18	66	3.26	23	5.09
38	Barbados	4.13	27	4.24	52	4.03
39	Brunei Darussalam	4.07	48	3.43	35	4.71
40	Slovenia	4.05	34	3.82	46	4.27
41	Oman	4.04	61	3.34	34	4.75
42	Hungary	4.00	41	3.66	40	4.35
43	Czech Republic	3.97	40	3.66	44	4.28
44	Montenegro	3.87	39	3.67	49	4.08
45	Latvia	3.87	38	3.68	51	4.06
46	Uruguay	3.83	53	3.39	45	4.27
47	Colombia	3.83	70	3.24	38	4.42
48	Panama	3.80	73	3.22	39	4.38
49	Costa Rica	3.75	46	3.50	53	3.99
50	Brazil	3.74	50	3.40	48	4.08
51	Cyprus	3.73	45	3.50	55	3.97
52	Mexico	3.72	72	3.23	47	4.22
53	Russian Federation	3.72	54	3.38	50	4.06
54	Jordan	3.70	49	3.42	54	3.98
55	China	3.69	83	3.08	42	4.29
56	India	3.67	43	3.63	73	3.71
57	Slovak Republic	3.67	44	3.54	66	3.80
58	Mongolia	3.65	86	3.02	43	4.28
59	Azerbaijan	3.65	59	3.35	57	3.94
60	Italy	3.63	37	3.69	80	3.57
61	Rwanda	3.62	58	3.35	61	3.88
62	Egypt	3.60	67	3.26	58	3.93
63	Croatia	3.59	55	3.38	68	3.79
64	Turkey	3.54	68	3.26	63	3.82
65	Cape Verde	3.53	76	3.20	62	3.86
66	Dominican Republic	3.53	79	3.16	59	3.89
67	Senegal	3.51	60	3.35	75	3.67
68	Philippines	3.50	56	3.37	76	3.62
69	Seychelles	3.49	78	3.19	69	3.78
70	Sri Lanka	3.47	62	3.33	77	3.62
71	Kenya	3.47	47	3.46	84	3.47
72	Peru	3.45	77	3.20	74	3.70
73	Gambia, The	3.44	63	3.31	79	3.57
74	Moldova	3.43	84	3.05	65	3.80
75	Vietnam	3.39	89	2.97	64	3.81
76	Georgia	3.39	97	2.90	60	3.88
77	Poland	3.38	64	3.31	86	3.45
78	Macedonia, FYR	3.36	92	2.96	70	3.77
79	Nigeria	3.34	65	3.28	88	3.40
80	Mauritius	3.33	82	3.10	78	3.57
81	Ukraine	3.32	74	3.21	87	3.43
82	Greece	3.31	80	3.12	83	3.51
83	Armenia	3.31	69	3.26	90	3.37
84	Guatemala	3.31	57	3.36	100	3.26
85	El Salvador	3.30	103	2.85	71	3.76
86	Indonesia	3.30	101	2.85	72	3.74
87	Bulgaria	3.30	75	3.20	89	3.39
88	Thailand	3.28	108	2.77	67	3.79
89	Albania	3.26	88	2.99	81	3.54
90	Ecuador	3.25	90	2.97	82	3.52
91	Jamaica	3.23	81	3.10	92	3.36
92	South Africa	3.23	51	3.40	112	3.05
93	Mali	3.17	71	3.23	108	3.11
94	Argentina	3.14	91	2.96	96	3.32
95	Trinidad and Tobago	3.12	100	2.87	91	3.37
96	Bosnia and Herzegovina	3.12	96	2.90	95	3.33
97	Romania	3.12	94	2.92	97	3.31
98	Serbia	3.09	105	2.83	93	3.36
99	Iran, Islamic Rep.	3.09	106	2.82	94	3.36
100	Ghana	3.08	85	3.04	107	3.11
101	Kuwait	3.04	125	2.60	85	3.47
102	Tajikistan	3.03	111	2.75	98	3.31
103	Guyana	3.02	107	2.80	102	3.24
104	Venezuela	3.01	95	2.91	106	3.11
105	Botswana	2.97	114	2.73	103	3.21
106	Pakistan	2.97	99	2.88	113	3.05
107	Cambodia	2.94	124	2.62	101	3.26
108	Honduras	2.94	98	2.89	114	2.99
109	Liberia	2.91	110	2.75	109	3.08
110	Ethiopia	2.90	127	2.53	99	3.27
111	Morocco	2.89	122	2.65	105	3.13
112	Zambia	2.89	115	2.71	110	3.07
113	Benin	2.88	87	3.01	123	2.75
114	Bolivia	2.88	123	2.62	104	3.14
115	Uganda	2.86	121	2.65	111	3.07
116	Lebanon	2.86	102	2.85	120	2.86
117	Mozambique	2.82	116	2.71	117	2.93
118	Nicaragua	2.80	120	2.67	118	2.93
119	Cameroon	2.78	104	2.84	126	2.72
120	Côte d'Ivoire	2.77	93	2.93	129	2.61
121	Paraguay	2.75	109	2.76	122	2.75
122	Namibia	2.75	117	2.70	121	2.80
123	Kyrgyz Republic	2.75	126	2.56	115	2.93
124	Malawi	2.73	112	2.74	127	2.71
125	Burkina Faso	2.72	118	2.70	124	2.74
126	Bangladesh	2.71	128	2.52	116	2.90
127	Tanzania	2.61	136	2.34	119	2.89
128	Zimbabwe	2.55	119	2.68	132	2.42
129	Nepal	2.54	135	2.36	125	2.73
130	Suriname	2.53	113	2.74	137	2.33
131	Timor-Leste	2.50	132	2.38	128	2.61
132	Gabon	2.42	129	2.44	133	2.41
133	Sierra Leone	2.42	133	2.37	131	2.46
134	Mauritania	2.39	130	2.42	136	2.36
135	Madagascar	2.38	139	2.25	130	2.50
136	Guinea	2.33	131	2.40	140	2.25
137	Swaziland	2.33	140	2.25	134	2.40
138	Libya	2.32	137	2.33	138	2.31
139	Chad	2.30	138	2.33	139	2.26
140	Lesotho	2.21	144	2.03	135	2.39
141	Haiti	2.20	134	2.37	142	2.03
142	Algeria	2.11	143	2.08	141	2.15
143	Yemen	2.08	142	2.20	143	1.96
144	Burundi	2.06	141	2.23	144	1.90

