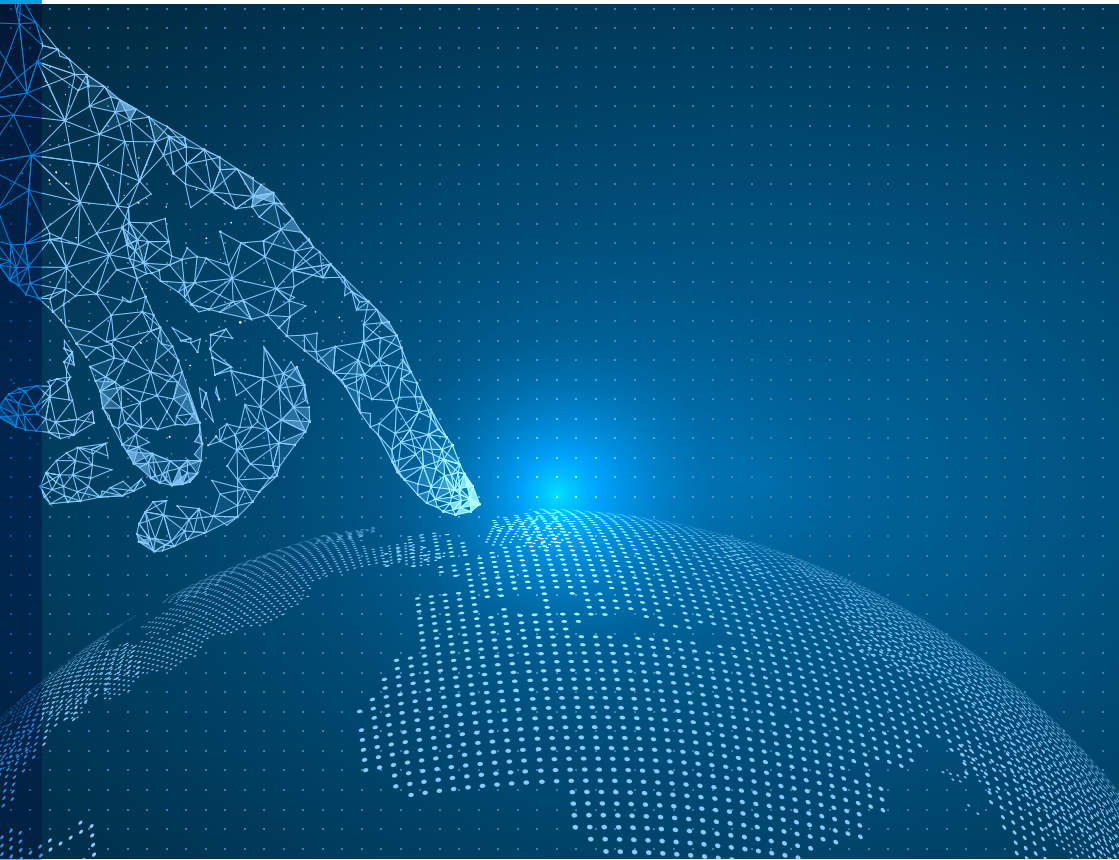


ICT-centric economic growth, innovation and job creation



ICT-centric economic growth, innovation and job creation 2017

Editors: Ahmad R. Sharafat
William H. Lehr



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FOREWORD

I am pleased to present this compelling book on ICT④SDGs, which focuses on ICT-centric economic growth, innovation and job creation. The Sustainable Development Goals (SDGs), adopted in 2015 and referred to as the 2030 Agenda for Sustainable Development, are universal as they embody a universally shared vision of progress towards a safe, just and sustainable space for all human beings.

Telecommunications and information communication technologies (ICTs) cut across all SDGs and are an enabler for growth and development. As the international community works towards achieving the SDGs, it is important to remember that access to ICTs is key to social and economic development: the work of the ITU's Telecommunication Development Sector is therefore essential in achieving the 2030 Development Agenda.

This study, written by leading scholars and experts from around the world, aims to address the challenges and opportunities offered by ICTs in the areas of innovation, governance, education, job creation and economic growth. I highly recommend that all stakeholders, including policy-makers, regulators, operators, and investors, as well as people in the industry and academia, read and use the findings of this study, as it sheds light on some of the greatest opportunities of today's world.

I would like to express my sincere gratitude to everyone involved in the preparation of this book. In particular, I would like to express my appreciation to Dr. A. R. Sharafat (Tarbiat Modares University, Tehran, Iran), Dr. W. H. Lehr (Massachusetts Institute of Technology, Cambridge, Massachusetts, USA), Dr. T. Unwin (Royal Holloway, University of London, London, United Kingdom), Dr. E. Giovannetti

ICT-centric economic growth, innovation and job creation

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Brahima Sanou

Director

Telecommunication Development Bureau (BDT)

International Telecommunication Union

PREFACE

The idea for this book emerged not long after the United Nations adopted the expanded set of Sustainable Development Goals (SDGs) in 2015 that were intended to motivate and coordinate international development efforts through 2030. As anyone who has been involved in Information and Communication Technologies (ICTs) has long known, and increasingly everyone else involved in development efforts now recognizes, ICTs are permeating all aspects of the global economy and society. ICTs are transforming how all goods and services – not just digital or information goods - are designed, produced, distributed, and sold. They are transforming how citizens, consumers, industry, and governments acquire and share knowledge about the world. To participate in the global information economy, one has to be a digital citizen. ICTs must play a central role in developing solutions to address climate change, respond to growing global competition, and to meet the rising expectations and needs of all segments of society, including the poorest, least skilled, or otherwise marginalized.

ICTs will also cause disruptions in traditional economic and social structures, resulting in Digital Divides, that will need to be navigated and the pains of disruptions mitigated if the positive benefits that ICTs promise are to be realized. Although the potential for ICTs to contribute positively is well-established, ICTs accelerate and amplify changes that can also be negative if not countered. For example, ICTs can accelerate growing income disparity and foster winner-take-all economics if explicit efforts to ensure inclusion, universal accessibility, and support for skills development are not adopted. In short, achieving the SDGs will require designing and adopting ICT-centric strategies for economic growth, employment opportunities, government policies, regulatory frameworks, markets, and education.

Whereas much of the earlier literature and efforts related to ICTs in development focused on the deployment of basic telecommunication and ICT infrastructure, the challenges facing the development potential in the global digital economy are much far-reaching and extensive. The SDGs focus on such lofty goals as eliminating poverty, improving participation in government, and building a healthy society and economy that is environmentally sustainable. Although ICTs are critical to the achievement of the SDGs, the SDGs do not explicitly address targets for ICTs nor explain how ICTs may best be employed to promote achievement of the SDGs.

As the United Nation's ICT development partner, the ITU Development Sector (ITU-D) has a central role to play in helping to promote and coordinate the effective use of ICTs in achieving the SDGs. Consequently, in anticipation of the ITU-D's 25th Silver Jubilee Anniversary and the World Telecommunications Development Conference (WTDC-17) in Buenos Aires in October 2017, the plan to prepare this book emerged. The goal was to assemble in a single volume, accessible to all development stakeholders, including both those new to development efforts as well as seasoned professionals, a fresh and realistic assessment of the social and economic implications of ICTs for SDGs, and to offer practical guidance on how best to ensure ICTs further progress toward the SDGs. An international team of experts drawn from diverse academic and professional backgrounds was assembled and together hammered out a framework for collecting an integrated set of complementary perspectives in a single resource. Each of the authors was tasked with providing a focused look from a distinct perspective to cover select aspects of the ICT④SDGs challenge. The perspectives and approaches range from academic discourses on the theoretical and empirical research to reviews of current trends and practices so as to consider and collect in a single, integrated volume the multiple ways in which ICT strategies need to be addressed to be successful. Individual chapters focus on summarizing the theoretical and empirical evidence of ICT impacts, on the role of government, on the design of a healthy innovation ecosystem, on the role of ICTs in education, and several other topics.

ICT-centric economic growth, innovation and job creation

Over two years, the team of experts collaborated in reviewing and commenting on each other's chapters, in sharing sources, and in helping to assemble a collection of illustrative case studies that supplement the main text. The chapter authors were supported in their efforts by the ITU and benefited from their discussions and outreach with their colleagues in the academic and professional communities where they each have their principal homes. We are honored to have been part of this project and are pleased with the result. We believe it will provide a good foundation and resource for on-going work on developing ICT-centric strategies for the development community in the years to come. Thus it is with pleasure that we present you with *ICT-centric economic growth, innovation and job creation*.

We are indeed grateful to Mr. Brahima Sanou, Director of Telecommunication Development Bureau (BDT) in the International Telecommunication Union (ITU) who initiated the project and provided us with encouragement and support to the fullest extent. He engaged academia in a meaningful and unprecedented manner in this journey and opened new opportunities for partnership with ITU. This work could not have come to this point without the passionate and unwavering engagement and support by Dr. Eun-Ju Kim, Chief of Innovation and Partnership Department (IP) and Administrator of ICT Development Fund (ICT-DF) in BDT/ITU, for which we are sincerely thankful. Our thanks also go to the renowned and outstanding scholars and scientists who collaborated in an exemplary way with us and authored different chapters. Finally, we would like to express our deep appreciation to Ms. A. Maia-Reboucas, Mr. M. Ba, Ms. M. A. Mozer Corral, and Mr. M. Adea in the ITU who helped us enormously by providing expert advice and ardent support throughout the entire process.

Ahmad R. Sharafat &

William H. Lehr (Editors)

Table of Contents

FOREWORD	i
PREFACE	iii
1 - ICT Engines for Sustainable Development	1
1.1 Background	1
1.2 Sustainability: The New Focus in Development	3
1.3 Review of Research Evidence of ICT Impacts	11
1.4 ICT Ecosystem	23
1.5 Motivation: Need an Agenda for Action	26
1.6 Conclusions and Organization of This Book	29
2 - ICTs, Sustainability and Development: Critical Elements...	37
2.1 Introduction	37
2.2 ICTs, Sustainable Development and SDGs	39
2.3 Essential elements for Successful Application of ICTs for Sustainable Development	49
2.4. Stakeholders and Partnerships in Delivering SDGs	58
2.5 Concluding Remarks: ICTs in Sustainable Development	61
Appendix A - The World Economic Forum's Global Education Initiative	66
3 - Digital Divide and Digital Multiplier: A Paradigm Shift through Innovation	72
3.1 Introduction	72
3.2 Innovation Ecosystems	74

ICT-centric economic growth, innovation and job creation

3.3 Examples of ICT-Centric Innovation Ecosystem and Their Relevance to SDGs	81
3.4 Roadmap to Enhance Digital Multipliers	87
3.5 Concluding Remarks	89
Appendix A Fostering Innovation in Indian Institute of Technology Madras Research Park	95
4 - The Role of Governments in ICT-Based Sustainable Development	109
4.1 Introduction.....	110
4.2 Outline	110
4.3 Objectives and Goals	112
4.4 The Organization of Governments and ICTs.....	119
4.5 ICT Market Policy	123
4.6 Non-ICT Markets Policy	156
4.7 Conclusion	181
5 - Business Models for ICT-Centric Sustainable Development	193
5.1 Introduction.....	193
5.2 Business Models for ICT-Based Innovative Ventures	197
5.3 Current Concepts in ICT-Based Products and Services ...	199
5.4 Business Model Design	204
5.5 Conclusion	210
6 - Job Creation and Sustainable Development	214
6.1 Introduction.....	2155
6.2 ICT Contribution to Job Creation	215

ICT-centric economic growth, innovation and job creation

6.3	ICT Contribution to Labor Conditions	230
6.4	Public Policy Implications	232
6.5	Concluding Remarks	236
7	- The Future of ICT-driven Education for Sustainable Development	239
7.1	Introduction.....	239
7.2	Education at Global Scale: Lifelong Learning, MOOCs and Education Hubs	242
7.3	The Future of ICT Curriculum and Content: The Innovation Imperative.....	250
7.4	Conclusion	255

Chapter 1

ICT Engines for Sustainable Development

*Ahmad R. Sharafat** *and* *William H. Lehr***

This chapter discusses the origins of the Sustainable Development Goals (SDGs) and their evolution from the preceding Millennium Development Goals (MDGs). A review of the literature on the socio-economic impacts of ICTs provides broad support for concluding that ICTs will have a significant impact on the realization of SDGs. The focus of this chapter is to highlight the range of coordinated actions that are required to promote positive ICT-centric innovation, job creation, and economic growth. This chapter also presents an overview of the ICT ecosystem, the organization of the book, and a summary of some of the key themes addressed.

1.1 Background

At the beginning of the new millennium, a summit of world leaders met at the United Nations in New York in September 2000 to adopt a set of Millennium Development Goals (MDGs) that were directed toward alleviating poverty and ameliorating the widening gap between the rich and poor that threatens the future of humanity and the planet. The MDGs established a set of eight goals for improving the lives of people in the least developed nations over the next fifteen years (see Table 1).

In 2015, the United Nations (UN) took stock of the progress made toward meeting the MDGs (United Nations, 2015a). Relative to 2000,

* Tarbiat Modares University, Tehran, Iran

** Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, USA

Table 1: Millennium Development Goals for 2000 to 2015

GOAL 1:	Eradicate extreme poverty and hunger
GOAL 2:	Achieve universal primary education
GOAL 3:	Promote gender equality and empower women
GOAL 4:	Reduce child mortality
GOAL 5:	Improve maternal health
GOAL 6:	Combat HIV/AIDS, malaria and other diseases
GOAL 7:	Ensure environmental sustainability
GOAL 8:	Develop a global partnership for development

Source: United Nations (2015a).

the UN noted that more than one billion people have been lifted out of extreme poverty and inroads have been made against hunger,¹ more girls have attended school than ever before,² new and innovative partnerships have been formed, and decision making in developed and developing countries has been reshaped. Nevertheless, in spite of these important accomplishments, none of the MDGs have been fully achieved. Inequalities persist and progress has been uneven. For example, the majority of the world's one billion extremely poor people live in just five countries, women continue to suffer from inadequate health and sanitation facilities, and disparities between rural and urban areas remain significant. Further progress requires renewed political will, and collective, long-term and coordinated efforts by all stakeholders to ensure that appropriate development goals are adopted and pursued.

In 2012, world leaders, including heads of state and civil society representatives, met in Rio de Janeiro to renew their joint efforts to

¹ In the developing countries, the proportion of the population living on less than \$1.25 per day declined from nearly half in 1990 to 14% by 2015, and over the same period, the proportion of undernourished people fell from 23% to 13% (United Nations, 2015, p. 4).

² Primary school net enrolment rates increased from 83% in 2000 to 91% in 2015 in developing regions, and the ratio of girls-to-boys enrolled in schools in Southern Asia has risen from 0.74 to 1.03 from 1990 to 2015 (United Nations, 2015, p. 4).

promote an economically, socially, and environmentally sustainable future for our planet and for present and future generations. The manifest that emerged from this meeting, called “The Future We Want,” articulates the participants’ common vision and established a charge to develop a new set of Sustainable Development Goals (SDGs) for the post-2015 era (RIO+20, 2012).

In 2015, senior government representatives met at the United Nations headquarters in New York to adopt a resolution by the General Assembly for transforming our world: the 2030 Agenda for Sustainable Development (United Nations, 2015b) (see Table 2).

The 2030 Agenda also announced a total of 169 specific targets to accompany the 17 SDGs. In addition to expanding the number of development goals from 8 to 17, which included several SDGs that specifically address planet-survival sustainability issues, the assembled representatives also agreed to target the goals more broadly. Whereas the MDGs were focused on the least developed countries, the SDGs are intended to apply to all nations.

1.2 Sustainability: The New Focus in Development

The common thread across the 17 SDGs is sustainability in its multiple dimensions. First and foremost, the development goals have to consider the sustainability of resources, including the health of the planet (environmental sustainability). In addition to protecting the natural environment, it is also important to consider how to ensure that the development goals are economically viable (economic sustainability) and consistent with sound public policies that support healthy governance systems (social and political sustainability). Although the SDGs overlap and achieving sustainability in each of the three senses noted above (environmental, economic, and social/political sustainability) is important for each of the SDGs, some SDGs emphasize one aspect more than others. For example, SDGs 13-15 emphasize the importance of environmental sustainability and the need to take action to address climate change, promote biodiversity, and protect our forests and oceans; whereas SDGs 4, 8, 9, and 12 focus more on ensuring economic sustainability by promoting goals designed

ICT-centric economic growth, innovation and job creation

to expand productive economic opportunities for all people; and SDGs 1, 3, 5, 11, 16, and 17 target issues impacting social and political sustainability by focusing on the stability, security, and openness of our social and political institutions, the rule of law, and policy processes.