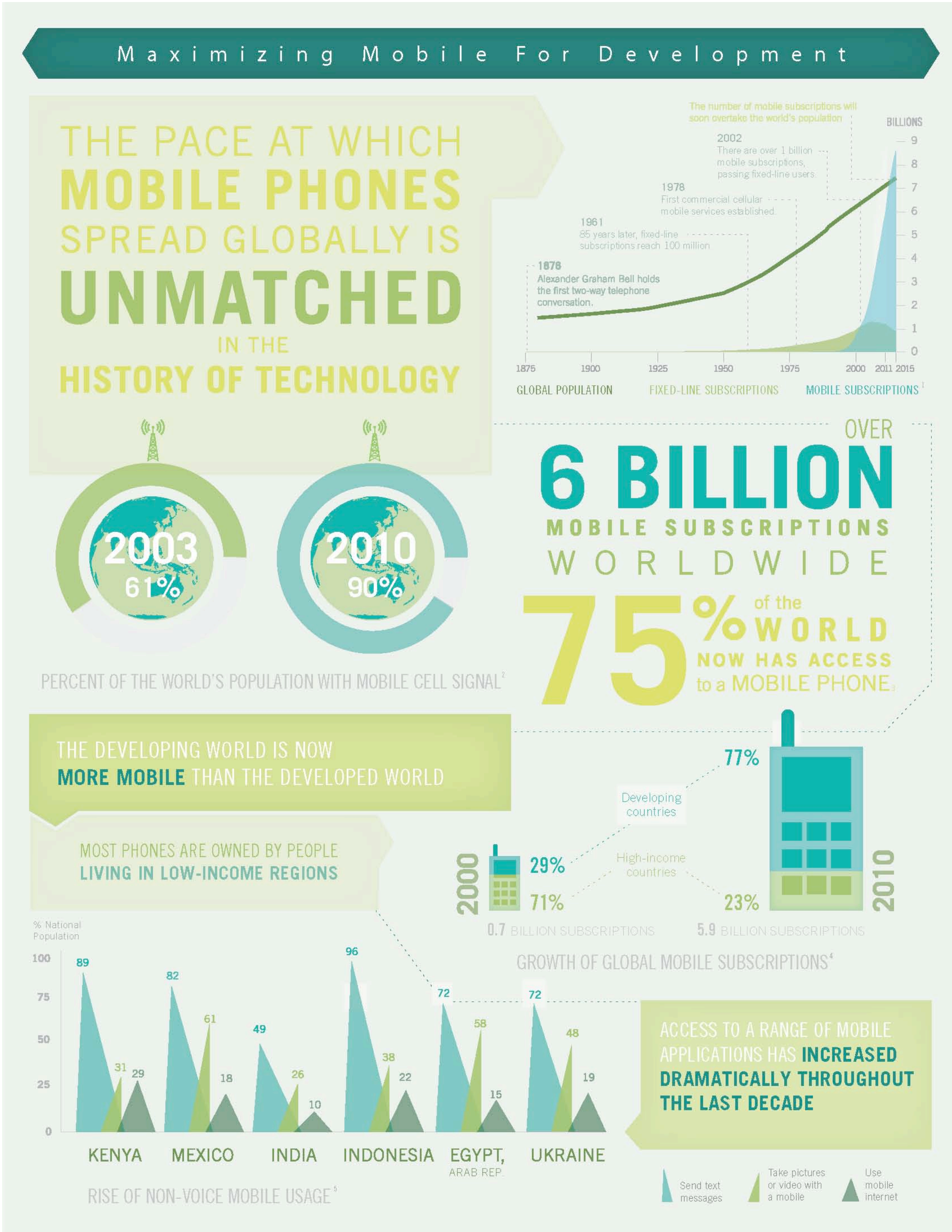
Impact Subindex (Bilbao-Osorio, Dutta & Lanvin, 2013, p. 15).

Table 2
Rank correlation among WEF, UNDP, ArCo, and RAND for the common 47 countries

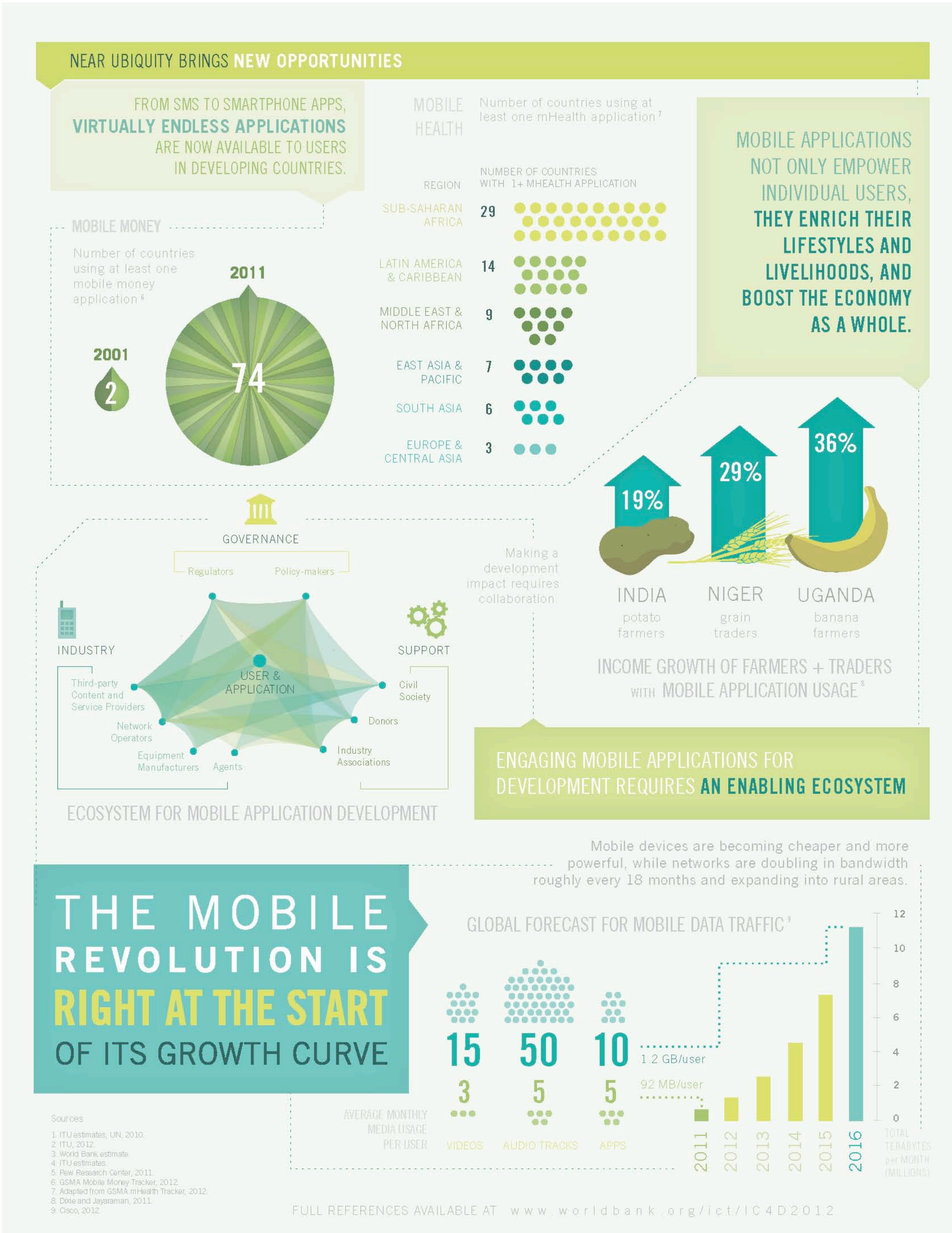
	1	2	3	4	5	6
	WEF	UNDP	ArCo	RAND	Rank mean	Standard deviation
US	1	2	4	1	2.0	1.41
Finland	3	1	2	4	2.5	1.29
Sweden	5	3	1	3	3.0	1.63
Canada	2	9	5	2	4.5	3.32
Australia	4	10	8	8	7.5	2.52
Norway	6	12	6	10	8.5	3.00
Japan	19	4	7	5	8.8	6.95
UK	8	7	11	9	88	1.71
Netherlands	11	6	9	12	9.5	2.65
Germany	12	11	10	6	9.8	2.63
South Korea	7	5	15	16	10.8	5.56
Israel	21	18	3	7	12.3	8.62
Belgium	10	14	13	13	12.5	1.73
New Zealand	9	15	12	17	13.3	3.50
Singapore	15	8	17	15	13.8	3.95
Austria	13	16	14	14	14.3	1.26
France	14	17	16	11	14.5	2.65
Ireland	23	13	18	18	18.0	4.08
Spain	22	19	20	21	20.5	1.29
Czech Republic	16	21	24	23	21.0	3.56
Italy	26	20	19	20	21.3	3.20
Slovenia	25	23	21	19	22.0	2.58
Hungary	17	22	25	26	22.5	4.04
Slovakia	24	24	23	25	24.0	0.82
Portugal	20	26	27	24	24.3	3.10
Greece	30	25	22	22	24.8	3.77
Poland	28	28	26	27	27.3	0.96
Malaysia	18	29	33	38	29.5	8.50
Bulgaria	38	27	28	28	30.3	5.19
Argentina	36	31	29	29	31.3	3.30
Chile	33	34	30	30	31.8	2.06
Costa Rica	27	33	34	34	32.0	3.37
Romania	35	32	31	31	32.3	1.89
Mexico	29	30	35	36	32.5	3.51
South Africa	34	35	32	32	33.3	1.50
Thailand	31	36	37	41	36.3	4.11
Brazil	37	37	38	35	36.8	1.26
Philippines	32	38	39	42	37.8	4.19
China	39	39	41	33	38.0	3.46
Peru	42	41	36	40	39.8	2.63
Bolivia	45	40	42	39	41.5	2.65
Ecuador	46	42	40	44	43.0	2.58
Egypt	43	43	44	43	43.3	0.50
India	44	46	47	37	43.5	4.51
Sri Lanka	40	45	43	47	43.8	2.99
Indonesia	41	44	45	46	44.0	2.16
Nicaragua	47	47	46	45	46.3	0.96

Rank correlation for e-readiness indices (Archibugi & Coco, 2005)

6.2 Mobile and Internet Penetration and Maximization

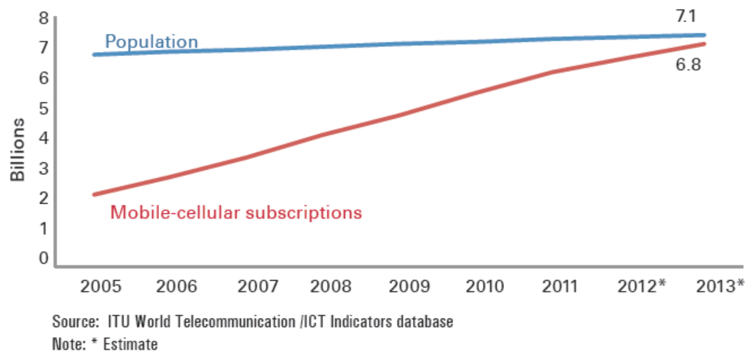


The World Bank: InfoDev, 2012a.



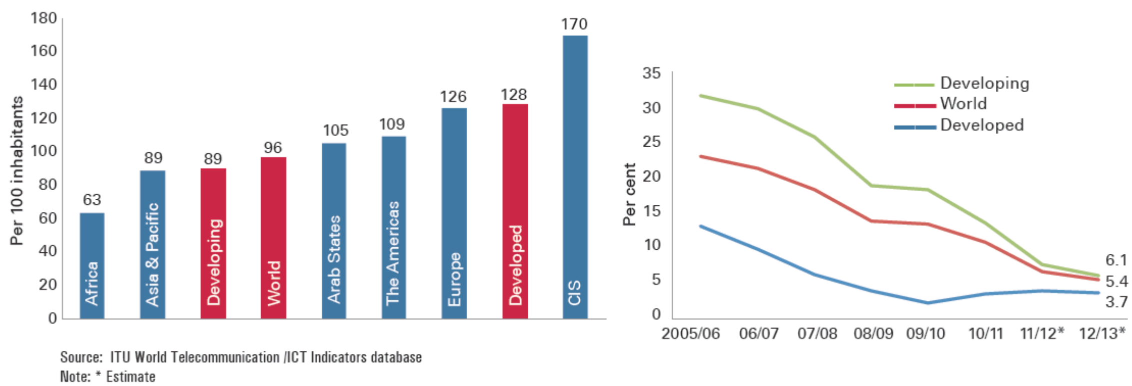
The World Bank: InfoDev, 2012a.

As the number of subscriptions approaches global population figures mobile-cellular growth slows



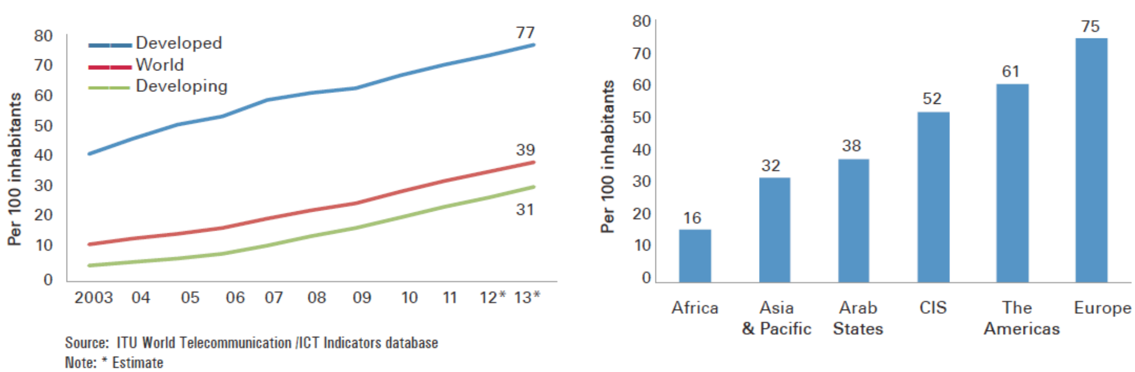
ITU, 2013, p. 1.

Mobile-cellular penetration, 2013*, and mobile-cellular subscription growth rates, 2005-2013*

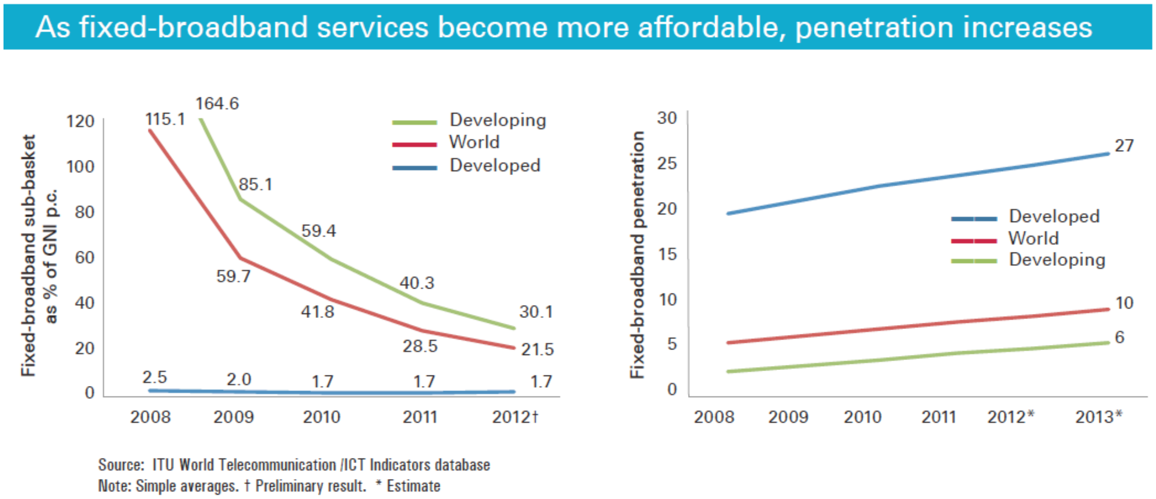


ITU, 2013, p. 1.

Internet users by development level, 2003-2013*, and by region, 2013*



ITU, 2013, p. 2.

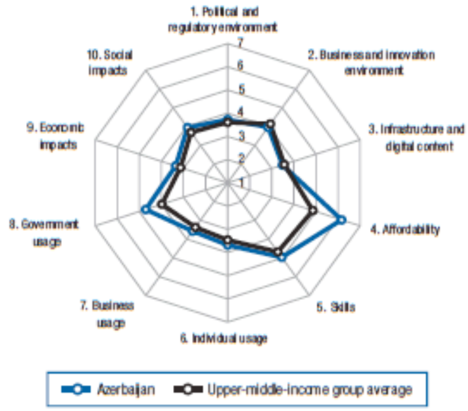

As fixed-broadband services become more affordable, penetration increases
Fixed-broadband sub-basket as % of GNI p.c.
120
100
80
60
40
20
0
164.6
115.1
85.1
59.4
59.7
40.3
41.8
30.1
28.5
21.5
2.5
2.0
1.7
1.7
1.7
2008
2009
2010
2011
2012†
Developing
World
Developed
Fixed-broadband penetration
30
25
20
15
10
5
0
27
10
6
Developed
World
Developing
2008
2009
2010
2011
2012*
2013*
Source: ITU World Telecommunication /ICT Indicators database
Note: Simple averages. † Preliminary result. * Estimate

ITU, 2013, p. 4.