Table 2: Sustainable Development Goals

GOAL 1:	End poverty in all its forms everywhere
GOAL 2:	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
GOAL 3:	Ensure healthy lives and promote well-being for all at all ages
GOAL 4:	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
GOAL 5:	Achieve gender equality and empower all women and girls
GOAL 6:	Ensure availability and sustainable management of water and sanitation for all
GOAL 7:	Ensure access to affordable, reliable, sustainable and modern energy for all
GOAL 8:	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
GOAL 9:	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
GOAL 10:	Reduce inequality within and among countries
GOAL 11:	Make cities and human settlements inclusive, safe, resilient and sustainable
GOAL 12:	Ensure sustainable consumption and production patterns
GOAL 13:	Take urgent action to combat climate change and its impacts
GOAL 14:	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
GOAL 15:	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
GOAL 16:	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
GOAL 17:	Strengthen the means of implementation and revitalize Global Partnership for Sustainable Development

The development community has come to recognize that without ensuring sustainability, all development efforts will be short-lived, and may cause more harm than good. One may argue that economic development comes at the cost of consuming more resources, with undesirable consequences on the environment such as climate change. As we will describe in this book, development efforts that are based on utilizing information and communication technologies (ICTs) have the potential to be significantly more environmentally friendly, consuming fewer resources, requiring less capital expenditure, and creating more jobs than might be achieved in the absence of ICT-fuelled growth strategies. However, if not used effectively, ICTs may actually make things worse.

The research literature on the socio-economic impacts of ICTs is extensive and provides ample evidence of the transformative potential of information and communication technologies for society and the economy.³ While empirical evidence demonstrates that the positive effects of ICTs in terms of driving economic growth, enhancing efficiency, and expanding markets are large; ICTs may also contribute to social and economic problems by accentuating equity divides and increasing the market power of dominant firms. Managing the growth of ICTs so the net social benefits are maximized presents a complex challenge.

A key characteristic of ICTs is that they facilitate richer, faster, and more flexible communications and decision-making by enabling electronic communication, information gathering, computation, and control at a distance. ICTs make it possible to share information more widely and more quickly, expanding the reach of markets across all components of economic production chains – from final goods and services to raw materials, from domestic commerce to international trade. This makes it feasible to more flexibly and dynamically reconfigure, and hence transform all aspects of how resources are

³ For example, see Bresnahan et al. (2002), Cardona et al. (2013), Gruber et al. (2014), Jorgenson (2001), Katz (2012), OECD (2004), Spiezza (2013), Van Reenen et al. (2010), Waverman et al. (2005), and World Bank (2016). The empirical evidence is discussed further below.

produced and used, fundamentally restructuring the economy and redefining how we as humans interact with each other and the world around us.

ICTs enable just-in-time production, outsourcing, “market-of-one” customization,⁴ and a host of other innovations that have helped expand inclusion, enabled flexibility in production, including labor flexibility, and expanded consumer choices, lowered quality-adjusted prices,⁵ and contributed to consumer welfare gains globally. The rise of business-to-business (B2B) and business-to-consumer (B2C) electronic commerce has revolutionized how commerce is organized within firms, across industries, and globally; helping to promote and sustain a huge expansion in international trade. On the one hand, this offers the promise of realizing specialization, scope, and scale economies on a global level. The ability to share information makes it feasible for lagging countries to catch up more quickly, and potentially leapfrog earlier generations of technical development,⁶ as good practices can be shared more readily. The increased dynamism of information-fuelled market decision-making may reduce entry barriers and foster innovation as entrepreneurs may exploit the ICT-enabled markets to rapidly scale

⁴ ICTs make it feasible to customize the production of goods and services to satisfy the demand associated with individual transactions (i.e., “market-of-one”). For example, on-line platforms exist to allow consumers to purchase made-to-order clothing, to match workers with jobs on a per-task basis, or to negotiate prices on a per-unit basis.

⁵ The benefits of ICTs in reducing consumer prices is evident in, but not limited to, technology intensive products. The price/performance of personal computers, cell phones, and other digital goods has fallen dramatically over time. In addition, the Internet allows consumers to compare prices and goods to better identify low-price suppliers (a price benefit) and goods that more closely match their tastes and requirements (a quality benefit). On the other hand, firms with market power may use ICTs to more effectively price discriminate so as to capture consumer surplus; and in the absence of effective competition policies, may abuse ICTs to collude.

⁶ ICTs accelerate the obsolescence of older technologies, creating a late-comer advantage for more recent adopters that can help close development gaps.

their businesses.⁷ Increasingly and worldwide, all sizes of businesses, but especially Small and Medium Enterprises (SMEs), are taking advantage of ICT-enabled capabilities and online platforms to enter new markets, better manage their operations, and communicate better with suppliers and customers. Governments can use ICTs to improve their ability to communicate with citizens and expand the delivery of government services. ICTs have a critical role to play in the real-time management of essential infrastructures from the management of energy grids to transportation networks, from water systems to public safety. The positive benefits that ICTs can potentially deliver in the future and have already delivered is evident in the progress we have collectively made toward realizing the MDGs discussed earlier.

While the potential benefits of ICTs for achieving the SDGs are significant, their realization depends on the existence of complementary elements.⁸ First, the basic ICT infrastructure needs to be in place. Today, that implies universal access to mobile broadband services, and that requires that access be available, affordable, and adopted.⁹ Simply having ICT equipment and facilities in-place does not produce benefits unless ICTs are used, and used effectively. Across the world, significant gaps in availability of basic ICT infrastructure persist, and while less

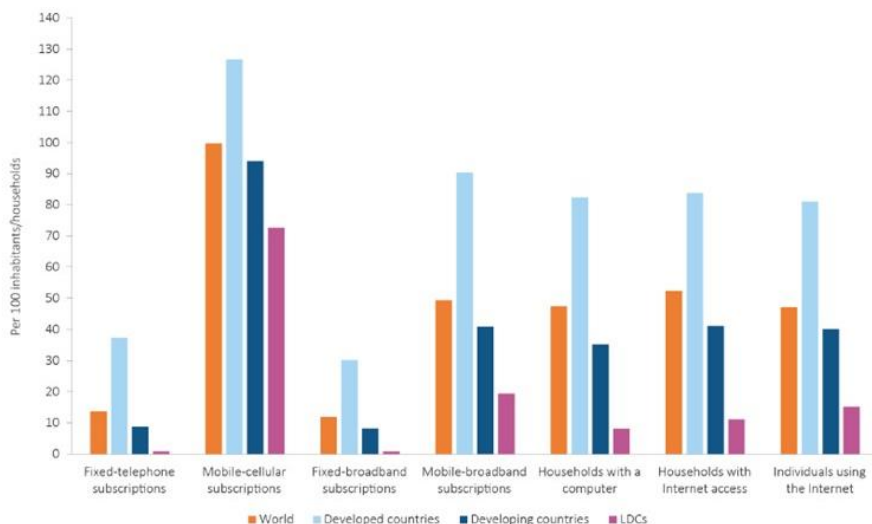
⁷ ICTs may also create informational asymmetries that can strengthen the competitive advantages of incumbents. Consequently, the impact of ICTs on competition depends on multiple factors and hence are inherently ambiguous.

⁸ The World Bank refers to these complementary components as the “analog” complements for the digital economy (see page 29, World Bank, 2016).

⁹ In the development literature, these terms may be used in multiple ways. Here, *availability* refers to the need to ensure that the basic infrastructure and services are in place so that the potential exists for users to access the services. If a country has no mobile networks, then there cannot be any mobile service subscribers. *Affordability*, or accessibility, refers to the necessity for additional complementary factors that make it feasible for users to adopt ICTs. If users cannot afford the services or requisite devices or lack the skills to use ICTs or awareness of the benefits of using ICTs, then users will not adopt and use the ICTs. If mobile broadband services are too expensive or potential users do not know how to use the devices or services, then they will not adopt the service. Finally, *Adoption* refers to the necessity of users actually acquiring and using the ICTs for the ICTs to have any material impact on economic and social outcomes.

ICT-centric economic growth, innovation and job creation

developed countries are closing the gap with respect to basic services, the quality and capabilities of the ICT infrastructure and services in the most advanced countries continues to raise the bar in system performance (see Figure 1). Thus, whereas much of the world's population has basic cell phone coverage, the goal now is to expand access to mobile broadband that has greater capabilities, capacity, and is more energy efficient.¹⁰



Notes: * ITU estimates.

Figure 1. ICT Penetration Levels by Level of Development¹¹

¹⁰ While basic Internet and mobile phone adoption is approaching saturation in most developed countries and growth in new subscribers has slowed, the growth in adoption and new subscribers in the developing world is much higher, but that is because significant digital divides continue to exist. Moreover, the pace of growth toward what ultimately is hoped to be close to 100% adoption for basic Internet, mobile phone and mobile broadband is much faster than the pace for adopting improved water, electricity, secondary school (see World Bank, 2016, p. 5-6). However, at the same time that basic access gaps are narrowing, gaps measured in other ways are widening (e.g., in terms of monthly data usage).

¹¹ See Chart 1.3: ICT Penetration Levels by Level of Development in ITU (2016), “Measuring the Information Society Report 2016,” International Telecommunications Union (ITU), available at <http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2016/MISR2016-w4.pdf>

ICT infrastructure alone, however, is not sufficient to realize the benefits of ICTs. Consumers and workers need to have access to devices and applications and have the requisite skills to utilize ICTs effectively; businesses need to adopt ICT-appropriate business practice reforms; and civil society and government institutions and policies need to be in place to support and encourage the beneficial changes that ICTs may bring, while helping to ameliorate and avoid the problems that ICTs can bring. On the positive side, there is the promise of economic growth expanding the global resource bounty that all might share. The ICT-enabled flexibility in organizing workplaces can expand to support gender equality and allow persons with disabilities or rural communities that are distant from markets to participate in economic activities. ICTs can expand leisure and allow consumers access a greatly expanded global shelf-space of goods and services. ICTs can improve the monitoring and control of how services from healthcare to power plants, from agriculture to government are managed. ICTs can expand inclusion and facilitate SME entry into markets by enabling secure digital identities that can help in providing access to financial resources, support for better transaction management, and help in securing markets from fraud.

On the negative side, imbalances in access to ICTs and the requisite complementary assets such as skills, can lead to unbalanced growth and increased economic and social inequalities. At best, inadequate attention to complementary assets will render investments in ICTs ineffective. Broadband access to a household without a device to make use of it, or the opportunity for a business to make use of B2B eCommerce platforms that cannot hire employees with the right skills to make use of the platform will prevent realization of the ICT benefits that might otherwise be realized.

At worst, ICTs may actually harm delivery of the SDGs. For example, ICTs currently account for approximately 10.5% of global energy consumption, and with the growth in ICTs intensity worldwide, are expected to consume upwards of 21% (or as much as 52%) by some forecasts unless ICTs become substantially more energy efficient (Andrae and Edler, 2015). ICTs will need to meet this challenge if they are not to become a significant contributor to climate change problems

and sustainability in their own right. Luckily, the history of ICT innovation reflected in Moore's Law in price-quality performance, which has characterized the history of ICTs more broadly, provides hopeful signs that ICTs can meet this challenge. For example, the evolution of cellular systems from second generation (2G) in 1991 to fourth generation (4G) systems in 2013 has resulted in a 175-fold improvement in spectral efficiency and reduced power requirements per data bit transferred (Clarke, 2014). Although these improvements do not translate directly into greener ICTs, the engineering community has identified multiple promising strategies for significantly improving the energy efficiency of ICTs (Bolla et al., 2011; Fettweis et al., 2008). In addition to becoming more energy efficient themselves, ICTs also are expected to play a critical role in ensuring all sectors of the economy become more energy efficient – a necessary requirement if global aspirations for improving quality of life are to be realized sustainably.¹²

ICTs and the rise of the global Internet necessarily focus attention on cybersecurity and the looming challenge that unreliable or insecure ICT infrastructure and services pose for social and political sustainability. As more and more of our basic infrastructure from traffic to power grids and business and government operations become increasingly dependent on ICTs, attacks on those ICTs pose a growing threat that will have to be addressed if the gains from ICTs already realized are to be sustained and future benefits realized. If citizens and consumers do not trust ICT services and those who provide them, then ICT driven market growth will stagnate and accentuate development gaps relative to markets where trust is better assured.

Another threat to sustainable development is rooted in the very efficiency gains that ICTs promise. Although the ability to automate many tasks is a fundamental vector by which ICTs can contribute to economic growth, the threat that future jobs may be done by machines (e.g., via artificial intelligence, etc.) instead of people poses a

¹² For example, a 2015 study by the Global e-Sustainability Institute estimated that ICTs have the potential to cut global carbon dioxide emissions by 20% by 2030, maintaining 2015 levels. (GeSI, 2015).

significant challenge for the future of work and social and political sustainability.

Finally, and perhaps most important, if the ICT-enabled economic growth proceeds without complementary improvements in the sustainability with which we use other resources, the expansion in global consumption of resources from water to energy will pose an even greater challenge. For example, although “global energy intensity, calculated in terms of final energy use per unit of gross domestic product (GDP), fell by 26% between 1990 and 2005,” final energy use per capita increased, principally due to the “growing wealth which leads to increased per capita demand for energy-using goods and services” (page 15, IEA, 2008). The energy use by data also highlights the significant differences in per capita energy use by rich and poor countries (Figure 2). ICTs have the potential to accelerate and amplify threats to our environment, security, and sense of well-being that may not be directly due to ICTs but may be worsened because of ICTs.¹³

ICTs make the world a smaller place. They have the potential to address challenges on an increasingly local level – customizing solutions to the needs of particular circumstances in time, space, and context – but also increasing the potential for interactions at a distance. Promoting ICTs that will succeed in advancing SDGs is a complex global challenge that will require coordinated efforts by stakeholders across the ICT-centric ecosystem. The right infrastructure will need to be matched with the right business practices, consumer awareness and trust in the innovations, and supportive government policies and institutions that will allow market processes to proceed efficiently.

1.3 Review of Research Evidence of ICT Impacts

In the following sub-sections, we review the evidence in the economic

¹³ If global consumption grows without further decoupling of energy demand and growth, if criminals or dictators are successful in their attempts to use ICTs to extend their reach and power, or if the explosion of unfiltered information confuses and frightens rather than informs citizens, then ICTs may aggravate existing problems.

literature on the empirical economic impacts that ICTs have had already on growth and the distribution of its benefits.

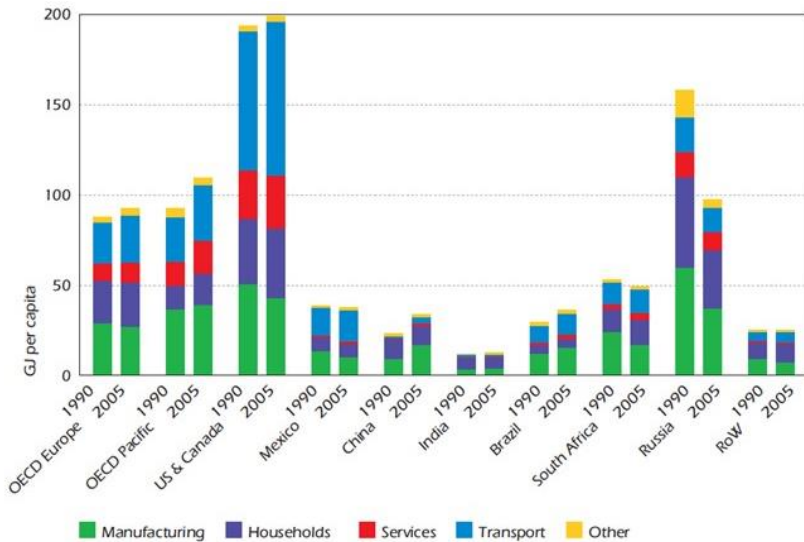


Figure 2. Total Energy Consumption per Capita, 2008¹⁴

1.3.1 ICT Contributions to Economic Growth

There is a sizable research literature documenting the significant contributions that ICTs have made to economic and productivity growth and efficiency at the macroeconomic and microeconomic levels. This is documented in numerous econometric studies of ICT impacts in cross-national, national, industry, and firm-level analyses; as well as numerous case study investigations of how ICTs transform productive activities.¹⁵ While the overall conclusion is clear, the results vary widely and precise characterization or quantification of the effects is

¹⁴ See Figure 2.6: Total Final Energy Consumption per Capita in IEA (2008), “Worldwide Trends in Energy Use and Efficiency,” International Energy Agency (IEA), available at https://www.iea.org/publications/freepublications/publication/Indicators_2008.pdf. Note: Other in Figure 2.6 includes construction and agriculture/fishing.