6.3 Select Country Profiles

Azerbaijan

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**56**	**4.1**
Networked Readiness Index 2012 (out of 142)	61	3.9
A. Environment subindex	**77**	**3.8**
1st pillar: Political and regulatory environment	66	3.7
2nd pillar: Business and innovation environment	86	4.0
B. Readiness subindex	**51**	**5.0**
3rd pillar: Infrastructure and digital content	75	3.8
4th pillar: Affordability	20	6.2
5th pillar: Skills	57	5.0
C. Usage subindex	**52**	**4.0**
6th pillar: Individual usage	64	3.7
7th pillar: Business usage	58	3.6
8th pillar: Government usage	34	4.7
D. Impact subindex	**59**	**3.6**
9th pillar: Economic impacts	59	3.4
10th pillar: Social impacts	57	3.9



The Networked Readiness Index in detail

	INDICATOR	RANK/144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	59	3.8
1.02	Laws relating to ICTs*	46	4.4
1.03	Judicial independence*	86	3.4
1.04	Efficiency of legal system in settling disputes*	76	3.6
1.05	Efficiency of legal system in challenging regs*	58	3.9
1.06	Intellectual property protection*	53	3.9
1.07	Software piracy rate, % software installed	99	87
1.08	No. procedures to enforce a contract	90	39
1.09	No. days to enforce a contract	5	237
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	81	4.8
2.02	Venture capital availability*	59	2.8
2.03	Total tax rate, % profits	77	40.0
2.04	No. days to start a business	34	8
2.05	No. procedures to start a business	48	6
2.06	Intensity of local competition*	131	3.8
2.07	Tertiary education gross enrollment rate, %	92	19.3
2.08	Quality of management schools*	123	3.3
2.09	Gov't procurement of advanced tech*	19	4.4
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	79	2,108.9
3.02	Mobile network coverage, % pop	1	100.0
3.03	Int'l Internet bandwidth, kb/s per user	64	19.1
3.04	Secure Internet servers/million pop	100	4.7
3.05	Accessibility of digital content*	71	5.0
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min.	28	0.15
4.02	Fixed broadband Internet tariffs, PPP $/month	16	18.55
4.03	Internet & telephony competition, 0–2 (best)	104	1.35
	5th pillar: Skills		
5.01	Quality of educational system*	109	3.1
5.02	Quality of math & science education*	99	3.5
5.03	Secondary education gross enrollment rate, %	48	96.9
5.04	Adult literacy rate, %	3	99.8

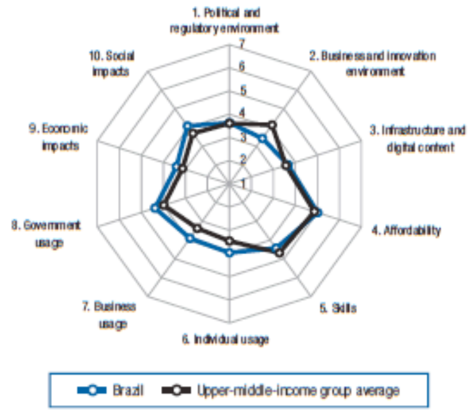
	INDICATOR	RANK/144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	64	108.7
6.02	Individuals using Internet, %	56	50.0
6.03	Households w/ personal computer, %	86	21.5
6.04	Households w/ Internet access, %	62	35.3
6.05	Broadband Internet subscriptions/100 pop.	53	10.7
6.06	Mobile broadband subscriptions/100 pop.	50	21.5
6.07	Use of virtual social networks*	41	5.9
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	73	4.7
7.02	Capacity for innovation*	39	3.5
7.03	PCT patents, applications/million pop.	77	0.4
7.04	Business-to-business Internet use*	78	4.8
7.05	Business-to-consumer Internet use*	77	4.4
7.06	Extent of staff training*	56	4.1
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	9	5.4
8.02	Government Online Service Index, 0–1 (best)	97	0.37
8.03	Gov't success in ICT promotion*	8	5.6
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	41	4.9
9.02	ICT PCT patents, applications/million pop.	95	0.0
9.03	Impact of ICTs on new organizational models*	39	4.6
9.04	Knowledge-intensive jobs, % workforce	69	20.3
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	37	4.9
10.02	Internet access in schools*	79	3.9
10.03	ICT use & gov't efficiency*	19	5.2
10.04	E-Participation Index, 0–1 (best)	81	0.13

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 148.

Brazil

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**60**	**4.0**
Networked Readiness Index 2012 (out of 142)	65	3.9
A. Environment subindex	**107**	**3.5**
1st pillar: Political and regulatory environment	78	3.6
2nd pillar: Business and innovation environment	126	3.4
B. Readiness subindex	**74**	**4.5**
3rd pillar: Infrastructure and digital content	62	4.2
4th pillar: Affordability	76	5.0
5th pillar: Skills	91	4.4
C. Usage subindex	**44**	**4.1**
6th pillar: Individual usage	58	4.0
7th pillar: Business usage	34	3.9
8th pillar: Government usage	48	4.4
D. Impact subindex	**50**	**3.7**
9th pillar: Economic impacts	50	3.4
10th pillar: Social impacts	48	4.1



The Networked Readiness Index in detail

	INDICATOR	RANK/144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	120	2.7
1.02	Laws relating to ICTs*	47	4.4
1.03	Judicial independence*	71	3.8
1.04	Efficiency of legal system in settling disputes*	84	3.5
1.05	Efficiency of legal system in challenging regs*	61	3.8
1.06	Intellectual property protection*	75	3.5
1.07	Software piracy rate, % software installed	40	53
1.08	No. procedures to enforce a contract	124	44
1.09	No. days to enforce a contract	111	731
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	50	5.3
2.02	Venture capital availability*	51	2.8
2.03	Total tax rate, % profits	136	69.3
2.04	No. days to start a business	141	119
2.05	No. procedures to start a business	132	13
2.06	Intensity of local competition*	45	5.1
2.07	Tertiary education gross enrollment rate, %	83	25.6
2.08	Quality of management schools*	52	4.4
2.09	Gov't procurement of advanced tech*	53	3.8
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	73	2,413.8
3.02	Mobile network coverage, % pop	24	100.0
3.03	Int'l Internet bandwidth, kb/s per user	47	28.0
3.04	Secure Internet servers/million pop	58	54.2
3.05	Accessibility of digital content*	82	4.9
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min.	130	0.68
4.02	Fixed broadband Internet tariffs, PPP $/month	11	16.58
4.03	Internet & telephony competition, 0–2 (best)	1	2.00
	5th pillar: Skills		
5.01	Quality of educational system*	116	3.0
5.02	Quality of math & science education*	132	2.6
5.03	Secondary education gross enrollment rate, %	19	105.8
5.04	Adult literacy rate, %	85	90.3

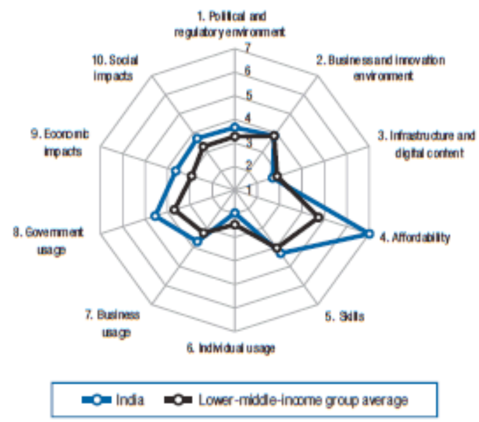
	INDICATOR	RANK/144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	40	124.3
6.02	Individuals using Internet, %	62	45.0
6.03	Households w/ personal computer, %	64	45.4
6.04	Households w/ Internet access, %	59	37.8
6.05	Broadband Internet subscriptions/100 pop.	63	8.6
6.06	Mobile broadband subscriptions/100 pop.	53	20.9
6.07	Use of virtual social networks*	47	5.8
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	47	5.2
7.02	Capacity for innovation*	34	3.7
7.03	PCT patents, applications/million pop.	50	2.8
7.04	Business-to-business Internet use*	40	5.5
7.05	Business-to-consumer Internet use*	28	5.3
7.06	Extent of staff training*	33	4.4
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	80	3.9
8.02	Government Online Service Index, 0–1 (best)	32	0.67
8.03	Gov't success in ICT promotion*	81	4.2
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	34	5.0
9.02	ICT PCT patents, applications/million pop.	56	0.4
9.03	Impact of ICTs on new organizational models*	34	4.7
9.04	Knowledge-intensive jobs, % workforce	75	19.3
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	68	4.2
10.02	Internet access in schools*	88	3.7
10.03	ICT use & gov't efficiency*	53	4.4
10.04	E-Participation Index, 0–1 (best)	31	0.50

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 157.

India

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**68**	**3.9**
Networked Readiness Index 2012 (out of 142)	69	3.9
A. Environment subindex	**85**	**3.8**
1st pillar: Political and regulatory environment	75	3.7
2nd pillar: Business and innovation environment	99	3.8
B. Readiness subindex	**68**	**4.7**
3rd pillar: Infrastructure and digital content	111	2.8
4th pillar: Affordability	1	7.0
5th pillar: Skills	95	4.3
C. Usage subindex	**81**	**3.4**
6th pillar: Individual usage	121	2.0
7th pillar: Business usage	45	3.7
8th pillar: Government usage	40	4.5
D. Impact subindex	**56**	**3.7**
9th pillar: Economic impacts	43	3.6
10th pillar: Social impacts	73	3.7



The Networked Readiness Index in detail

	INDICATOR	RANK/144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	53	3.9
1.02	Laws relating to ICTs*	52	4.3
1.03	Judicial independence*	45	4.5
1.04	Efficiency of legal system in settling disputes*	59	3.8
1.05	Efficiency of legal system in challenging regs*	52	3.9
1.06	Intellectual property protection*	63	3.7
1.07	Software piracy rate, % software installed	58	63
1.08	No. procedures to enforce a contract	131	46
1.09	No. days to enforce a contract	140	1,420
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	47	5.3
2.02	Venture capital availability*	26	3.4
2.03	Total tax rate, % profits	125	61.8
2.04	No. days to start a business	103	27
2.05	No. procedures to start a business	126	12
2.06	Intensity of local competition*	34	5.4
2.07	Tertiary education gross enrollment rate, %	96	17.9
2.08	Quality of management schools*	33	4.9
2.09	Gov't procurement of advanced tech*	83	3.4
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	102	744.7
3.02	Mobile network coverage, % pop	113	83.0
3.03	Int'l Internet bandwidth, kb/s per user	99	6.3
3.04	Secure Internet servers/million pop	106	2.9
3.05	Accessibility of digital content*	91	4.6
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min	6	0.04
4.02	Fixed broadband Internet tariffs, PPP $/month	4	14.75
4.03	Internet & telephony competition, 0–2 (best)	1	2.00
	5th pillar: Skills		
5.01	Quality of educational system*	34	4.4
5.02	Quality of math & science education*	30	4.7
5.03	Secondary education gross enrollment rate, %	108	63.2
5.04	Adult literacy rate, %	121	62.8

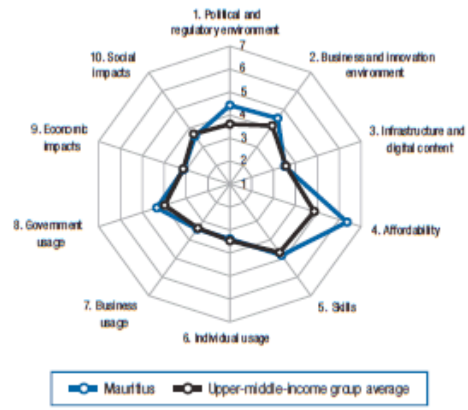
	INDICATOR	RANK/144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	117	72.0
6.02	Individuals using Internet, %	119	10.1
6.03	Households w/ personal computer, %	112	6.1
6.04	Households w/ Internet access, %	108	4.2
6.05	Broadband Internet subscriptions/100 pop.	102	1.1
6.06	Mobile broadband subscriptions/100 pop.	102	1.9
6.07	Use of virtual social networks*	96	5.1
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	40	5.2
7.02	Capacity for innovation*	42	3.5
7.03	PCT patents, applications/million pop.	62	1.3
7.04	Business-to-business Internet use*	59	5.1
7.05	Business-to-consumer Internet use*	76	4.4
7.06	Extent of staff training*	54	4.1
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	45	4.3
8.02	Government Online Service Index, 0–1 (best)	55	0.54
8.03	Gov't success in ICT promotion*	24	5.1
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	36	5.0
9.02	ICT PCT patents, applications/million pop.	57	0.3
9.03	Impact of ICTs on new organizational models*	27	4.9
9.04	Knowledge-intensive jobs, % workforce	n/a	n/a
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	64	4.3
10.02	Internet access in schools*	75	4.0
10.03	ICT use & gov't efficiency*	54	4.4
10.04	E-Participation Index, 0–1 (best)	70	0.18

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 198.

Mauritius

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**55**	**4.1**
Networked Readiness Index 2012 (out of 142)	53	4.1
A. Environment subindex	**41**	**4.5**
1st pillar: Political and regulatory environment	36	4.4
2nd pillar: Business and innovation environment	46	4.5
B. Readiness subindex	**54**	**5.0**
3rd pillar: Infrastructure and digital content	77	3.7
4th pillar: Affordability	12	6.4
5th pillar: Skills	67	4.8
C. Usage subindex	**65**	**3.7**
6th pillar: Individual usage	70	3.4
7th pillar: Business usage	73	3.4
8th pillar: Government usage	49	4.3
D. Impact subindex	**80**	**3.3**
9th pillar: Economic impacts	82	3.1
10th pillar: Social impacts	78	3.6



The Networked Readiness Index in detail

	INDICATOR	RANK/144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	19	4.8
1.02	Laws relating to ICTs*	43	4.5
1.03	Judicial independence*	34	5.1
1.04	Efficiency of legal system in settling disputes*	26	4.7
1.05	Efficiency of legal system in challenging regs*	30	4.5
1.06	Intellectual property protection*	54	3.8
1.07	Software piracy rate, % software installed	48	57
1.08	No. procedures to enforce a contract	56	36
1.09	No. days to enforce a contract	102	645
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	48	5.3
2.02	Venture capital availability*	56	2.8
2.03	Total tax rate, % profits	32	28.5
2.04	No. days to start a business	16	6
2.05	No. procedures to start a business	30	5
2.06	Intensity of local competition*	42	5.2
2.07	Tertiary education gross enrollment rate, %	74	32.4
2.08	Quality of management schools*	76	4.1
2.09	Gov't procurement of advanced tech*	74	3.5
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	77	2,265.8
3.02	Mobile network coverage, % pop	51	99.0
3.03	Int'l Internet bandwidth, kb/s per user	76	12.7
3.04	Secure Internet servers/million pop	49	116.6
3.05	Accessibility of digital content*	83	4.8
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min.	47	0.19
4.02	Fixed broadband Internet tariffs, PPP $/month	33	22.95
4.03	Internet & telephony competition, 0–2 (best)	1	2.00
	5th pillar: Skills		
5.01	Quality of educational system*	46	4.1
5.02	Quality of math & science education*	49	4.3
5.03	Secondary education gross enrollment rate, %	64	90.9
5.04	Adult literacy rate, %	94	88.5