¹⁵ See Note 4 *supra* for list of cites to survey articles and seminal research on the economic impacts of ICTs.

difficult for numerous reasons.¹⁶ First, ICTs are one of many inputs to productive activities and so measuring their impact on outputs such as GDP output or jobs is inherently difficult.¹⁷ Moreover, ICTs contribute to production in multiple ways – enhancing the efficiency of other inputs such as labor (e.g., by enabling skilled employees to shift attention from routine tasks that are automated to more complex tasks, thereby increasing the productivity of labor, capital (e.g., by allowing excess capacity to be more flexibly redirected to producing goods for other markets), and changing the fundamental ways in which resources are used (e.g., by allowing businesses to re-organize).

Second, the share of ICT factor inputs in total production is relatively small in monetary terms, which makes it difficult to measure ICT inputs accurately. This difficulty is further complicated by the rapid pace of ICT innovation and performance-price declines.¹⁸

Third, ICTs have the potential to be general purpose technologies – basic infrastructure for the economy – that can be used for many different productive activities within an organization and so the impacts of using ICTs spill over across the organization and its operations both upstream with suppliers and downstream to consumers (Bresnahan and Trajtenberg, 1995). For example, B2B eCommerce platforms can allow

¹⁶ In 1987, economist Robert Solow famously remarked that “you can see the computer age everywhere but in the productivity statistics.” One of the key reasons for this was the lack of suitable data to address the inherent measurement challenges. Using firm-level data, Brynjolfsson (1996) and Lehr and Lichtenberg (1999) demonstrated excess returns from investments in ICTs, and Jorgenson (2001) concluded that ICT investment explained a significant share of U.S. economic growth after 1995.

¹⁷ A key theme of this book is the need to coordinate policies and ensure that the necessary complementary assets are in place to enable ICTs to be productive. Subsequent chapters focus on a number of these, including ensuring a healthy environment for innovation (see Chapter 3), receptivity for new ICT-business models (see Chapter 5), and appropriate support for education and ICT skills development (see Chapter 7), among others.

¹⁸ To estimate productivity effects in value terms it is necessary to measure both the quantity and price of the ICT inputs accurately. When the volume of inputs is small, measurement errors loom larger. Identifying appropriate prices is difficult because the rate of economic depreciation is high.

businesses to source labor and other resources more efficiently and at lower costs; mobile phones can provide anywhere access to market relevant information to enable businesses to better manage their distribution chains; business decision systems enhance back-office operations from accounting to payroll management; and computer-aided manufacturing can directly contribute to the production of goods. The potential for ICTs to support innovation and industry, market, business, and production process restructuring is discussed further in Chapter 3.

Taken together, these measurement challenges have rendered it difficult to precisely quantify the economic impacts of ICTs.¹⁹ The best estimates available are for more developed countries where the ICT sector is larger (and hence measurement issues are less severe), where there is a longer history of ICTs in productive use (and hence more time for the impacts to be observed), and where the necessary data is more readily available. For example, in a classic study, Jorgenson (2001) estimated that ICTs added 1.2% to GDP growth and accounted for two-thirds of the total factor productivity growth from 1995 to 2000, thereby contributing to the explanation of the resurgence in economic growth in the United States in the latter half of the 1990s.²⁰ Moreover, countries that did not use ICTs tended to not perform as well. Fuss and Waverman (2005) attributed 60% of the slower labor productivity growth experienced by Canada (relative to the US) in 2003 to Canada's less intensive use of ICTs.

Although the results of studies vary significantly because of differences in focus, estimation methods, data sources, and the time frames studied, the general conclusion that ICTs have contributed significantly positively to economic growth and productivity outcomes at the economy, sector, and firm-level is generally well-supported in the literature. For example, the World Bank (2016) concluded that “the

¹⁹ The challenge of measuring positive economic effects in the face of continued significant investment in ICTs by businesses has been termed the Solow Paradox after Nobel-prize-winning economist Robert Solow's famous 1987 quip that “you can see the computer age everywhere but in the productivity statistics” (Solow, 1987).

²⁰ Jorgenson (2001).

accumulation of ICT capital accounted for almost 20 percent of global growth between 1995 and 2014,”²¹ but notes that these studies result in a wide range of estimates. Other surveys which find both a wide-dispersion in estimates, but also support the general conclusion of significant positive effects include Cardona et al. (2013), Katz (2012), Spiezia (2013), and Van Reenen et al (2010).

Although the empirical evidence is less extensive, ICTs generally have been found to produce similarly positive economic impacts in studies that focus on less developed countries (Stanley et al., 2015; Aker and Mbiti, 2010, BIRTHAL et al., 2015; Fu and Akter, 2016).²² Indeed, because the level of adoption and ICT capital stocks and investment are lower in developing countries, there are likely to be an ample supply of under-exploited opportunities that have the potential to deliver high social returns from strategic ICT investments, even if macroeconomic studies may fail to detect significant effects until critical mass is achieved.²³

Moreover, while more recent studies conclude that ICTs are still adding significantly to economic and productivity growth, the contribution is at a lower level than what was observed before 2005, leading some to downplay the potential of ICTs to drive economic transformations and

²¹ World Bank (2016), p. 55.

²² The developing market evidence is less well-established for multiple reasons. First, reliable data is typically harder to acquire for developing countries. Second, because the availability of ICTs is of more recent vintage and adoption is lower, measurement errors make it more difficult to estimate effects precisely, and can result in failure to observe measurable effects. Also, since it takes time for the effects of ICTs to percolate through the economy, the full impacts have yet to be observed in many markets. Third, the status of other infrastructures and complementary assets (such as well-established legal frameworks, well-developed industry supply-chains, etc.) that are required to exploit ICTs productively tend to be less advanced in developing markets.

²³ Koutroumpis (2009) and Roller & Waverman (2001) found that a critical level of adoption needs to be achieved before broadband access produces significant measurable economic growth impacts. While it is certainly plausible that certain types of ICTs, including broadband, may demonstrate such a characteristic, it is also plausible that this effect is due to measurement errors that fail to capture the high-returns that may be associated with strategically targeted investments in low ICT development contexts.

faster economic growth (Gordon, 2000, 2014). If global economic growth is slower, then it will be more difficult to raise living standards and reduce equity divides. This will make it harder to make progress toward realizing the SDGs.²⁴

Across most countries, ICT intensity is increasing.²⁵ This is evidenced by the near universal availability of mobile telephone services and the rapid expansion in availability of broadband services. For example, mobile broadband adoption globally was minimal in 2007, but had risen to 40.9% by 2016; although differences between and within countries are large – with adoption exceeding 90% in developed countries but only 19% in less developed countries.²⁶ Moreover, the digital divides²⁷

²⁴ Economists are not in agreement whether economic productivity growth will return to the higher rates observed during earlier periods, and what the role of ICTs will be. For example, Brynjolfsson and McAfee (2014) tout the ability of robots and other ICT innovations like Big Data to deliver significant productivity improvements; and Branstetter and Sichel (2016) note that productivity growth has stagnated in the past before returning to robust levels and note that innovation in the ICT sectors continues at a rapid pace. Meanwhile, Acemoglu et al. (2014) find that data on ICT-intensive manufacturing in the U.S. raises concerns about whether ICTs are driving beneficial productivity outcomes.

²⁵ Digital intensity may be measured in multiple ways. For example, the ITU uses digital intensity to refer to the level of ICT usage and adoption and measures it with three indicators: % of population using the Internet; number of fixed broadband lines per capita; and the number of active mobile broadband subscriptions per capita (ITU, 2016, p. 9).

²⁶ See Broadband Commission for Sustainable Development (2016).

²⁷ We are using the term *Digital Divides* here as short-hand to refer to differences in access and/or adoption of digital infrastructure and services. Such differences may be measured in many ways and are often summarized in terms of a weighted index of multiple indicators. These are sometimes referred to as e-Readiness indices and may include measures such as the number of computers per capita, Internet access penetration, mobile network coverage by technology generation, etcetera. Examples of such indices include the ITU's ICT Development Index (IDI), which is a composite measure of ICT infrastructure and access indicators, ICT use or intensity indicators, and ICT capability or skill indicators (ITU, 2016); the Economist Intelligence Unit's digital economy or e-Readiness rankings index, which is based on a weighted index of metrics clustered into multiple categories, including Connectivity and Technology Infrastructure, Business Environment, Social and Cultural Environment, Legal Environment, Government Policy and

are large within countries and across industrial sectors. The ICT sectors themselves and certain other sectors like finance and insurance are heavy users of ICTs, whereas certain other sectors like agriculture and construction have been relatively slower adopters. Moreover, the poor, rural, less educated, elderly, women and persons with disabilities also tend to be less likely to be using ICTs. Addressing these digital divides and making sure that digital literacy is widespread will be critical if ICTs are to reduce rather than accentuate inequalities.

A key feature of digital technologies is that adoption can occur quite quickly once the infrastructure is in place, which raises hope that digital divides might be closed relatively fast and that the gaps between developed and less developed economies may narrow.

Because the ICT sector represents a small share of the total economy (about 6% of OECD countries, but a much lower share in developing countries) and ICT jobs tend to require higher skills and education, the potential for ICTs to lead to job growth is greatest in other sectors (see Figure 3).

Moreover, since ICT workers tend to be both better skilled and better paid, their increased income helps fuel job growth throughout the economy (see Table 3). One study conducted using U.S. data found that each new ICT job resulted in 4.9 additional jobs in other sectors (Moretti & Thulin, 2013).

In addition to producing significant benefits in terms of economic and productivity growth and jobs, ICTs also help deliver significant benefits in consumer surplus. On-line information and markets make it feasible for consumers to compare prices and product features from a wider selection of vendors, not just those locally available but potentially from around the world. The increased competition fuelled by ICTs

Vision, and Consumer and Business Adoption (EIU, 2010); the European Union's Digital Economy & Society Index (DESI) which includes measures of connectivity, human capital, use of the Internet, integration of digital technology, and digital public services (see <https://ec.europa.eu/digital-single-market/en/desi>); or the World Wide Web Foundation's WebIndex that seeks to measure the Web's global impact with a series of indicators on social, political, and economic metrics related to use of the Web (see thewebindex.org).

helps enhance the quality/performance of goods and services, while driving down prices. A study using U.S. data concluded that the median individual in the U.S. saves \$3,000 annually because of the Internet (Goolsbee and Klenow, 2006); while a Boston Consulting Group study found “that the value consumers place on mobile technologies ranges from \$700 to \$6,000 per user” (BCG, 2015).²⁸

1.3.2 ICTs and Skill Biases

ICTs can both complement and substitute for labor in the production of goods and services. ICTs are most likely to complement higher-skilled workers and hence there is a skill bias associated with ICT-centric economic growth. The benefits of ICTs for higher-skilled and better-educated workers can come in several forms. On the one hand, ICTs can free more skilled workers from time-consuming routinized tasks and allow them to direct their efforts to more complex, cognitively machine tool may be able to out-produce a number of manual laborers.

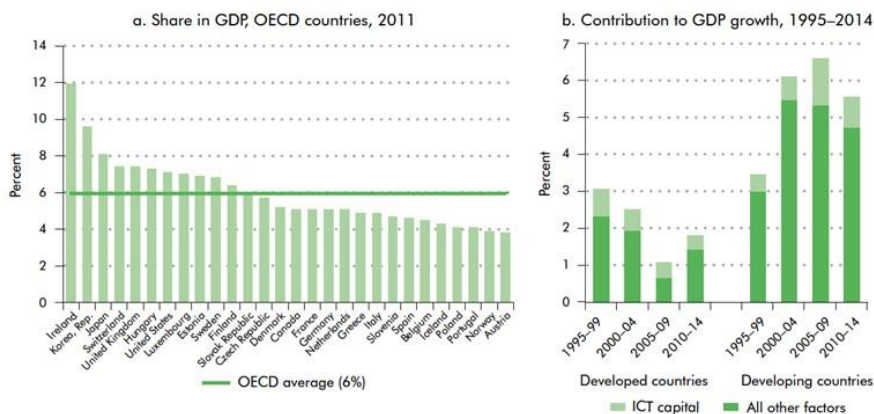


Figure 3. ICT Sector as Share of GDP and Contribution to Growth²⁹

²⁸ The BCG study looked at consumer behavior in six countries -- the U.S., Germany, South Korea, Brazil, China, and India. Consumer valuations for mobile technology were derived from conjoint analysis of survey response data comparing preferences over alternative service bundles (BCG, 2015).

²⁹ See Figure 0.10: The size of the ICT sector and its contribution to GDP growth is still relatively modest, World Bank (2016), “World Development Report 2016:

Table 3. Summary of Research Results on Skill-biased Change³⁰

Authors	Country	Findings
Akerman, Gaarder, and Mogstad (2015)	Norway	Broadband adoption in firms complements skilled workers performing nonroutine tasks and substitutes for workers performing routine tasks.
Autor, Katz, and Kearney (2008)	United States	Patterns of wage inequality are best explained by a modified version of the skill-biased technical change hypothesis, which emphasizes information technology in complementing abstract (high-education) tasks and substituting for routine (middle-education) tasks.
Autor, Katz, and Krueger (1998)	United States	Digital technologies widen wage differentials. Skill upgrading within industries accounts for most of the growth in the relative demand for college workers, especially in more computer-intensive industries.
Berman, Somanathan, and Tan (2005)	India	Trade openness and reform promote technology adoption and diffusion and increase the nonproduction worker shares of employment and total wages in manufacturing, even within industries.
Gaggl and Wright (2014)	United Kingdom	A tax allowance on ICT investments among small firms leads, in the short run, to an increase in demand for nonroutine cognitive-intensive work, some substitution of routine cognitive work, and no effect on manual work.
Marouani and Nilsson (2014)	Malaysia	Without skill-biased technological change, skilled wage earners should expect lower wages and higher unemployment, and unskilled labor should expect higher wages and lower unemployment.
Srouf, Taymaz, and Vivarelli (2013)	Turkey	Domestic and imported technologies increase the demand for skilled labor five to six times more than the corresponding demand for unskilled labor.

Alternatively, ICTs create new job opportunities in the digital economy for those with the ICT skills required to undertake them. For example, the rise of mobile broadband creates a market for local application developers, but writing software applications requires ICT skills that need to be learned. Additionally, the inherent flexibility of ICTs allows them to help drive the innovation cycle across all sectors ever-faster, meaning that ICTs contribute to accelerated obsolescence of skills. This may be especially threatening to older workers who are unable to learn new skills as the ICT-enabled economy continues to grow and evolve.

In the long-term, as ICT capabilities continue to grow, the range of human activities that may be amenable to automation will expand. By some estimates, up to two thirds of jobs are potential candidates for automation. ICTs make jobs more geographically footloose as multinational corporations chase lower cost labor around the globe. While the threat of automation is a challenge, we will have to address,

Digital Dividends,” released May 2016, available at <http://www.worldbank.org/en/publication/wdr2016>

³⁰ See Table 2.4: Recent evidence on skill-biased technological change in World Bank (2016), “World Development Report 2016: Digital Dividends,” released May 2016, available at <http://www.worldbank.org/en/publication/wdr2016>.

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in the near to medium term, that this is more likely a threat for the most developed countries rather than developing nations. First, developing nations with much lower ICT intensity still have a long way to go in coming up the ICT intensity curve before the benefits of increasing ICTs begin to slow. In many developing countries, economic growth is limited by resource shortages across the board – from labor skills to medical supplies, from access to reliable power to supply chain logistics support. ICTs can help with all of these and in so doing expand job opportunities in bricks-and-mortar businesses. For example, on-line platforms and more secure banking and finance services can fuel market growth by allowing developing country businesses to tap into global markets. Moreover, as ICTs help the economy grow, the growing demand for consumer goods and services will help stimulate growth in domestic jobs to satisfy those needs, especially for non-traded goods and services.