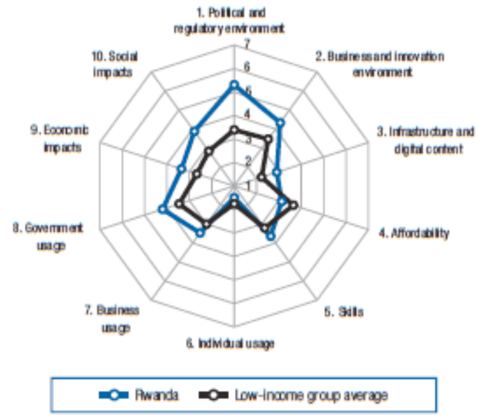
	INDICATOR	RANK/144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	85	99.0
6.02	Individuals using Internet, %	81	35.0
6.03	Households w/ personal computer, %	68	38.2
6.04	Households w/ Internet access, %	60	36.4
6.05	Broadband Internet subscriptions/100 pop.	60	8.9
6.06	Mobile broadband subscriptions/100 pop.	68	12.5
6.07	Use of virtual social networks*	76	5.4
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	55	4.9
7.02	Capacity for innovation*	112	2.7
7.03	PCT patents, applications/million pop.	103	0.1
7.04	Business-to-business Internet use*	48	5.3
7.05	Business-to-consumer Internet use*	92	4.1
7.06	Extent of staff training*	37	4.3
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	48	4.3
8.02	Government Online Service Index, 0–1 (best)	85	0.43
8.03	Gov't success in ICT promotion*	22	5.1
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	56	4.7
9.02	ICT PCT patents, applications/million pop.	77	0.1
9.03	Impact of ICTs on new organizational models*	62	4.3
9.04	Knowledge-intensive jobs, % workforce	88	15.8
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	63	4.3
10.02	Internet access in schools*	72	4.1
10.03	ICT use & gov't efficiency*	56	4.4
10.04	E-Participation Index, 0–1 (best)	96	0.08

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 226.

Rwanda

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**88**	**3.7**
Networked Readiness Index 2012 (out of 142)	82	3.7
A. Environment subindex	**29**	**4.8**
1st pillar: Political and regulatory environment	13	5.3
2nd pillar: Business and innovation environment	59	4.3
B. Readiness subindex	**116**	**3.2**
3rd pillar: Infrastructure and digital content	105	3.0
4th pillar: Affordability	116	3.1
5th pillar: Skills	113	3.6
C. Usage subindex	**107**	**3.1**
6th pillar: Individual usage	139	1.5
7th pillar: Business usage	67	3.5
8th pillar: Government usage	59	4.2
D. Impact subindex	**61**	**3.6**
9th pillar: Economic impacts	58	3.4
10th pillar: Social impacts	61	3.9



The Networked Readiness Index in detail

	INDICATOR	RANK/144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	9	5.2
1.02	Laws relating to ICTs*	34	4.9
1.03	Judicial independence*	25	5.3
1.04	Efficiency of legal system in settling disputes*	15	5.1
1.05	Efficiency of legal system in challenging regs*	17	4.8
1.06	Intellectual property protection*	32	4.8
1.07	Software piracy rate, % software installed	n/a	n/a
1.08	No. procedures to enforce a contract	3	23
1.09	No. days to enforce a contract	3	230
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	87	4.7
2.02	Venture capital availability*	27	3.4
2.03	Total tax rate, % profits	41	31.3
2.04	No. days to start a business	5	3
2.05	No. procedures to start a business	3	2
2.06	Intensity of local competition*	98	4.4
2.07	Tertiary education gross enrollment rate, %	123	6.6
2.08	Quality of management schools*	73	4.2
2.09	Gov't procurement of advanced tech*	10	4.5
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	140	23.3
3.02	Mobile network coverage, % pop	80	97.3
3.03	Int'l Internet bandwidth, kb/s per user	111	4.4
3.04	Secure Internet servers/million pop	130	0.9
3.05	Accessibility of digital content*	95	4.6
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min.	81	0.32
4.02	Fixed broadband Internet tariffs, PPP $/month	134	232.09
4.03	Internet & telephony competition, 0–2 (best)	59	1.93
	5th pillar: Skills		
5.01	Quality of educational system*	50	4.1
5.02	Quality of math & science education*	62	4.1
5.03	Secondary education gross enrollment rate, %	131	35.8
5.04	Adult literacy rate, %	115	71.1

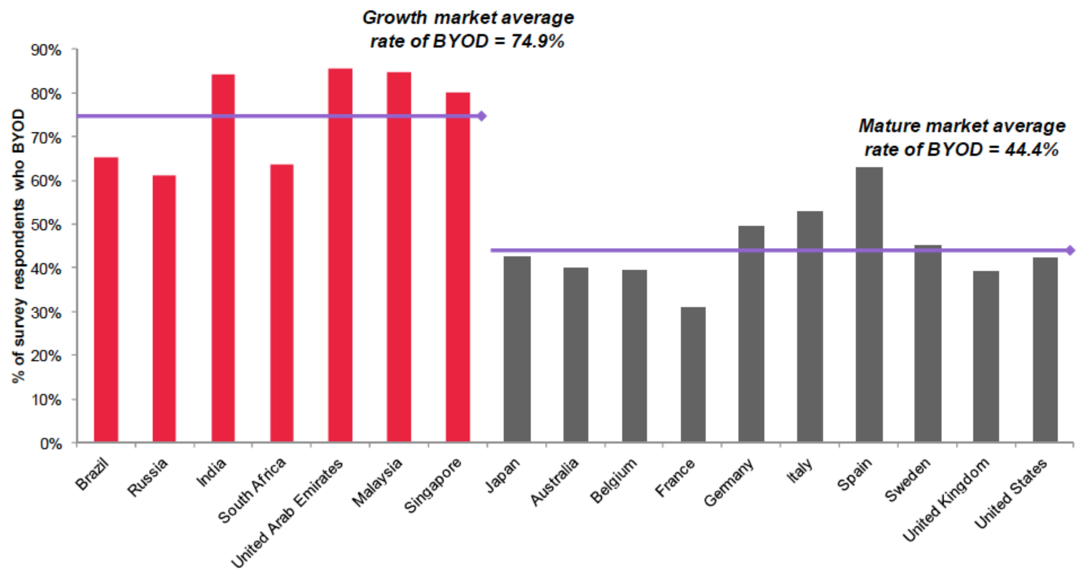
	INDICATOR	RANK/144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	138	40.6
6.02	Individuals using Internet, %	124	7.0
6.03	Households w/ personal computer, %	139	1.3
6.04	Households w/ Internet access, %	112	3.2
6.05	Broadband Internet subscriptions/100 pop.	132	0.0
6.06	Mobile broadband subscriptions/100 pop.	110	1.0
6.07	Use of virtual social networks*	128	4.4
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	84	4.6
7.02	Capacity for innovation*	55	3.3
7.03	PCT patents, applications/million pop.	123	0.0
7.04	Business-to-business Internet use*	n/a	n/a
7.05	Business-to-consumer Internet use*	n/a	n/a
7.06	Extent of staff training*	69	3.9
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	10	5.4
8.02	Government Online Service Index, 0–1 (best)	103	0.34
8.03	Gov't success in ICT promotion*	n/a	n/a
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	45	4.8
9.02	ICT PCT patents, applications/million pop.	95	0.0
9.03	Impact of ICTs on new organizational models*	61	4.3
9.04	Knowledge-intensive jobs, % workforce	n/a	n/a
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	50	4.7
10.02	Internet access in schools*	66	4.3
10.03	ICT use & gov't efficiency*	13	5.4
10.04	E-Participation Index, 0–1 (best)	111	0.03

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

Bilbao-Osorio, Dutta & Lanvin, 2013, p. 252.