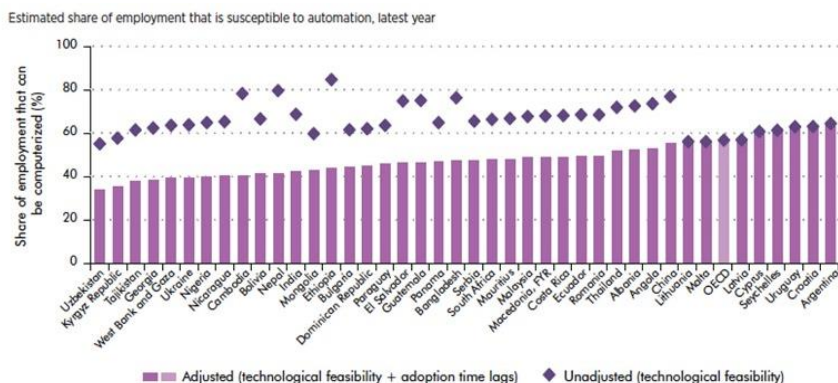


Figure 4. Jobs Susceptible to Automation³¹

On a global basis, the increased domestic and international competition that ICTs can help facilitate may benefit consumers by expanding their choices for goods and services, but may harm workers to the extent the

³¹ See Figure 4. From a technological standpoint, two-thirds of all jobs are susceptible to automation in the developing world, but the effects are moderated by lower wages and slower technology adoption, in World Bank (2016), “World Development Report 2016: Digital Dividends,” released May 2016, available at <http://www.worldbank.org/en/publication/wdr2016>.

competition puts greater pressure on wages. Moreover, because ICTs increase the flexibility with which work may be organized, ICTs can help expand access to labor markets and thereby increase inclusion; but the increased labor supply may contribute to additional downward wage pressure. Many of the new flexible jobs, which ICTs enable (e.g., in the sharing economy), come with reduced employer commitments. Workers' bargaining power may be reduced and social safety nets rendered less effective. Finally, the accelerated pace of economic change and flexibility in resource uses and management enabled by ICTs is tending to reduce job tenure. Successful workers in the digital economy are often those best able to reposition themselves with new skills as markets shift on a faster and global basis.

1.3.3 ICTs' Impact on Inclusion and Equity

ICTs have the potential to enhance inclusion by making information more widely accessible and can allow individuals and SMEs to participate more easily in economic activities by lowering transaction costs and economic barriers to entry.³² ICTs enhance the flexibility with which resources may be managed and shared. New platforms for on-line labor markets can improve the matching between potential employers and those looking for work, and on-line education can help workers upgrade their skills. Enabling more flexible work schedules and telecommuting can open labor markets to those previously excluded. This can promote gender equality and expand options for labor force participation from other disadvantaged groups such as persons with disabilities. For example, the rise of the sharing economy provides a vehicle for leveraging existing capital in economy to be utilized to create additional jobs. The potential for ICTs to redefine workplace opportunities and expand inclusion are addressed further in subsequent chapters.³³ Although the potential exists for ICTs to expand

³² At the same time, it can further reinforce exclusion of the unconnected individuals. This echoes a recurring theme: while appropriate use of ICTs can result in progress toward realization of SDGs; failure to adopt ICTs or to use ICTs appropriately can lead to a worsening of conditions.

³³ For example, Chapter 3 discusses how ICTs can contribute to the vibrancy of the innovation ecosystem; Chapter 5 discusses new types of ICT-enabled business and

inclusion, and the improvements observed since 2000 demonstrate some success in addressing those goals, ICTs also have the potential to exclude.

From the prior discussion, it should be clear that ICTs pose a significant risk of increasing income disparity unless countries are successful in ensuring that the necessary complementary assets are in place. If workers do not develop the skills, or if outmoded regulatory rules limit the ability of enterprises to adopt best-practiced ICT strategies, then workers and businesses in those markets will suffer. It is not an option to sit on the sidelines while others adopt ICT efficient production technologies. As noted before, countries that have lagged in deploying ICTs have also lagged in economic growth. While ICTs help developing countries catch up and narrow the gap with more developed countries, failure to keep pace with ICT developments can result in countries falling even further behind and at a faster rate. Peer countries that are more ICT advanced are more likely to benefit from competitive advantages wherever along the development scale those peers find themselves.

The evidence that ICTs can accentuate income disparities is evident in the declining share that labor has in national incomes.³⁴ Capital and ICTs have grown, while labor's share has declined. The owners of capital tend to be wealthier and the increasing income disparity has been a by-product of increasing economic growth. Additionally, some ICT markets give rise to "winner-take-all" type economics as first-movers and those with the largest scale displace or acquire smaller rivals. ICTs can help this happen by rendering historic limits to firm-scale less effective. For example, corporate enterprise resource planning (ERP) and other ICT management tools make it feasible for the largest

market models; and Chapter 6 focuses directly on the impacts of ICTs for employment opportunities.

³⁴ See Figures 5 and 6 or Karabarbounis and Neiman (2014). The World Bank report notes that in "the United States, at the technological frontier, the share of income going to routine labor has fallen from 38 to 23 percent since the late 1960s, with a simultaneous rise in the non-routine labor share from 24 to 34 percent." (World Bank, 2016).

businesses to scale multinationally, while keeping costs low. ICTs also contribute to strategic agility, allowing the large multinationals to more effectively target would-be competitors.

To date, it appears that the benefits of ICTs have accrued disproportionately to the wealthy, who also tend to be the more highly skilled, live in locations with easier access to ICT infrastructure, and have the financial resources to adopt ICTs. The wealthy are typically more likely to live in urban rather than rural areas, and with wealth often come better access to education and reduced barriers to acquiring the other elements that are needed to make productive use of ICTs. Increasing disparities in incomes, education, and economic opportunity pose a significant threat to sustainable development goals.

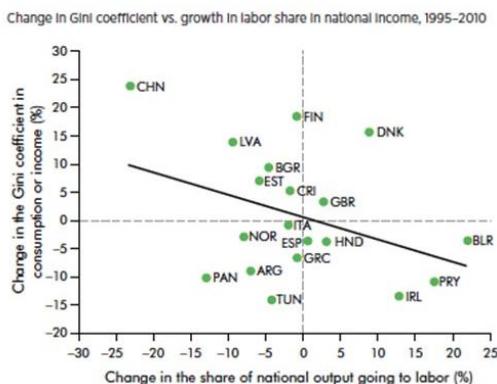


Figure 5. Falling Labor Share of Income, #2³⁵

1.4 ICT Ecosystem

A fresh look is needed at the interactions of major elements that affect the ICT sector on a global scale. In the literature, such elements and their interactions are collectively called the ICT ecosystem. The World Economic Forum (2009) characterized “ICT as a transformative economic catalyst,” and identified six key pillars for the ICT ecosystem

³⁵ See Figure 6: Falling labor shares in national income are associated with rising inequality, in World Bank (2016), “World Development Report 2016: Digital Dividends.,” <http://www.worldbank.org/en/publication/wdr2016>.

(WEF, 2009).³⁶ The effects of ICTs spill-over across business functions, sectors, and national borders means that ICT-enabled development goals cannot be pursued solely on a sector-specific or national basis, but need to be addressed holistically and globally as well as on a cross-sectoral basis. Recognition of this fact motivated policymakers to expand application of the SDGs to all nations. Moreover, the need to consider the effects of complex feedback mechanisms that operate across all layers of civil society, the economy, and across government spheres, necessitates adopting strategies for sustainability that are mutually reinforcing in order to be effective. The overall system functions when multiple underlying factors align to reinforce one another.

The above-mentioned underlying factors include infrastructure investment, applications and contents, markets and competition, policies and regulations, government budgets, and ICT skills and education. Figure 7 is a pictorial presentation of the ICT ecosystem. In this representation, the ICT ecosystem is viewed as having four major pillars. The first pillar is the government, which sets the stage for other players by determining policies, enforcing regulations, shaping markets and enabling competition, and by enacting laws. Government policies that affect the ICT ecosystem include environmental policy and sustainability initiatives, trade policy, monetary policy, cultural policy, intellectual property policy, cybersecurity policy, public safety policy, disaster mitigation policy, and fiscal (taxes and incentives) policy. The second pillar is the enabling elements that includes ICT skills and education, the innovation environment, the markets for applications and content and ICT goods and services, and the atmosphere for ICT-enabled entrepreneurship. The third pillar is the ICT infrastructure investment by the operators, service providers and the businesses that adopt and use ICTs. Finally, the fourth pillar is comprised of the people who are engaged in multiple roles as consumers, employees, and

³⁶ The six pillars of the ICT ecosystem identified by the World Economic Forum are (1) Infrastructure investment; (2) Applications and Content; (3) Markets and Competition; (4) Policies and Regulations; (5) Government Budgets; (6) Skills and Education for IT (WEF, 2009, p1-2).

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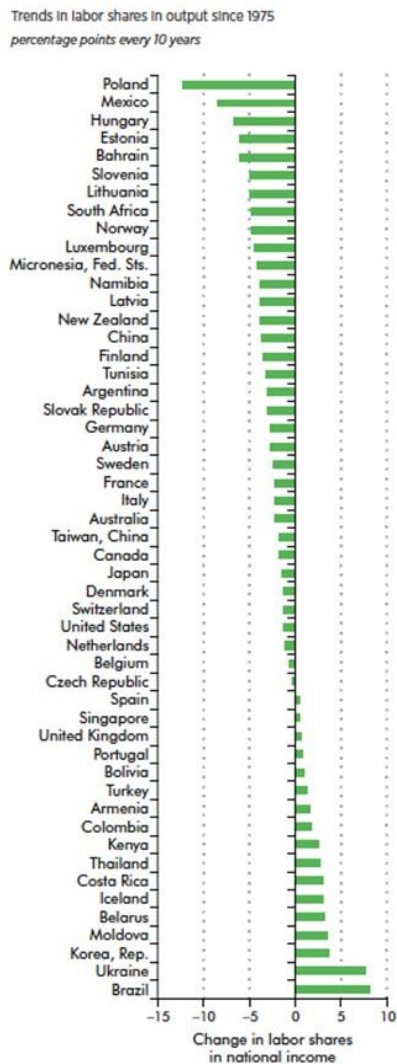


Figure 6. Falling Labor Share of Income #1³⁷

³⁷ See Figure 0.15: Labor shares of national income are falling in many countries, including some developing countries, in World Bank (2016), “World Development Report 2016: Digital Dividends,” released May 2016, available at <http://www.worldbank.org/en/publication/wdr2016>.

citizens. In many cases, the interdependence and interactions between the above mentioned elements that are vital in a healthy ecosystem are often either misaligned or paid inadequate attention in practice, resulting in the waste of valuable scarce resources and stagnation. In the following chapters, important elements that form a vibrant, productive, and agile ICT ecosystem that makes sustainable development a reality are discussed in more detail.

1.5 Motivation: Need an Agenda for Action

Considering the pivotal role of ICTs in shaping the future, we need to develop a carefully planned global agenda for action by different stakeholders involved in the ICT ecosystem. Furthermore, an appropriate long-term agenda needs to be cognizant of current trends that are shaping how ICTs are evolving. These include such things as the growth of the Internet of Things (IoT), cloud computing, future wireless networks and services including 5G and beyond, big data analytics, artificial intelligence, robotics, etc. Although the precise future of such developments remains uncertain, the impact of those transitions will be global. Consequently, all countries (not just those that lead in the development and adoption of next generation ICTs) should have plans to best address these trends. Since it is not possible to plan for all contingencies, the plans need to be sufficiently flexible to adapt as the uncertain future unfolds.

Moreover, the agenda for action depends on many socio-cultural-political factors that are specific to each country/region, and because the effects of ICTs spill across regional and national boundaries, the interaction effects of national policies on a global and regional level need to be considered.³⁸ Hence, it is not possible to specify a single universal set of actions that all countries should employ to promote

³⁸ For example, ICT-enabled smart manufacturing in the United States that may contribute to U.S. GDP growth but at the same time reduce U.S. multinational demand for labor in developing markets where the activity might previously been undertaken, resulting in a negative employment shock in those former-outsourcing markets.

ICT-centric economic growth, innovation and job creation

sustainable development in all situations. Nevertheless, it is reasonable to specify certain broad guidelines.

In devising the necessary plan for action, policymakers need to carefully assess the existing points of strength and weakness in each case, and identify potential areas that can be considered as pivotal in attaining realistic, yet sustainable development goals. In promoting the development goals, it will be necessary to address the conflicts between stakeholders that are a commonality in most change processes, especially the ones as potentially disruptive and significant as those that ICTs may enable. For example, the pace and success of ICT adoption across consumers, businesses, and markets will be uneven. There will be leading and lagging adopters and not all stakeholders will be equally positioned to take advantage of the benefits of ICTs. Evidence shows that firms that are better at utilizing ICTs and adopt ICTs sooner tend to perform better. The shifts in market shares are likely to please some participants while displeasing others. ICT-driven changes in the skill requirements for work will force adjustment costs that will impact markets asymmetrically.

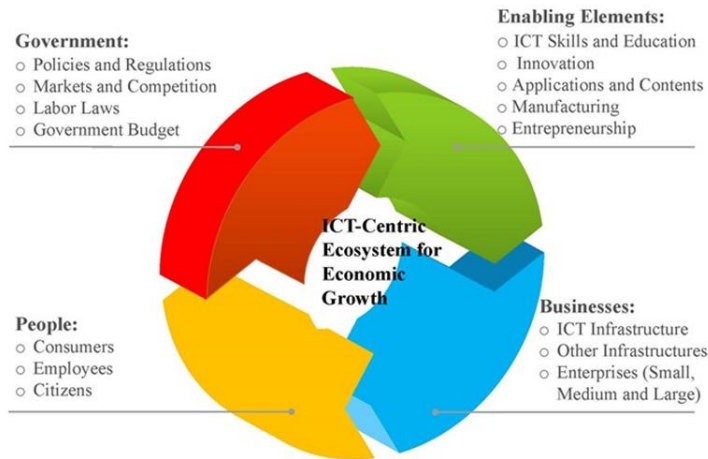


Figure 7. ICT Ecosystem Representation

In subsequent chapters of this book, we will discuss specific actions that different stakeholders need to undertake to further the SDGs, but here we provide some rough guidelines for an action plan that groups recommendations into three clusters. First, there are the things that nations must do if they are to realize any significant benefits from ICTs in progressing toward their SDGs. Some of these are obvious. We might paraphrase those as “stop doing things that are obviously counter-productive and fix what is obviously wrong.” Second, there are some obvious capabilities that need to be proactively promoted and universally embraced. And, third, there are certain challenges that we know ICTs will confront us with, and which we know that no single country can address on its own.

Examples of the first sets of recommendations include eliminating obvious barriers to innovation and successful adoption and use of ICTs. For example, to succeed in a connected world, it has to be possible for workers, consumers and citizens to be connected. Basic affordable access to mobile broadband is a minimum requirement and needs to be part of any national SDG roadmap. Additionally, digital literacy and appropriate ICT skills, which imply at least a minimum level of educational attainment are necessary for ICTs to be productive. Basic political stability and civil society security are necessary to enable stakeholders (consumers, investors, business managers, government policymakers, etc.) to have the minimal level of trust in the economy and society to make planning even worthwhile. These are just some of the essential base-level requirements that must be met before it becomes reasonable to consider in greater detail how best to employ ICTs to promote SDGs. Additional critical factors are addressed in subsequent chapters.

Examples of the second types of things to do are those that all nations will need to do to benefit from ICTs and minimize the harm from the unavoidable disruptions that increasing ICT intensity will bring. Avoiding ICTs is not really an option in a world that is becoming smaller because of the globalization enabled by ICTs. ICTs are transforming all aspects of our social and economic lives, and while the effects on different stakeholders will vary, everyone will be impacted. The rise of e-Commerce and the faster clock speed with which markets

and firms may restructure impacts all sectors in all countries. Consumers who may never purchase goods online are affected when the selection and prices of off-line goods from bricks-and-mortar providers respond to the on-line competition. When all of one's peers, friends or family go on-line with social networks, one can choose to follow or become isolated. As ICTs make economic activity more geographically and globally footloose, shocks in one market (labor, final goods, capital, or other resources) can impact other markets more easily (whether in the same or different countries). In such a world, the only way to be successful is to adapt to ICT induced changes. If you know you have to confront change, then you know you need systems that are capable of flexible adaptation. In the digital economy, job tenures may be short and markets may shift rapidly and unexpectedly. It is not enough to master a static set of skills; instead workers should commit to lifelong learning. Chapter 7 addresses the requisite changes in education systems. Additionally, public policies are needed to minimize adjustment costs that may include revising the social safety net. These are addressed in Chapter 4.

Finally, to address the challenges that require a level of global coordination, it is important that countries build capacity and multi-stakeholder partnerships to engage with those looming problems. Examples of those include addressing cybersecurity threats, global inequality, and climate change. None of those problems can be adequately addressed by any single nation. Actions by one country can invalidate actions by another. Therefore, international cooperation and multi-stakeholder partnership to promote SDGs will be critical, as addressed by SDG 17. Ensuring ICT networks, platforms, and markets to be interoperable and interconnected is one core element of any successful strategy.

1.6 Conclusions and Organization of This Book

In this chapter, we explained why ICTs are indispensable for achieving the SDGs and reviewed the evidence of the significant economic impacts of ICTs, while noting the necessity of greatly enhancing the energy efficiency of ICTs and of other critical resources across the economy if future global growth is to be sustainable. The SDGs present

bold and difficult challenges, and realizing the SDGs require international cooperation as well as the development and implementation of new, ICT-enabled technologies, solutions, and application across all sectors of the economy from water management to retail trade, and from healthcare to education. Solutions that are responsive to the development context and are capable of evolving in the face of rapid change need to be crafted. We also presented our view of the ICT-centric ecosystem for economic development and growth, and highlighted the complex and interdependent technical, social and business relationships that must interact productively to achieve sustained progress. This ecosystem functions when multiple underlying factors align to reinforce one another. These factors include government policies and actions, infrastructure investment, applications and content, markets and competition, government budgets, and ICT skills and education. Stakeholders representing all of these interests need to coordinate their activities to realize the SDGs.

In what follows, we present a brief description of the remaining chapters.

Chapter 2 focuses on the basic pre-conditions and interfaces that are needed to ensure that ICT initiatives are environmentally, economically, and socially/politically sustainable. It focuses specifically on the importance of universal infrastructure, the need for affordable technologies, the need for appropriate skills and awareness, and the importance of locally relevant content. The chapter emphasizes that different stakeholders that are concerned with developing policies and implementing programs and projects for using ICTs to promote sustainable development, need to address issues of empowerment, focus on the needs of the poorest, develop innovative technological solutions and new business models, legislate new regulations through which governments facilitate the ICT sector, and ensure that there is an effective security and resiliency within the systems. The chapter concludes with a brief analysis of the role of multi-stakeholder partnerships in implementing such initiatives.

Chapter 3 explains how the digital divide can be transformed into the digital multiplier if a multi-stakeholder approach is adopted to support

ICT-enabled innovation. The stakeholders include interests from government, industry, academia, consumers, finance, entrepreneurs and others. The interactions among these stakeholders and their role in promoting productive innovation are best understood by focusing on how the stakeholders interrelate, taking account of the potential for positive spill-overs to create digital multipliers. In addition, Chapter 3 identifies the risks and the likely sources of failure that can prevent establishing a vibrant, energetic, and forward looking ICT-centric environment that will foster beneficial innovations and productivity growth.

Chapter 4 focuses on the role of the government as a key stakeholder and driver for the initiatives needed to promote progress toward the SDGs. Governments have a critical role in catalyzing change, promoting trust and assisting the management of risks and disruptions associated with ICT-driven change, in helping to stimulate demand for ICTs, in setting and leading public policies, in long term planning, and in establishing and securing legal frameworks that are conducive to sustainable development. In addition, government sponsorship of universal service obligations and safety-net policies are important to ensure equitable distribution of the benefits of ICT-driven growth, so that all segments of society share in the benefits, including those who are under-privileged or reside in remote areas.

Chapter 5 describes the potential for ICTs to empower new business models and discusses their implications for making progress toward realization of the SDGs. The chapter reviews business models for ICT-driven ventures, the role for government initiatives, and how ICTs can support innovative solutions to longstanding development goals. Key issues that are addressed include stakeholder values and their alignment, the implications of alternative ICT-enabled designs, and the importance of appropriately managing channels and securing stakeholder trust and awareness. The chapter concludes with a discussion of the scalability and sustainability of these new business models.

Chapter 6 reviews the impact of ICTs on employment, and outlines three types of employment effects: the “construction effect” which yields direct, indirect and induced jobs resulting from the deployment

of telecommunication networks and data centers; the “spill-over effect” on jobs in the traditional economy, which can simultaneously lead to new jobs triggered by unlocking scalability in certain sectors while reducing jobs through enhanced productivity in other labor-intensive industries; and the “innovation” effect, which involves creation of new jobs due to the development and introduction of new services and applications. Additionally, empirical evidence is reviewed on the impact of ICTs on labor conditions, emphasizing positive contributions, such as flexibility and income growth. On the basis of this evidence, public policy prescriptions are outlined to maximize job creation and help mitigate any potential disruptions in labor markets that are likely to occur as a result of the diffusion of ICTs.

Chapter 7 addresses the implications of ICTs for education and skills development. The rapidly emerging ICT ecosystem plays a disruptive role in education and conversely education has a vital influence on the shape of the ICT sector itself. This interaction of education and new ICTs creates a need for change in order to maximize possibilities to achieve the SDGs. The needed changes encompass brick-and-mortar versus virtual classrooms, modes of teaching and learning, curriculum design and delivery, the need for introducing new courses that are essential for making progress in the new job environment, and lifelong learning.

References

- Acemoglu, D., D. Autor, D. Dorn, G. Hanson and B. Price (2014), “Return of the Solow paradox? IT, productivity, and employment in US manufacturing,” *The American Economic Review*, 104(5): 394-399.
- Aker, J. C., & Mbiti, I. M. (2010), “Mobile Phones and Economic Development in Africa,” *The Journal of Economic Perspectives*, 24(3), 207-232.
- Alaaraj, H. and F. Ibrahim (2014), “An overview and classification of e-readiness assessment models,” *Int. J. Sci. Res. Publ.*, 4(12).
- Andrae, A. and T. Edler (2015), “On global electricity usage of communication technology: trends to 2030,” *Challenges*, 6(1), 117-157.
- BCG (2015), “The Mobile Revolution: How mobile technologies drive a trillion-dollar impact,” Boston Consulting Group (BCG), report prepared for Qualcomm, Jan. 2015.

https://eliasgagas.files.wordpress.com/2015/03/the_mobile_revolution_jan_2015_tcm80-180510.pdf.

Birthal, P., et al. (2015), "The impacts of information on returns from farming: evidence from a nationally representative farm survey in India," *Agricultural Economics*, 46(4), 549-561.

Bolla, R., R. Bruschi, F. Davoli, and F. Cucchietti (2011), "Energy efficiency in the future internet: A survey of existing approaches and trends in energy-aware fixed network infrastructures," *IEEE Commun. Surveys & Tutorials*, 13(2), pp.223-24.

Bresnahan, T., E. Brynjolfsson and L. Hitt (2002), "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence," *The Quarterly Journal of Economics*, 117(1): 339-376.

Bresnahan, T. and M. Trajtenberg (1995), "General purpose technologies 'Engines of growth'?" *Journal of Econometrics*, 65(1): 83-108.

Broadband Commission for Sustainable Development (2016), *The State of Broadband: Broadband Catalyzing Sustainable Development*, ITU/UNESCO, September 2016.

Brynjolfsson, E. (1996), "The contribution of information technology to consumer welfare," *Information Systems Research*, 7(3): 281-300.

Brynjolfsson E. and A. McAfee (2014), *The Second Machine Age: Work, Progress, and Technology in a Time of Brilliant Technologies*, W. W. Norton and Company, New York, 2014.

Cardona, M., T. Kretschmer and T. Strobel (2013), "ICT and productivity: conclusions from the empirical literature," *Information Economics and Policy*, 25(3): 109-125.

Clarke, R. (2014), "Expanding mobile wireless capacity: The challenges presented by technology and economics," *Telecommunications Policy*, 38(8-9), 693-708.

Czernich, N., O. Falck, T. Kretschmer, and L. Woessmann (2011), "Broadband Infrastructure and Economic Growth," *The Economic Journal*, 121(552), 505-532.

EIU (2010), "Digital economy rankings 2010: Beyond e-Readiness," *Economist Intelligence Unit (EIU)*. https://www-35.ibm.com/services/us/gbs/bus/pdf/eiu_digital-economy-rankings-2010_final_web.pdf.

EU (2017), "Digital Economy & Society Index (DESI) ," EU. <https://ec.europa.eu/digital-single-market/en/desi>.

Fettweis, G. and E. Zimmermann (2008), "ICT energy consumption-trends and challenges," *Proceedings of the 11th International Sym. on Wireless Personal Multimedia Communications*, Vol. 2, No. 4.

ICT-centric economic growth, innovation and job creation

Fu, X. and S. Akter (2016), “The Impact of Mobile Phone Technology on Agricultural Extension Services Delivery: Evidence from India,” *Journal of Development Studies*, 52(11), 1561-1576.

Fuss, M. and L. Waverman (2005), “Canada’s productivity dilemma: The role of computers and telecom,” Appendix E-1 to Bell Canada’s Submission to the Telecommunications Policy Review Panel. <http://www.itu.int.libproxy.mit.edu/osg/spuold/dtis/documents/Papers/productivitydilemma.pdf>.

Gruber, H., J. Hatonen and P. Koutroumpis (2014), “Broadband access in the EU: An assessment of future economic benefits,” *Telecommunications Policy*, 38 (11), 1046-1058.

Holt, L. and M. Jamison (2009) “Broadband and contributions to economic growth: lessons from the US experience,” *Telecommunications Policy*, 33 (10–11), 575–581.

IEA (2008), “Worldwide Trends in Energy Use and Efficiency,” International Energy Agency (IEA).
https://www.iea.org/publications/freepublications/publication/Indicators_2008.pdf.

ITU (2016), “Measuring the Information Society Report 2016.”

Goolsbee, A. and P. Klenow (2006), “Valuing consumer products by the time spent using them: An application to the Internet,” *American Economic Review*, 96(2), 108-113.

Gordon, R. (2014), “The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections,” National Bureau of Economic Research Working Paper Series, No. 19895.

Gordon, R. (2000), “Does the ‘New Economy’ measure up to the great inventions of the past?” National Bureau of Economic Research (NBER) Working Paper 7833, August 2000.

Jorgenson, D. (2001), “Information technology and the US economy,” *The American Economic Review*, 91(1), 1-32.

Karabarbounis, L. and B. Neiman (2014), “The global decline of the labor share,” *The Quarterly Journal of Economics*, 129(1), pp.61-103.

Katz, R. (2012), “The impact of broadband on the economy: Research to date and policy issues,” ITU Telecommunications Development Sector, Broadband Series, April 2012.

Koutroumpis, P. (2009), “The economic impact of broadband on growth: A simultaneous approach,” *Telecommunications Policy*, 33(9): 471-485.

Lehr, B. and F. Lichtenberg (1999), “Information technology and its impact on productivity: Firm-level evidence from government and private data sources, 1977-1993,” *The Canadian Journal of Economics*, 2, 335-362.

ICT-centric economic growth, innovation and job creation

Moretti, E. and P. Thulin (2013), “Local multipliers and human capital in the United States and Sweden,” *Industrial and Corporate Change*, 22(1), 339-362.

OECD (2004), “The Economic Impact of ICT: Measurement, Evidence, and Implications,” Organization for Economic Co-operation and Development (OECD), 2004.

RIO+20 (2012), “The Future We Want, Final Document of the RIO+20 Conference,” Rio de Janeiro, Brazil, 20-22 June 2012.

Röller, L. and L. Waverman (2001), “Telecommunications infrastructure and economic development: A simultaneous approach,” *American Economic Review*, 91 (4), 909-923.

Solow, R. (1987), “Manufacturing Matters, a review of *The Myth of the Post-Industrial Economy* by Stephen S. Cohen and John Zysman,” *New York Times Book Review*, July 12, 1987.

Spiezia, V. (2013), “ICT investments and productivity,” *OECD Journal: Economic Studies*, 2012(1), 199-211.

Stanley, T., C. Doucouliagos, and P. Steel (2015), “Does ICT Generate Economic Growth? A Meta-Regression Analysis,” Deakin University Working Paper, No. 2015_9, 2015.

United Nations (2015a), “The Millennium Development Goals Report 2015,” United Nations, July 2015.

United Nations (2015b), “Transforming our World: the 2030 Agenda for Sustainable Development,” Resolution A/RES/70/1 adopted by the UN General Assembly on 25 September 2015.

Van Reenen, et al. (2010), “The economic impact of ICT,” Final Report of the EU Commission’s Economic Impact of ICT Project, Centre for Economic Performance, London School of Economics, January 2010.
http://www.eurosfaire.prd.fr/7pc/doc/1291302690_econ_impact_of_ict_2010.pdf.

Waverman, L., M. Meschi and M. Fuss (2005), “The impact of telecoms on economic growth in developing countries,” *The Vodafone Policy Paper Series*, 2(03): 10-24.

World Bank (2016), “Digital Dividends, World Development Report 2016,” World Bank, Washington DC, ISSN 0163-5085, 2016.

WEF (2009), “ICT for Economic Growth: A Dynamic Ecosystem Driving the Global Recovery,” World Economic Forum (WEF).
http://www3.weforum.org/docs/WEF_IT_DynamicEcosystem_Report_2009.pdf.

World Wide Web Foundation (2017), “WebIndex”.

Biographies

Ahmad Reza Sharafat is Professor of Electrical and Computer Engineering at Tarbiat Modares University, Tehran, Iran; Invited Member of the Iranian Academy of Sciences; Chairman of IEEE Iran Section; Chairman of ITU-D Study Group 2 in Geneva, Switzerland; Vice-Chairman of Telecommunication Development Advisory Group (TDAG) also in Geneva, Switzerland; Editor of the International Journal of Wireless Information Networks; and Editor of Scientia Iranica. He has 7 Iranian patents and one US patent, published three books and more than 150 papers in refereed scholarly journals and professional international conferences. He received his B.Sc. degree from Sharif University of Technology, Tehran, Iran, and his M.Sc. and Ph.D. degrees both from Stanford University, Stanford, California, all in Electrical Engineering in 1975, 1976, and 1981, respectively. He is a senior member of IEEE and Sigma Xi.

William H. Lehr is an Economist and Research Scientist in the Computer Science and Artificial Intelligence Laboratory (CSAIL) at the Massachusetts Institute of Technology (MIT), where he is part of the Advanced Network Architectures Group. Dr. Lehr's research focuses on the economic implications of ICT technologies for public policy, industry structure, and the evolving Internet ecosystem. He is engaged in multiple multidisciplinary research projects focusing on issues such as broadband Internet access, cybersecurity, next generation network architectures, and spectrum management reform. In addition to his academic work, Dr. Lehr advises public and private sector clients in the US and abroad on ICT strategy and policy matters. Dr. Lehr holds a PhD in Economics from Stanford University and an MBA in Finance from the Wharton School, and MSE, BA, and BS degrees from the University of Pennsylvania.

Chapter 2

ICTs, Sustainability and Development: Critical Elements

*Tim Unwin**

This chapter examines the interface between ICTs and sustainability, especially focusing on environmental issues and the conditions that need to be in place for ICT initiatives to be sustainable socially and economically. It focuses specifically on the importance of universal infrastructure, the affordability of technologies, the need for appropriate skills and awareness, and the importance of locally relevant content. For these to be delivered, the chapter emphasises that those who develop policies and implement programmes and projects to use ICTs to promote sustainable development need to address issues of empowerment, focus on the needs of the poorest, develop innovative technological solutions and new business models, legislate new kinds of regulation through which governments facilitate the ICT and telecommunication sector, and ensure that there is effective security and resilience within the systems being developed. The chapter concludes with a brief analysis of the role of multi-stakeholder partnerships in implementing such initiatives.

2.1 Introduction

This chapter builds on the discussions in Chapter 1 concerning the interface between ICTs, sustainability and development. It seeks to provide recommendations to address some of the concerns of those who are *critical* of the role of ICTs in the sustainable development agenda,

* Royal Holloway, University of London, London, United Kingdom

and focuses on the elements that are *critically* important to have in place to ensure the successful use of ICTs for sustainable development (Unwin, 2017). This duality of meanings of the word *critical* builds on the observations in Chapter 1 that, although ICTs can indeed be used to contribute positively to sustainable development, this need not always be the case. We seek here to identify practical ways through which ICTs can indeed contribute beneficially, whilst also reducing the inequalities that have all too often been associated with the economic growth model that has dominated the rhetoric associated with the use of ICTs for development over the last two decades. The chapter highlights some of the most important recommendations arising from academic critiques and evidence of good practice relating to the use of ICTs for sustainable development. It begins by expanding the discussion of Chapter 1 on the interrelationships between the ideas of sustainability and development in the context of ICTs, and then examines some of the environmental impacts of ICTs, before highlighting critical factors essential for ICTs to contribute across the board to the Sustainable Development Goals (SDGs), and concluding with recommendations about the role of partnerships in delivering such initiatives.

Whilst Chapter 1 has emphasised many of the contributions of ICTs to development, several recent reports have recognized that these have not always been as successful as their proponents had anticipated, and in particular that their contribution to economic growth has usually been associated with increasing inequalities. The World Bank's (2016, p.2) *World Development Report* for 2016 thus offered a more balanced view of the impact of digital technologies, noting that "Although there are many individual success stories, the effect of technology on global productivity, expansion of opportunity for the poor and the middle classes, and the spread of accountable governance has so far been less than expected". The UNDP (2015, p.24) in its 2015 *Human Development Report* likewise focused especially on this increasing inequality, commenting that

"Even with all the economic and technological advancements at the world's disposal, people do not have equitable benefits from progress, human capabilities and opportunities do not always flourish, human security is at stake, human rights and freedoms are not always

protected, gender inequalities remain a challenge, and future generations' choices do not get the attention they deserve.”