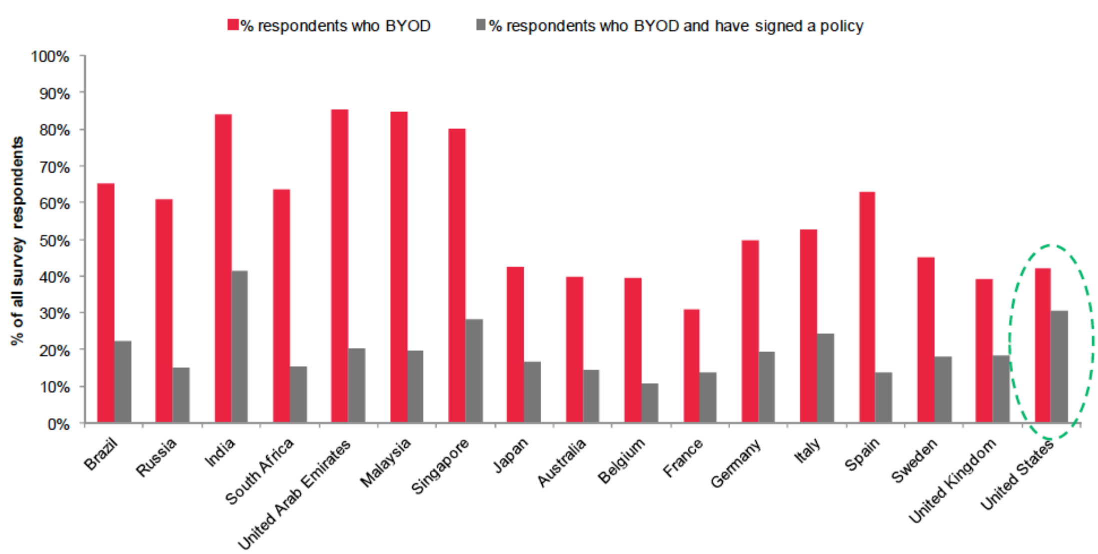
6.4 BYOD

Figure 1: Divergence between average rates of BYOD in growth markets vs mature markets



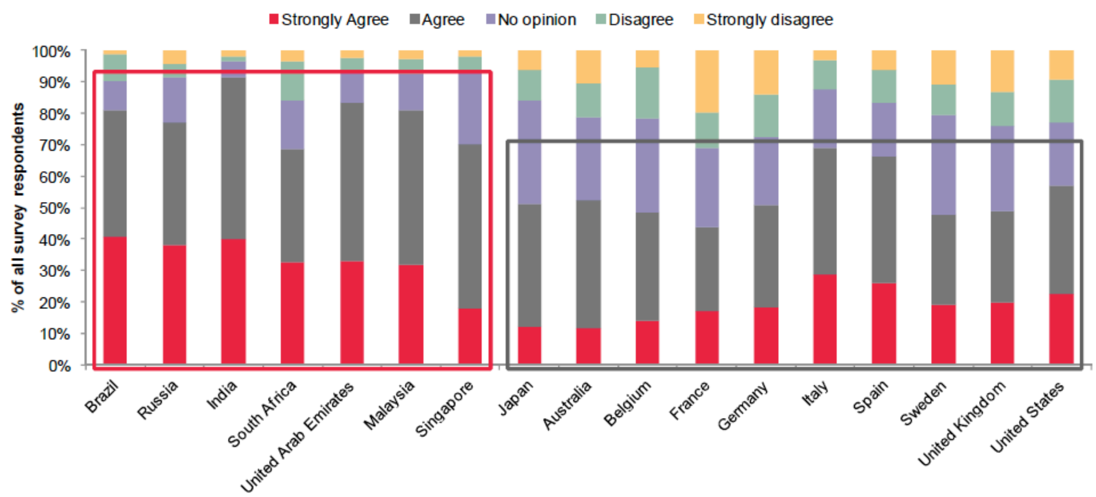
Drury & Absalom, 2013, p. 2.

Figure 2: Lack of BYOD management is an issue everywhere



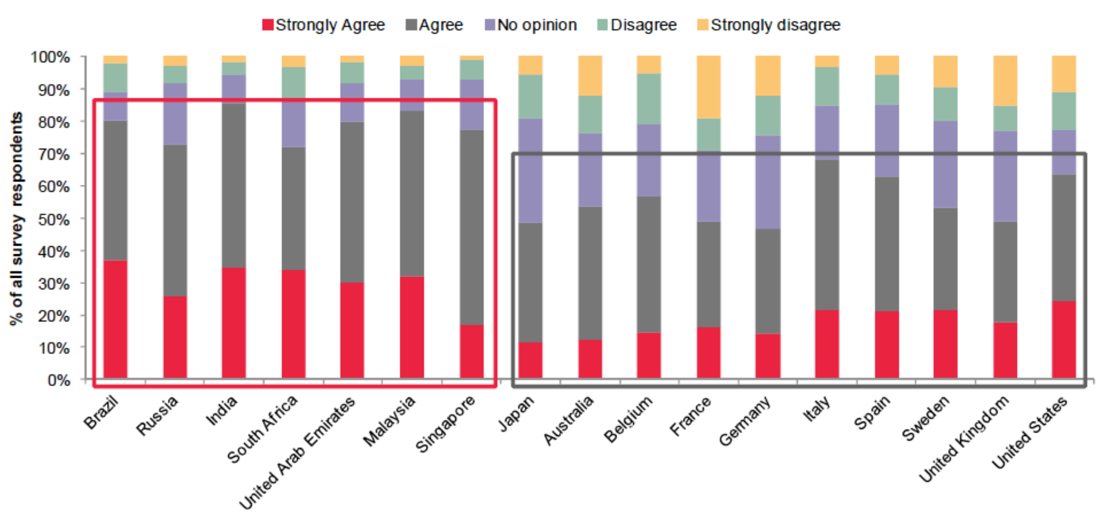
Drury & Absalom, 2013, p. 5.

Figure 3: "Being able to access corporate emails and other business apps outside official working hours enables me to do my job better" – breakdown by market



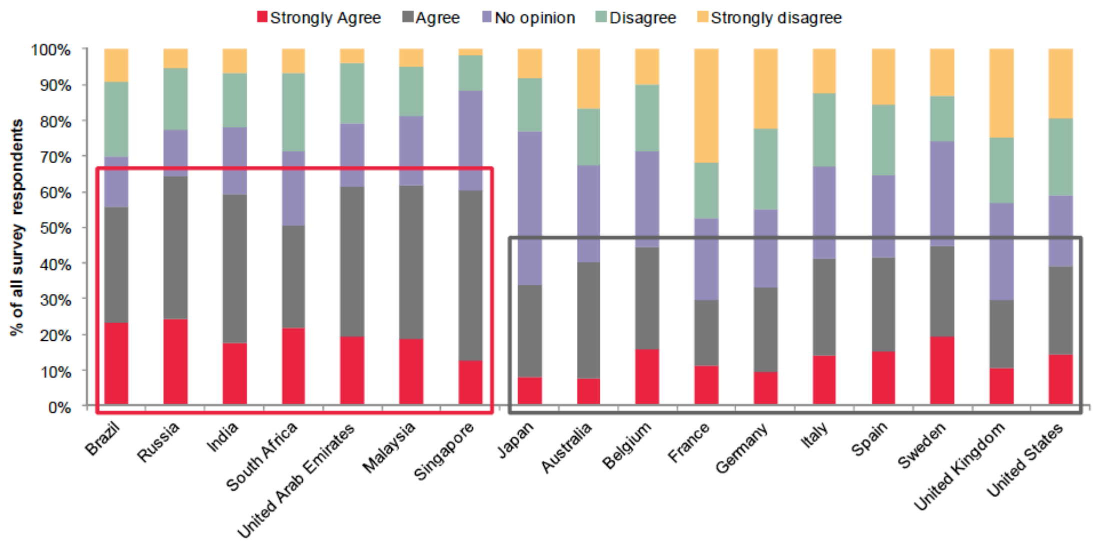
Drury & Absalom, 2013, p. 6.