This chapter therefore examines how the contradictions between the technological impact on growth and inequality (see also Oxfam, 2017) can be resolved, and what needs to be in place to ensure that ICTs do indeed contribute effectively to the SDGs, in all their diversity. It focuses especially on the interests of different stakeholders in the use of ICTs for sustainable development, and on the role of effective partnerships in their delivery.

Recommendation 1. Stakeholders involved in delivering ICT-based interventions intended to enhance sustainable development through economic growth should ensure that these also explicitly address the reduction of inequalities. For ICTs effectively to deliver the SDGs they must be used to empower the poorest, and not just deliver economic growth.

2.2 ICTs, Sustainable Development and SDGs

2.2.1 Sustainability and Development

The previous chapter provided an overview of the evolution of global agreements mediated by the UN from the eight MDGs in 2000 to the 17 SDGs with their 169 targets in 2015. It also noted the differing ways through which sustainability can be considered, focusing especially on its environmental, economic and social dimensions. This section drills down more deeply into these observations to explore the tensions contained in the juxtaposition of the notions of sustainability and development, to discuss some of the challenges of implementing the SDGs, and to examine what needs to be done for ICTs to contribute effectively to their achievement.

The notion of “sustainable development” has its formal origins in the *Our Common Future* report of the Brundtland Commission (1987), which encapsulated the core idea that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This was based on three core concepts: the importance of bringing the

environment into discussions of development; a focus on *needs*, especially those of the poorest; and the *limitations* imposed by existing technology and social organisation. One of its advantages is that it is sufficiently broad for different stakeholders to reach consensus by including their own varying conceptualisations of “sustainability” and “development” within it, but its over-defined character and openness to ambiguity has meant that it has also been widely criticised (Redclift, 2005). The fundamental tension at its heart is that sustainability implies the *maintenance* of certain characteristics or constancy, whereas the central meaning of development implies *change* or growth. Any consideration of sustainable development therefore forces a normative consideration of what people want to maintain and what they wish to be changed. ICTs as accelerators of change can be used to accentuate different kinds of impacts, and this chapter therefore explores how they can be used not only to deliver positive rather than negative aspirations of change, but also to contribute to the maintenance of certain values and characteristics. The SDGs are a valiant attempt to resolve these contradictions, whilst also providing roles for different UN agencies to perform in seeking to benefit their member countries.

It is important to highlight here that there are fundamental differences of opinion about the meaning of development alongside the differing meanings of sustainability already mentioned. The hegemonic position encapsulated in the original MDGs is that economic growth is the main vehicle through which poverty can indeed be eliminated, and this has largely been carried forward into the SDGs (Sachs, 2005; Unwin, 2007; Carant, 2017). However, as noted above, this economic growth agenda has led to much greater inequality in the world, and there is now increasing recognition of the importance of relative definitions of poverty, as against the absolute ones associated with most growth models (O’Boyle, 1999). This in turn has led to growing support for the notion that development needs to address the reduction of inequalities as much as it does economic growth. One small step towards recognising this has been the emphasis in SDG 10 on reducing inequality within and among countries (<http://www.un.org/sustainabledevelopment/inequality/>) (Freistein and Mahler, 2016). This chapter therefore lays the foundations for a wider

consideration of the ways through which ICTs can support the SDGs by exploring ICTs and sustainability in the environmental context, and also through the sustainability of ICT interventions specifically designed to address both absolute and relative poverty.

2.2.2 ICTs, WSIS Process and SDGs

The World Summit on the Information Society (WSIS, Geneva 2003 and Tunis 2005) was of considerable importance in shaping the way the UN system has incorporated ICTs into its development initiatives. Subsequent WSIS Annual Forums, co-organised by the ITU, UNESCO, UNCTAD and UNDP, have provided regular opportunities for all UN agencies and others to meet to discuss progress on the 18 Action Lines agreed at WSIS, and the 2015 meeting was particularly important in shaping their integration with the emerging SDGs (ITU 2015a) (Figure 1). Despite strong arguments that universal connectivity to the Internet should have been one of the SDGs, the emerging agreement among those involved in finalising them during 2015 was that they should be treated only in a supporting or facilitating role, thus featuring in but four of the final 169 Targets (Table 1). Only one of these mentions (9c) was overtly directed to increasing access to ICTs; the others focused on using them to enhance scholarships, to empower women, and to operationalise the technology bank.

The failure to appreciate sufficiently that inequality in access to ICTs is rapidly increasing social, economic and political inequality, all of which threaten the stability of countries and thus their ability to deliver economic growth, was a lost opportunity. The failure to have this core requirement more prominently featured within the SDGs undermines the very foundations of all of the other SDGs, and the consequences of this may well exert a persistent negative impact in the long term ability to achieve them. Without sufficiently addressing inequitable access, and the reasons why people do not use the Internet more extensively, the *sustainability* of the intended *development* interventions that are indeed mentioned as Goals is brought into question. Indeed, it seems probable that an increasing rate of inequality in access to ICTs will create increasing economic and social disadvantage and inequality.

For many, the mention of increasing access to ICTs in Target 9c has been a sufficient catalyst to initiate new projects to achieve this goal. It is salient to note, however, that no expectations were set on the meaning of “significant” or the levels to which countries might aim to increase such access, and few countries have yet specified such targets. Figure 1 highlights the main areas of intersection between the WSIS Action Line and the SDGs at Goal, rather than Target level, and shows clearly that UN agencies are advocating and developing initiatives through which ICTs can be used to influence all of the Goals; even those with the fewest relevant Action Lines, such as Goal 7 (“Ensure access to affordable, reliable, sustainable and modern energy for all”) and Goal 15 (“Sustainably manage forest, combat desertification, halt and reverse land degradation, halt biodiversity loss”), each had three pertinent Action Lines delivering on them. Interestingly, both these Goals were overtly environmental, suggesting that further work is necessary on exploring the links between ICTs and environmental issues. Significantly for the arguments of this chapter, ICTs were also not particularly prominent in the Action Lines addressing Goal 10 on inequality.

The large number of SDGs and their associated targets are a reflection of the desire for comprehensiveness, and for the interests of all UN agencies to be included, but suffer from the drawback of being cumbersome and difficult to remember. Moreover, individual countries are meant to be developing plans with specific targets through which they will “end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind” (UN, 2017). Not only is this optimistic, but the practical reality is that few poor countries have yet embarked on the critical requirement to identify specific targets from the 169 listed in the SDGs, and yet it is already two years into the 15-year period during which they are meant to be attained (OECD, 2016a). A critical first step through which ICTs can be used more effectively to contribute to the SDGs must therefore be for each country to declare specific target figures for the four actions noted in Table 1.

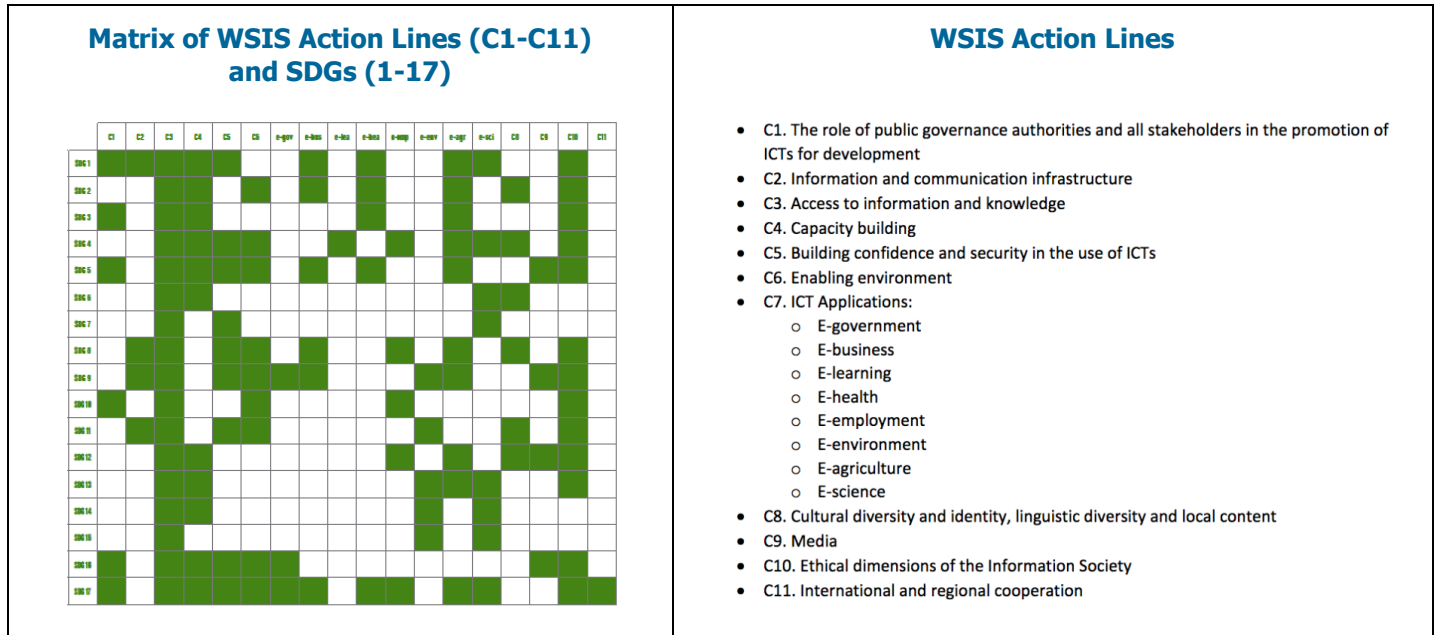


Figure 1. WSIS Action Lines and SDGs

Source: ITU (2015)

Table 1. ICT-related Targets in SDGs.

4b) By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing states and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries.

5b) Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.

9c) Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

17.8) Fully operationalise the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

Source: <http://www.un.org/sustainabledevelopment/>

Recommendation 2: Governments should urgently put in place clear quantitative and qualitative national targets for delivering on SDG targets 4b, 5b, 9c and 17.8, as well as for how ICTs can contribute to the most locally relevant other SDG targets, supported where requested by relevant international agencies. Delivery against these targets should be carefully monitored by governments on an annual basis, and appropriate actions taken to respond to differences in performance against the targets. Relevant international organisations should coordinate and report annually on national delivery against targets.

However, as indicated in Figure 1, ICTs can contribute very much more broadly to the issues included in the other SDGs, and countries should thus also consider specific targets for these. Failure to carefully monitor these targets and act on them accordingly could mean that the unfettered growth of the ICT sector might adversely affect the potential

achievement of some or all of these goals. This is particularly so with respect to the environmental implications of ICT growth, to which attention now turns.

2.2.3 Environmental Implications of ICTs

This book focuses primarily on economic aspects of the use of ICTs, and particularly their contributions to economic growth, employment and innovation (UNCTAD, 2013, 2015; Statistics Netherlands, 2015; World Bank, 2016). However, it is important here to explore some aspects of the environmental impacts of such activities, especially if they are expected to contribute to wider sustainability. The fundamental challenge is that many aspects of the ICT sector are themselves highly unsustainable (Unwin 2017). Two main related issues are of concern here, and need to be overcome if ICTs are truly going to be seen as contributing positively to sustainable development: first their direct environmental impact; and second the business model upon which much of the sector is based (see Chapter 5).

There is considerable debate as to the extent to which the ICT industry is indeed environmentally sustainable. Certainly, some strides have been made in this direction, but there has not yet been a sufficiently comprehensive overview of the sector's global environmental impact to support a definitive judgement. Many companies are now much clearer than they were a few years ago about their sustainability credentials, and seek to promote themselves as being more sustainable. Apple, for example, which was once widely criticised about its sustainability, now claims that "We take the same innovative approach to the environment that we do with our products. We are creating new solar energy projects to reduce our carbon footprint. We are switching to greener materials to create safer products and manufacturing processes. We are protecting forests and making sure they are managed sustainably. We are even creating a more mindful way to recycle devices using robots" (<http://www.apple.com/environment/>). The company also publishes an annual environmental responsibility report that summarises information about their actions with respect to climate change, resources and safer materials (Apple, 2016). However, comprehensive environmental reporting across the sector is lacking, and the reality is that there

remains little certainty about the overall environmental cost-benefit analysis of the ICT sector. Many companies have been able to show that they contribute positively on specific aspects of environmental impact, such as being carbon-neutral or their contribution to lowering carbon emissions or footprints (Ericsson, 2015), and some have gained ISO 14001 certification, which is intended as an assurance of environmental friendliness, a means to reduce waste, and to demonstrate environmental credentials.

However, this is fundamentally different from claiming that the sector as a whole is contributing positively and sustainably to the physical environment. Moreover, some of the raw materials that are essential for mobile phone production are produced by people working in conditions of slavery, which as Bales (2016) has argued lie at the interface between environmental destruction and human trafficking. This is hardly sustainable by any definition of the term. Some efforts have, nevertheless, been made to treat the issue of ICTs and sustainability more systemically. The ITU's (2012) toolkit on environmental sustainability has, for example, highlighted some of the issues particularly well, noting that although the ICT sector's carbon emissions are rising, it can have a wider effect on increased energy efficiencies in other sectors. As it observes, "A significant challenge for ICT companies is that in enabling better environmental performance elsewhere, the ICT sector is itself taking on significant burdens" (ITU, 2012: 1). Much of the cause of this is the very substantial demand of ICTs for electricity, both for their own direct functioning, and also for the air conditioning that is required to prevent them overheating. Creating ICTs with lower energy requirements, and using renewable sources of energy, such as solar, wind and water are all important ways through which such demand can be alleviated. It is also important that the indirect impact of ICTs on the environment, through their contribution to economic growth more widely, be taken into consideration in any comprehensive evaluation.

The Global e-Sustainability Initiative (GeSI) has also produced reports (GeSI, 2008) that have sought to address some specific aspects of sustainability, and most recently it has developed a Sustainability Assessment Framework (SASF) that companies and organisations can

use to evaluate their overall sustainability. This is built on four main elements, the environment, human rights, utility and benefits (Figure 2), and comprises approximately 100 indicators upon which organisations can assess their sustainability. Nevertheless, even this fails to take a sufficiently holistic perspective on the environmental sustainability of specific sector-wide impacts, such as total carbon emissions, on the environment, let alone the wider impact of the entire ICT and telecommunication sector on natural ecosystems (Bekaroo *et al.*, 2016). To give but one example, no current ICT environmental impact assessment sufficiently considers the environmental impact of satellites and their debris in space, which is becoming an increasingly serious challenge for the sector (Kessler and Cour-Palais, 1978; David, 2009; Liou, 2011; ESA 2017). It is estimated that there are more than 100 million pieces of debris circulating the earth, many of which derive from telecommunication satellites. Despite recent initiatives by the Japan Aerospace Exploration Agency, which launched a space rubbish collector in 2016, this problem is only likely to get worse in the immediate future as more Low Earth Orbit and Geostationary satellites are launched for communication purposes (Williams, 2017). Even though increasing areas of the world are being connected by land-based technologies, satellites still have an important role to play in broadcasting and providing connectivity to those living in the least connected areas of the earth. The SASF goes some way to monitoring the environmental impact of the sector, but it is at present too limited, and a third far-reaching recommendation of this chapter is thus:

Recommendation 3: A comprehensive and holistic independent analysis of the direct and indirect environmental impacts of the entire ICT sector should be undertaken as a matter of urgency to highlight areas where improvements can be made and damaging practices reduced. This should especially include debris mitigation measures for telecommunication satellites. ICT companies should be required by national governments to report annually on delivery against key environmental indicators recommended by such a report. The potential of ICTs to reduce environmental impacts in other sectors should also be exploited urgently so as to limit their negative externalities on the environment.

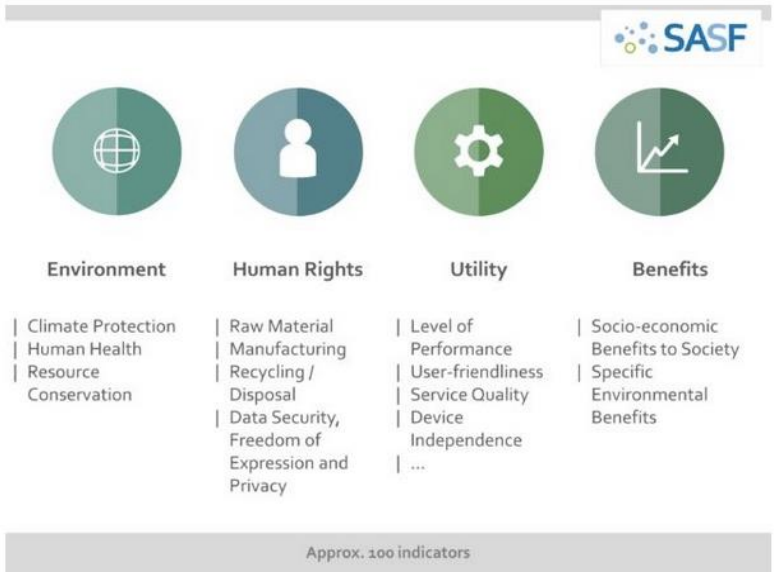


Figure 2. Global e-Sustainability Initiative's Sustainability Assessment Framework

Source: GeSI (2016).