Figure 4: "I like the flexibility of being able to access corporate emails and other business apps outside official working hours" – breakdown by market



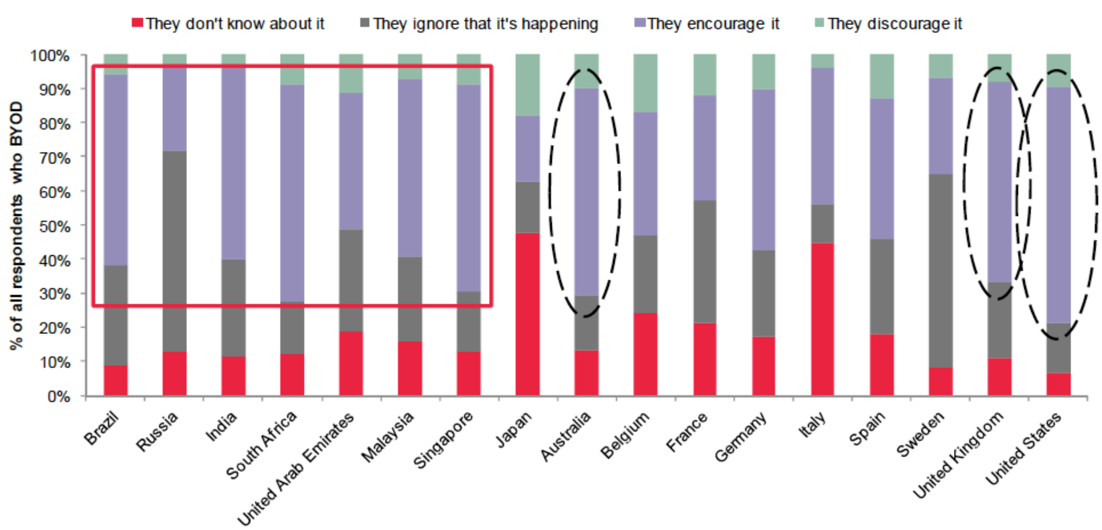
Drury & Absalom, 2013, p. 7.

Figure 5: "I would like to use a single phone for work and personal use" – breakdown by market



Drury & Absalom, 2013, p. 8.

Figure 6: Employer's IT department's attitude towards BYOD – breakdown by market



Drury & Absalom, 2013, p. 10.

6.5 The World Bank 2013 Country Classifications

East Asia and Pacific		developing only: 24
American Samoa	Malaysia	Samoa
Cambodia	Marshall Islands	Solomon Islands
China	Micronesia, Fed. Sts	Thailand
Fiji	Mongolia	Timor-Leste
Indonesia	Myanmar	Tuvalu
Kiribati	Palau	Tonga
Korea, Dem. Rep.	Papua New Guinea	Vanuatu
Lao PDR	Philippines	Vietnam

The World Bank, 2013a.

Europe and Central Asia		developing only: 21
Albania	**Hungary**	Romania
Armenia	Kazakhstan	Serbia
Azerbaijan	Kosovo	Tajikistan
Belarus	Kyrgyz Republic	Turkey
Bosnia and Herzegovina	Macedonia, FYR	Turkmenistan
Bulgaria	Moldova	Ukraine
Georgia	Montenegro	Uzbekistan

The World Bank, 2013a.

Latin America and the Caribbean		developing only: 26
Argentina	Ecuador	Nicaragua
Belize	El Salvador	Panama
Bolivia	Grenada	Paraguay
Brazil	Guatemala	Peru
Colombia	Guyana	St. Lucia
Costa Rica	Haiti	St. Vincent and the Grenadines
Cuba	Honduras	Suriname
Dominica	Jamaica	Venezuela, RB
Dominican Republic	Mexico	

The World Bank, 2013a.

Middle East and North Africa		developing only: 13
Algeria	Jordan	Tunisia
Djibouti	Lebanon	West Bank and Gaza
Egypt, Arab Rep.	Libya	Yemen, Rep.
Iran, Islamic Rep.	Morocco	
Iraq	Syrian Arab Republic	

The World Bank, 2013a.

South Asia		all developing: 8
Afghanistan	India	Pakistan
Bangladesh	Maldives	Sri Lanka
Bhutan	Nepal	

The World Bank, 2013a.

Sub-Saharan Africa		developing only: 47
Angola	Gambia, The	Rwanda
Benin	Ghana	São Tomé and Principe
Botswana	Guinea	Senegal
Burkina Faso	Guinea-Bissau	Seychelles
Burundi	Kenya	Sierra Leone
Cameroon	Lesotho	Somalia
Cape Verde	Liberia	South Africa
Central African Republic	Madagascar	South Sudan
Chad	Malawi	Sudan
Comoros	Mali	Swaziland
Congo, Dem. Rep.	Mauritania	Tanzania
Congo, Rep	Mauritius	Togo
Côte d'Ivoire	Mozambique	Uganda
Eritrea	Namibia	Zambia
Ethiopia	Niger	Zimbabwe
Gabon	Nigeria	

The World Bank, 2013a.

Low-income economies ($1,035 or less)		36
Afghanistan	Gambia, The	Myanmar
Bangladesh	Guinea	Nepal
Benin	Guinea-Bisau	Niger
Burkina Faso	Haiti	Rwanda
Burundi	Kenya	Sierra Leone
Cambodia	Korea, Dem Rep.	Somalia
Central African Republic	Kyrgyz Republic	**South Sudan**
Chad	Liberia	Tajikistan
Comoros	Madagascar	Tanzania
Congo, Dem. Rep	Malawi	Togo
Eritrea	Mali	Uganda
Ethiopia	Mozambique	Zimbabwe

The World Bank, 2013a.

Lower-middle-income economies ($1,036 to $4,085)		48
Armenia	India	Samoa
Bhutan	Kiribati	São Tomé and Principe
Bolivia	Kosovo	Senegal
Cameroon	Lao PDR	Solomon Islands
Cape Verde	Lesotho	Sri Lanka
Congo, Rep.	**Mauritania**	Sudan
Côte d'Ivoire	Micronesia, Fed. Sts.	Swaziland
Djibouti	Moldova	Syrian Arab Republic
Egypt, Arab Rep.	Mongolia	Timor-Leste
El Salvador	Morocco	Ukraine
Georgia	Nicaragua	Uzbekistan
Ghana	Nigeria	Vanuatu
Guatemala	Pakistan	Vietnam
Guyana	Papua New Guinea	West Bank and Gaza
Honduras	Paraguay	Yemen, Rep.
Indonesia	Philippines	Zambia

The World Bank, 2013a.

Upper-middle-income economies ($4,086 to $12,615)		55
Angola	**Fiji**	Palau
Albania	Gabon	Panama
Algeria	Grenada	Peru
American Samoa	**Hungary**	Romania
Argentina	Iran, Islamic Rep.	Serbia
Azerbaijan	**Iraq**	Seychelles
Belarus	Jamaica	South Africa
Belize	Jordan	St. Lucia
Bosnia and Herzegovina	Kazakhstan	St. Vincent and the Grenadines
Botswana	Lebanon	Suriname
Brazil	Libya	Thailand
Bulgaria	Macedonia, FYR	**Tonga**
China	Malaysia	Tunisia
Colombia	Maldives	Turkey
Costa Rica	**Marshall Islands**	Turkmenistan
Cuba	Mauritius	Tuvalu
Dominica	Mexico	Venezuela, RB
Dominican Republic	Montenegro	

The World Bank, 2013a.

High-income economies ($12,616 or more)		75
Andorra	French Polynesia	Norway
Antigua and Barbuda	Germany	Oman
Aruba	Greece	Poland
Australia	Greenland	Portugal
Austria	Guam	Puerto Rico
Bahamas, The	Hong Kong SAR, China	Qatar
Bahrain	Iceland	**Russian Federation**
Barbados	Ireland	San Marino
Belgium	Isle of Man	Saudi Arabia
Bermuda	Israel	Singapore
Brunei Darussalam	Italy	Sint Maarten
Canada	Japan	Slovak Republic
Cayman Islands	Korea, Rep.	Slovenia
Channel Islands	Kuwait	Spain
Chile	**Latvia**	St. Kitts and Nevis
Croatia	Liechtenstein	St. Martin
Curaçao	**Lithuania**	Sweden
Cyprus	Luxembourg	Switzerland
Czech Republic	Macao SAR, China	Trinidad and Tobago
Denmark	Malta	Turks and Caicos Islands
Estonia	Monaco	United Arab Emirates
Equatorial Guinea	Netherlands	United Kingdom
Faeroe Islands	New Caledonia	United States
Finland	New Zealand	**Uruguay**
France	Northern Mariana Islands	Virgin Islands (U.S.)

The World Bank, 2013a.