The second very significant, and insufficiently addressed, issue concerns the explicit obsolescence and waste implications of the dominant business models adopted by many companies in the ICT sector. Its emphasis on innovation and dynamic *change*, which are usually seen as being positive and lie at the very heart of the sector, is often diametrically opposed to the inherent interests of *sustainability*. This is well exemplified by the short life-spans of most modern smartphones compared with those of old fixed-line telephones. Likewise, all too frequently hardware changes require users to purchase new software, and new software eventually requires people to buy new hardware.

Opportunities for new technological solutions to enable more sustainable practices and business models need to be explored urgently. The importance of fashion has also become central to much digital technology, with consumers being encouraged to buy the latest, most modern, device with the newest technological enhancements, rather

than keeping their old, perfectly adequately functioning current device (Hassan and Unwin, 2017). Not only does this mean that consumers regularly have to pay more for the technologies that they purchase, thereby generating enhanced corporate profits and fuelling the wealth of the world's richest people, but it also has a direct environmental impact in the form of e-waste. Much e-waste contains concentrated amounts of potentially harmful products, and in recent years a substantial trade has developed whereby poorer countries of the world have become dumps for such waste, with severe environmental damage resulting (Frazzoli *et al.*, 2010). Whilst waste-processing communities such as Guiyu in China have developed to gain economic benefit from e-waste, and recycling can help provide a partial solution for many materials, the fundamental point remains that the sector as a whole is built on a model that generates very substantial waste, rather than one that is focused inherently on sustainability. The UN's STEP (Solving The E-waste Problem; <http://www.step-initiative.org/>) initiative is one attempt to address these issues at a global scale, but many more local initiatives are needed, such as the UK's Restart platform (<https://therestartproject.org>) which works with communities, schools, and companies to value and use electronics longer whilst documenting the barriers to doing so.

Recommendation 4: Stakeholders, and especially the private sector, should draw on examples of existing good practices to develop new business models that focus on increased durability and sustainability of their technologies, whilst maintaining affordability. These should include an increase in the amount of hardware that is readily upgradable, and software that is compatible with older hardware, especially at the lower end of the market spectrum, and a reduction in the amount of e-waste.

2.3 Essential elements for Successful Application of ICTs for Sustainable Development

Chapter 1 highlighted three of the important elements that must be in place for ICTs to contribute to economic growth: infrastructure, access and skills. This closely parallels The World Economic Forum's (2016)

analysis of the four barriers that need to be overcome if everyone is to be able to benefit from effective use of the Internet: Infrastructure; affordability; skills, awareness and cultural acceptance; and local adoption and use (see also The Earth Institute Columbia University and Ericsson, 2016).

Recommendation 5: Stakeholders should work collaboratively and in multi-stakeholder partnerships, drawing on existing good practices, to enhance usage of appropriate ICTs, especially the Internet by the poorest and most marginalised, through addressing, in the order of priority: provision of appropriate infrastructure; the affordability of appropriate ICTs; the skills, awareness and cultural acceptance for all people to use ICTs; and the enhancement of local adoption and use.

Infrastructure includes not only connectivity, such as mobile broadband, but also the electricity that is essential to power all ICTs. In 2016, approximately 95% of the world's population lived in an area covered by a mobile network, with mobile-broadband networks reaching 84% of the world's population (ITU, 2016a). However, this by no means implies that everyone within these areas of connectivity is connected, and levels of connectivity vary considerably not only between, but also within, countries. Only some 67% of the world's rural people are thus currently reached by mobile-broadband networks. Furthermore, considering the presence of infrastructure alone is insufficient, because reliability, speeds and costs of connectivity also vary significantly, usually to the disadvantage of the poor and marginalised. Nevertheless, it is crucial that sufficient infrastructure is in place so that most people most of the time can have the possibility of connectivity.

Even where connectivity exists, though, many people do not use digital technologies, either because they cannot afford them or because they do not see a use for them. In practice, 3.9 billion people, representing 53% of the world's population, are still not using the Internet (ITU, 2016a), and are therefore unable to gain the benefits that it can provide. Usage rates vary considerably. Only 22% of Europeans do not use the Internet, and yet three-quarters of African people do not use it. Affordability is critical, but difficult to define, and both governments and the private sector can do much to influence the costs of connectivity in different

contexts as discussed below. Prices of both handsets and connectivity have fallen considerably in recent years in most countries, but there remain marked differences between the affordability of these technologies for poor consumers in different parts of the world (Table 2). For example, the ITU's mobile cellular sub-basket shows that costs vary from 0.09% of gross national income per capita (GNI pc) to 53.55% GNI pc in Malawi (ITU, 2016b). Likewise, costs of the fixed broadband sub-basket vary from 0.26% GNI pc in Kuwait to 1832.36% GNI pc in the Central African Republic, and of mobile broadband (500 MB) from 0.07% GNI pc in Norway to 127.27% GNI pc in Guinea-Bissau (ITU, 2016b). Lessons need to be shared between countries so that the high costs of access prevalent in many countries can be reduced to those where it is more affordable.

Table 2: Top five countries with the cheapest mobile-cellular services in different regions (PPP\$, 2015)

Table 4.3: Top five countries with the cheapest mobile-cellular services in each region, PPP\$, 2015

Europe		Asia & Pacific		The Americas	
Country	PPP\$	Country	PPP\$	Country	PPP\$
Estonia	4.67	Sri Lanka	2.45	Costa Rica	5.51
Lithuania	5.59	Bangladesh	4.14	Venezuela	10.41
Latvia	6.84	Iran (I.R.)	5.43	Paraguay	10.45
Austria	6.97	China	6.63	Jamaica	13.10
Cyprus	8.56	Pakistan	7.04	Mexico	13.90
Arab States		CIS		Africa	
Country	PPP\$	Country	PPP\$	Country	PPP\$
Sudan	5.96	Kyrgyzstan	10.56	Kenya	7.96
Tunisia	8.52	Georgia	12.49	Ethiopia	8.70
United Arab Emirates	9.15	Russian Federation	13.46	Mauritius	9.18
Jordan	10.21	Kazakhstan	14.02	Namibia	9.54
Egypt	16.78	Armenia	17.26	Nigeria	10.17

Note: Georgia exited the CIS on 18 August 2009 but is included in the ITU/BDT administrative region for the CIS countries.
Source: ITU.

Source: Table 4.3 in ITU (2016b)

Note: PPP = Purchasing Power Parity, which is a means of comparison based on the relative costs of living and inflation rates in different countries.

People also need to have the knowledge and skills to be able to take advantage of connectivity. This is not simply the knowledge of how to use the Internet to gain useful information, but also the knowledge

about how it can help them improve their lives. Hence, education more broadly is a crucial requirement for more widespread use of the Internet. Such education goes far beyond merely digital skills acquisition. Moreover, designers need to do much more to make such technologies user friendly and more intuitive for marginalised groups. Education needs to inculcate an awareness that ICTs can indeed be used to enhance health, employability, and knowledge acquisition, both through the acquisition of information but also through enhanced communication. Recent research by the OECD (2016b) is striking in this context because it shows that the already advantaged use the Internet more effectively for enhancing their careers, whereas poorer, less privileged people, tend to use it mainly for games and interacting with friends. Interestingly, disadvantaged students in all OECD countries spent at least as much time online as did advantaged students, but in half of the countries they actually spent more time than the advantaged students. However, disadvantaged students did not use it for productive purposes, preferring to chat or play videogames, whereas the advantaged students used it for information gathering or reading news. Yet again, ICTs seem to enhance inequality rather than reduce it. Furthermore, education needs to help people better understand the risks of using ICTs, and the privacy and security issues that need to be considered.

The fourth element identified by the World Economic Forum (2016) is local adoption and use, which they suggest depends much on the existence of relevant local services that people value, as well as the provision of relevant content in local languages. The interface between the digital economy and retail business is crucial here, with e-commerce, for example, only being viable where logistics permit goods ordered online actually to be supplied on the ground. This is why some companies are seeking to use drones to deliver goods or provide services to places that might otherwise be inaccessible within the time frame expected by consumers. Likewise, content in local languages that is relevant to the needs of poor people is essential if the elite language users of the Internet are not to be yet further advantaged. It has been estimated, for example, that almost 80% of online content was available in one of only 10 languages in 2016

(<http://www.internetworldstats.com/stats7.htm>). To enable such local content to be used effectively, though, it is also important that the capacity of ICT professionals to support and deploy such solutions is enhanced.

In order to overcome these barriers, and ensure that SDG 10 on inclusion has a chance of being delivered alongside the SDGs more concerned with economic growth, such as SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), and SDG 11 (sustainable cities and communities), it is essential that governments, the private sector and civil society work together effectively to deliver on the needs of all citizen-consumers, rather than just enhancing the economic, social and political benefits of the already-connected and privileged segments of society. Whilst this book focuses primarily on ways through which ICTs can contribute to the economic growth agenda, it is crucial to realise that the very basis upon which economic growth can be achieved will be under threat unless inequality is also addressed. As the OECD (2015) has shown, rising inequality creates social and political tensions that are not only a drain on the economy, but also reduce GDP growth, and prevent lower income people from realising their economic potential.

Recommendation 6: Governments should engage pro-actively in open, transparent and honest conversations with the private sector, civil society and citizens about how best to respond to the needs of the poorest and most marginalised, and the policies that should be in place to reduce inequalities through the use of ICTs.

There have been many recipes for what needs to be done to help ensure that the barriers of infrastructure, affordability, skills, and local use, are indeed overcome so that ICTs can deliver on their potential contribution to the attainment of the SDGs. Typical of these is an ICT4SDG agenda proposed by the Earth Institute at Columbia University and Ericsson outlined in Table 3. Many of these recommendations resonate with those that are also advocated in this book, although different authors are inclined to prioritise different factors, and some aspects of this approach, such as the emphasis on Public-Private Partnerships alone are problematic.

**Table 3. ICT④SDGs Agenda Proposed by
Earth Institute (Columbia Univ.) & Ericsson**

Ways through which ICT can help implement SDGS	Actions required to create an enabling framework
1. Accelerated upscaling of critical services in health, education, financial services, smart agriculture, and low-carbon energy systems.	1. Universal broadband by 2020
2. Reduced deployment costs addressing urban and rural realities	2. Enabling policy framework
3. Enhanced public awareness and engagement.	3. Rapid ICT rollout
4. Innovation, connectivity, productivity and efficiency across many sectors	4. New public-private partnership
5. Faster upgrading in the quality of services and jobs	5. Upgrade science, technology, engineering and mathematics (STEM) skills
	6. Harness big data

Source: Earth Institute @ Columbia University and Ericsson, 2016, p.9 and p.11.

It is important to recognise two main ways through which ICTs can contribute to the SDGs: directly through the impact that they have on the lives of individual poor and marginalised people; and structurally through the ways that they can enable the delivery of all of the SDGs themselves. Table 4 draws on the World Economic Forum's (2016) proposed agenda, but illustrates that priorities for action vary depending on whether people are connected, have access, or are already using the Internet.

The use of ICTs is not a silver bullet that can be used simply to deliver the SDGs, and varying technologies need to be incorporated systemically in a holistic way if they are indeed going to be used

Table 4. Agenda for Facilitating Access to the Internet by Marginalised Populations

	Those without access	Those with access but not using	Those with access and using
Extending infrastructure	Providing infrastructure	Enhancing quantity and quality of existing infrastructure	Enhancing quality of existing infrastructure
Affordability	Lowering costs, technical innovation and new business models	Lowering costs, technical innovation and new business models	Lowering costs, technical innovation and new business models
Skills and critical awareness	Improving digital literacy and understanding	Improving digital literacy and understanding of appropriate use	Improving digital literacy and understanding of appropriate use
Local adoption, adaptation and use	Ensuring context relevant content	Ensuring production and use of context relevant content	Ensuring production and use of context relevant content

Source: based on Unwin (2017) and in part on World Economic Forum (2016).

Note: items in bold indicate highest priorities, with darker shading indicating the most important priorities, and lighter shading less important.

effectively by people and their governments, the private sector and civil society in making the world a more sustainable and fairer place in which to live. This has, for example, been recognised in the work of the ITU's m-Powering development initiative, which has emphasised the importance of mobile broadband in achieving the SDGs, but above all

that any mobile-for-development initiative must involve as many relevant stakeholders as possible in delivering it, and especially that governments need to adopt a comprehensive approach involving many different departments and sectors for such initiatives to be successful and sustainable (ITU, 2015b).

Five main enabling mechanisms need to be put in place if everyone is to use ICTs effectively to enhance their lives, and especially if organisations involved in delivering the SDGs are to be successful (Unwin, 2017). First, there must be a clear emphasis not just on economic growth but also on *empowerment*, whereby not only poor people but also those working in organisations and companies committed to delivering the SDGs, can become stronger and more confident through the use of ICTs to have greater control over their lives. Such empowerment comes in part from a better understanding of the complexities of the interface between ICTs and development, and a clear realisation that they have both negative and positive outcomes. The challenge is to reduce the negative and enhance the positive, but unless people are made more aware of the negative they will be unable to find innovative ways to address it. This is in part why this chapter has emphasised the challenges associated with the tendency of ICTs to enhance both inequality and unsustainability. Unless we recognise and acknowledge this, we will not be able to address it effectively. Moreover, for poor people to be empowered they must have more of a voice in initiatives that are designed to help them. We need to work *with* poor people rather than *for* them, and ensure that not only our language but our practice delivers on this commitment.

Second, new ways must be found for resolving the contradictions implicit within the SDGs, and especially in balancing the potential for ICTs to contribute to increasing inequality and growth. If SDG 10 is to be delivered, it is essential that much more emphasis than has heretofore been the case is given to creating solutions that focus on the *interests of the poorest and most marginalised*, and not simply assuming that the contributions of ICTs to economic growth will deliver significant benefits to them.

Third, *innovative new technological solutions* need to be found through which some of the outcomes in Table 4 can be achieved. Chapter 3, in particular, examines ways through which the old business-as-usual approach can be revitalised through a focus on digital entrepreneurship and innovation. Rather than emphasising connectivity to the *next* billion, technical solutions that will deliver connectivity for the poorest and most marginalised should be prioritised, and to reflect the assertion that they are indeed of most importance, they should be called the *first* billion rather than the bottom billion. Connectivity alone, though, is insufficient, and as the remaining chapters of this book emphasise we need to enhance affordability, ease of use, and relevance of content and services if the SDGs are to be achieved. Education in its widest sense is crucial if ICTs are to be used effectively for sustainable development. ICTs can indeed support education in innovative ways, but this needs to be balanced by wider learning within those companies and organisations about how best to implement effective initiatives that contribute to the SDGs.

Fourth, there is no doubt that the private sector will find innovative ways through which ICTs can contribute to economic growth, but *governments and international organisations* have a crucial role in both enabling this to happen and ensuring that the poor and marginalised can benefit. It is here that *regulation* has a key role to play, and where re-conceptualising it as facilitation has much to offer. It is important therefore that governments use regulation effectively to facilitate the private sector in delivering appropriate ICT solutions to as many people as possible, but governments also have a responsibility for ensuring that all of their citizens can receive the benefits of ICTs for sustainable development. This will require governments to be innovative and open to new approaches and ideas, especially with reference to such devices as Universal Service Funds (USF), which have not proven to be as successful in redistributing the benefits of ICTs as many had anticipated (GSMA, 2013). Governments will also need to use their own resources to help subsidise or fund many aspects of the empowerment of the poorest of their citizens through the use of ICTs.

Fifth, this book does not focus particularly strongly on issues surrounding *digital security and resilience*. Nevertheless, as the world

becomes more reliant on interconnected technologies, and especially as the Internet of Things and 5G systems and networks begin to be rolled out, digital security will become ever more significant. It is crucial that these systems are made as resilient as possible so that when the inevitable hacking or take-downs happen, services can be brought back on-stream as soon as possible. The threat to critical infrastructures (for example, Butts and Sheno, 2012) is all too often ignored, especially in poorer countries, and if ICTs are to be used effectively in delivering the SDGs it is essential that they are made as secure and resilient as possible, and also that individual concerns over privacy are addressed appropriately by governments and the private sector.

All of these mechanisms are dependent on the involvement of a diversity of stakeholders and a commitment to effective partnerships, and it is therefore to these that the final section of this chapter now turns.

2.4. Stakeholders and Partnerships in Delivering SDGs

The above account has emphasised the importance of many different actors working together holistically and collaboratively if ICTs are indeed to be used effectively in contributing to the SDGs. In much work on the use of ICTs in development, the terms “stakeholder” and “partner” are used interchangeably to refer to such actors, but it is very important to distinguish their meaning. Stakeholders are those who have an interest in an activity, usually but not necessarily a financial interest. In contrast, partners are those who voluntarily enter an agreement to work together to deliver an output, with profits and losses usually being shared proportionally.

Stakeholder theory (Steurer *et al.*, 2005) has come to prominence largely in a neo-liberal context explicitly to provide a framework for considering the relationships between the private sector and civil society, at a time when government intervention in the economy has been declining. It has thus increasingly been used in an ICT context to refer to multi-stakeholder models of Internet governance, whereby governments, the private sector and civil society work together to reach mainly policy level agreements. However, it is extremely difficult to

group all the different actors together in this threefold classification, and international organisations have often therefore treated researchers, foundations and donors as additional separate categories. The ITU, for example, now has a specific category of Academia Membership. Moreover, most uses of the term in the ICT context fail sufficiently to consider the most important stakeholder, namely the user, be it as a consumer for the private sector, or a citizen for governments. A key theme of this book is that if ICTs are going to be used effectively to deliver on the SDGs it is important that people who use, or are intended to use, the technologies are considered both conceptually and practically as one of the major stakeholders. Indeed, the distributed and widespread reach of ICTs itself provides an important vehicle through which new methods of interaction between on the one hand people, and on the other governments and companies can take place. It is also important that citizen-consumers have a greater voice in the development of policies that will have such a significant influence in their future lives, especially when critical issues such as privacy and security are being debated. Recent work by Nesta, for example, has highlighted the potential of collective intelligence to develop new kinds of government decision making at a range of scales (Saunders and Mulgan, 2017).

The notion of multi-stakeholderism, however, is problematic both as an idea and as a practice (e.g., see Laprise and Musiani, 2015; Hoffman, 2016). For example, the Tunis Agenda did not adequately explicate the roles of the different sectors in Internet governance (WSIS, 2005, Para. 35): states were seen as having a sovereign right over policy authority; the private sector as having an important technical and economic role in the development of the Internet; and civil society as being important, especially at the community level. The role of international organisations was considered to be in facilitating public policy discussions, and in developing technical standards and policies. These various stakeholders have different interests, and each has sought to shape the multi-stakeholder dialogue in their own interests, leading to considerable overlap, competition, and duplication of effort. If ICTs are indeed going to be used more effectively to deliver the SDGs, ways need to be found to reduce such overlap and ensure a more integrated

approach to global and national policy making. This will require the organisations participating in the dialog to relinquish some of their own interests for the greater good, to accept enhanced collaboration between different organisations, and a reduction in the expansionist agendas of some organisations.

The notion of partnerships is also frequently applied to the delivery by many stakeholders of practical development-related programmes and projects on the ground (Geldof *et al.*, 2011). Such partnerships are important because many different skills, experiences and resources are required if ICT initiatives are to be successfully implemented in delivering the SDGs. Initially these were conceptualised as Public-Private Partnerships (PPPs), reflecting the neo-liberal shift towards increasing private sector delivery of what had previously been considered public sector activity (Unwin, 2015). However, the failure of many PPPs in delivering sustainable ICTs for development initiatives, which was often attributed to PPPs not sufficiently involving civil society or indeed other stakeholders, notably the end users, has led to the increasing use of the terms multi-sector, or multi-stakeholder partnerships (MSPs), to emphasise that in most instances private sector companies and governments cannot successfully deliver such initiatives alone. A key learning from many such partnerships has also been that it is much better to involve the business-end of companies than their Corporate Social Responsibility (CSR) departments in implementing projects, because the business-end has more experience in ensuring delivery and profitability, and thus sustainability, whereas projects that rely on external CSR funding frequently collapse when that funding runs out. A further challenge with multi-stakeholder partnerships is that all too often well-intentioned stakeholders come together to deliver an intervention but fail to sufficiently draw on existing good practices in implementing partnerships. It is not easy to deliver partnerships, and often it is more cost effective to use traditional contracts to ensure effective implementation, but there are good partnerships models that can be used so that new initiatives do not reinvent the wheel and repeat the mistakes made in previous projects (see Appendix A).

Recommendation 7: A flexible and effective multi-sector partnership (governments, private sector, civil society, and citizens) approach (MSPs), which goes beyond just the combined interests of the public and private sectors in public-private partnerships (PPPs), is important for implementing ICT initiatives that contribute to sustainability. However, delivering effective partnerships is difficult, and all engaged in so doing should ensure that they draw on existing models of good practice.

2.5 Concluding Remarks: ICTs in Sustainable Development

This chapter has provided an overview of the critical elements that need to be in place for ICTs to be able to contribute effectively to delivering the SDGs. It has highlighted some of the conceptual challenges around the notion of sustainability, both in the context of development and in the sustainability of ICTs themselves. These need to be overcome if ICTs are to contribute effectively to the delivery of sustainable development. It has also identified the most important (critical) elements that need to be in place to ensure that ICTs are indeed used appropriately, especially for the economic growth, employment, and innovation dimensions of the SDGs that are explored in this book: appropriate universal infrastructure, including electricity, must be present; the technologies must be affordable, especially for the poorest and most marginalised; people need to have the appropriate skills and awareness of how to use ICTs to enhance their lives and deliver the SDGs; and there needs to be locally relevant content.

The chapter has emphasised that to achieve these goals, those who develop policies and implement programmes and projects need to address issues of empowerment, focus on the needs of the poorest, develop innovative technological solutions and new business models, legislate new kinds of regulation through which governments facilitate the ICT and telecommunication sector, and ensure that there is effective security and resilience within the systems being developed.

Finally, multi-stakeholder partnerships can be an effective mechanism for implementing ICT initiatives that will contribute to the SDGs, but

these need to draw on appropriate good practices so that the past failures of many such partnerships can be avoided (Unwin, 2015). Above all, it is important that system-wide and comprehensive initiatives are implemented to bring together the full diversity of relevant stakeholders, and especially the intended users, if ICT initiatives are indeed to deliver effectively on the SDGs.

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References

- Apple (2016). Environmental Responsibility Report: 2016 Progress Report, Covering Fiscal Year 2015. Cupertino, CA: Apple.
- Bales, K. (2016). *Blood and Earth: Modern Slavery, Ecocide, and the Secret to Saving the World*. New York, NY: Spiegel & Grau.
- Bekaroo, G., Bokhoree, C. and Pattinson, C. (2016). Impacts of ICT on the natural ecosystem: a grassroot analysis for promoting socio-environmental sustainability. *Renewable and Sustainable Energy Reviews*, 57: 1580-1595.
- Brundtland Commission (1987) *Our Common Future*. Oxford, UK: Oxford University Press.
- Butts, J. and Shenoi, S. (eds) (2012). *Critical infrastructure Protection VI*. Heidelberg, Germany: Springer and International federation for information Processing.

ICT-centric economic growth, innovation and job creation

- Carant, J.B. (2017). Unheard voices: a critical discourse analysis of the Millennium Development Goals' evolution into the Sustainable Development Goals. *Third World Quarterly*, 38(1): 16-41.
- David, L. (2009). Space littering can impact earth's atmosphere. *Space.com*, 19: May 2009. <http://www.space.com/6720-space-littering-impact-earths-atmosphere.html>.
- Earth Institute @ Columbia University and Ericsson (2016). ICTs and SDGs Final Report: How Information and Communication Technology Can Accelerate Action on the Sustainable Development Goals. New York, NY: The Earth Institute Columbia University and Ericsson.
- Ericsson (2015). *Technology for Good: Ericsson Sustainability and Corporate Responsibility Report 2015*. Stockholm, Sweden: Ericsson.
<https://www.ericsson.com/assets/local/about-ericsson/sustainability-and-corporate-responsibility/documents/2015-corporate-responsibility-and-sustainability-report.pdf>.
- ESA. (2017). Seventh European Conference on Space debris.
<https://conference.sdo.esoc.esa.int/>.
- Frazzoli, C., Orisakwe, O.E., Dragone, R. and Mantovani, A. (2010). Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios. *Environmental Impact Assessment Review*, 30: 388-399.
- Freistein, K. and Mahlert, B. (2016). The potential for tackling inequality in the Sustainable Development Goals. *Third World Quarterly*, 37(12): 2139-2155.
- Geldof, M., Grimshaw, D., Kleine, D. and Unwin, T. (2011). What are the key lessons for ICT4D partnerships for poverty reduction? Systematic review report, London: Department for International Development.
http://r4d.dfid.gov.uk/PDF/Outputs/SystematicReviews/DFID_ICT_SR_Final_Report_r5.pdf
- GeSI (2008). The Contribution the ICT Industry can Make to Sustainable Development. Brussels, Belgium: Global e-Sustainability Initiative.
<http://gesi.org/files/Reports/The%20Contribution%20the%20ICT%20Industry%20Can%20Make%20to%20Sustainable%20Development.pdf>.
- GeSI (2016). *The Sustainability Assessment Framework*. Brussels, Belgium: Global e-Sustainability Initiative (<http://gesi.org/SASF>).
- GSMA (2013). *Universal Service Fund Study*. London, UK: GSMA.
- Hassan, B. and Unwin, T. (2017). Student mobile identity in Pakistan: on, in and through the phone. *Information Technologies and International Development*,
- Hoffman, J. (2016). Multi-stakeholderism in Internet governance: putting a fiction into practice. *Journal of Cyber Policy*, 1(1): 29-49.

ICT-centric economic growth, innovation and job creation

ITU (2012). *Toolkit on Environmental Sustainability for the ICT Sector*, Geneva, Switzerland: ITU. https://www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000060001PDFE.pdf.

ITU (2015a). *Advancing Sustainable Development Through Information and Communication Technologies: WSIS Action Lines Enabling SDGs*. Geneva, Switzerland: ITU.

ITU (2015b). *m-Powering Development Initiative Report 2015*. Geneva, Switzerland: ITU.

ITU (2016a). *ICT Facts and Figures*. Geneva, Switzerland: ITU. <https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf>.

ITU (2016b). *Measuring the Information Society Report, 2016*. Geneva, Switzerland: ITU.

Kessler, D.J. and Cour-Palais, B.G. (1978). Collision frequency of artificial satellites: the creation of a debris belt. *Journal of Geophysical Research*, 83: 2637-2646.

Laprise, J. and Musiani, F. (2015). Internet Governance, in: Mansell, R. and Ang, P.H. (eds) (2015) *The International Encyclopedia of Digital Communication and Society*. Chichester, UK: Wiley-Blackwell, 1-9.

Liou, J.-C. (2011). An active debris removal parametric study for LEO environment remediation. *Advances in Space Research*, 47(11): 1865-1876.

O'Boyle, E.J. (1999). Toward an improved definition of poverty. *Review of Social Economy*, 57(3): 281-301.

OECD (2015). *In It Together: Why Less Inequality Benefits All*. Paris, France: OECD.

OECD (2016a). *Measuring Distance to the SDGs Targets: A Pilot Assessment of Where OECD Countries Stand*. Paris, France: OECD.

OECD (2016b). Are there differences in how advantaged and disadvantaged students use the Internet?, *PISA in Focus*, 64.

Oxfam (2017). *An Economy for the 99%: It's Time to Build a Human Economy that Benefits Everyone, Not Just the Privileged Few*. Oxford, UK: Oxfam GB.

Redclift, M. (2007). Sustainable development (1987-2005): an oxymoron comes of age. *Sustainable Development*, 13: 212-227.

Sachs, J. (2005). *The End of Poverty: How we Can Make it Happen in Our Lifetime*. London, UK: Penguin Books.

Saunders, T. and Mulgan, G. (2017). *Governing with Collective Intelligence*. London, UK: Nesta.

ICT-centric economic growth, innovation and job creation

Statistics Netherlands (2015). *ICTs and Economic Growth*. The Hague, Netherlands: Statistics Netherlands.

UN (2017). Sustainable Development Goals: 17 Goals to Transform our World. <http://www.un.org/sustainabledevelopment/development-agenda/>.

UNCTAD (2103). Information Economy Report 2013: The Cloud Economy and Developing Countries. Geneva, Switzerland: UNCTAD.

UNCTAD (2105). Information Economy Report 2015: Unlocking the Potential of E-commerce for Developing Countries. Geneva, Switzerland: UNCTAD.

UNDP (2015). *Human Development Report 2015: Work for Human Development*. New York, NY: United Nations Development Programme.

Unwin, T. (2007). No end to poverty. *Journal of Development Studies*, 45(3): 929-53.

Unwin, T. (2015). Multistakeholder partnerships, in: Mansell, R. and Ang, P.H. (eds) *The International Encyclopedia of Digital Communication and Society*. Chichester, UK: John Wiley, 634-44.

Unwin, T. (2017). *Reclaiming Information and Communication Technologies for Development*, Oxford, UK: Oxford University Press.

Williams, M. (2017). Eye-opening numbers on space debris. <https://phys.org/news/2017-03-eye-opening-space-debris.html.satellite>

World Bank (2016). *World Development Report*. Washington DC: World Bank.

World Economic Forum (2016). Internet for All: A Framework for Accelerating Internet Access and Adoption. Cologny, Switzerland: World Economic Forum.

WSIS (2005) Tunis Agenda for the Information Society, WSIS-05/TUNIS/DOC/6(Rev. 1)-E. <http://www.itu.int/net/wsisis/docs2/tunis/off/6rev1.html>

Appendix A

The World Economic Forum's Global Education Initiative

*Alex Wong (World Economic Forum)
and
Tim Unwin (UNESCO Chair in ICT4D)³⁹*

Many people talk about partnerships in the use of ICTs for development, but few deliver them effectively in the interests of the poorest and most marginalised. In part, this is because they do not draw on existing good practices, and in part because so many people in the sector want to reinvent the wheel. However, some partnerships have indeed been effective, not only for the partners themselves, but also for the intended beneficiaries. One such initiative was the World Economic Forum's Global Education Initiative (GEI) that ran between 2003 and 2011, culminating in its Partnerships for Education initiatives with UNESCO that sought to draw together lessons learnt about delivering educational partnerships, especially through the use of ICTs. This Appendix draws especially on the findings of this initiative, to provide recommendations about good practices that can be followed by all those interested in delivering effective ICT4D partnerships in response to the SDGs.

³⁹ This Appendix draws in part on Global Education Initiative: Retrospective on Partnerships for Education Development 2003-2011, Geneva: World Economic Forum, and on MultiStakeholder Partnerships in Information and Communication for Development Interventions, T. Unwin in Mansell, R. and Ang, P.H. (eds.) International Encyclopaedia of Digital Communication and Society, Chichester: Wiley, 634-644, 2015.

There exist many models of effective partnership delivery. One of the best known is that developed over many years by The Partnering Initiative (Tennyson, 2011). This is circular in design, involving four broad stages: scoping and building; managing and maintaining; reviewing and revising; and sustaining outcomes (Figure A1); once the circle has been completed, the partnership can reinvent itself, or cease functioning. Alternative models, though, can often be more appropriate for delivering effective development interventions, since such circular partnerships tend to place more emphasis on maintaining the partnership than on what it actually achieves in terms of development outcomes (Unwin, 2005).



Figure A1. The Partnering Initiative's Partnering Cycle

Source: http://thepartneringinitiative.org/what_is_partnering.jsp

Cassidy's linear model derived from his work with the World Economic Forum's GEI provides a useful alternative framework that very much places the emphasis on the final results that are clearly articulated and agreed by partners at the beginning of the process (Figure A2). There are five core elements to Cassidy's model drawn from the empirical experience of the GEI's ICT for education partnerships:

ICT-centric economic growth, innovation and job creation

1. The leadership, governance and decision making processes, as well as a clear monitoring and evaluation strategy need to be in place throughout the entire process.
2. Three elements are essential at the beginning: core values and objectives; the vision, goals and objectives; and organisational readiness. Without any of these, the partnership will flounder.
3. A project management office of some kind needs to be put into place, to deliver the management, planning, communications and resource mobilisation elements of the partnership.
4. This then enables the interactions between the various partners and the intended beneficiaries, in Cassidy's case the schools and communities, to be implemented effectively.
5. Ultimately, this will then lead to effective and relevant results in terms of educational outcomes.

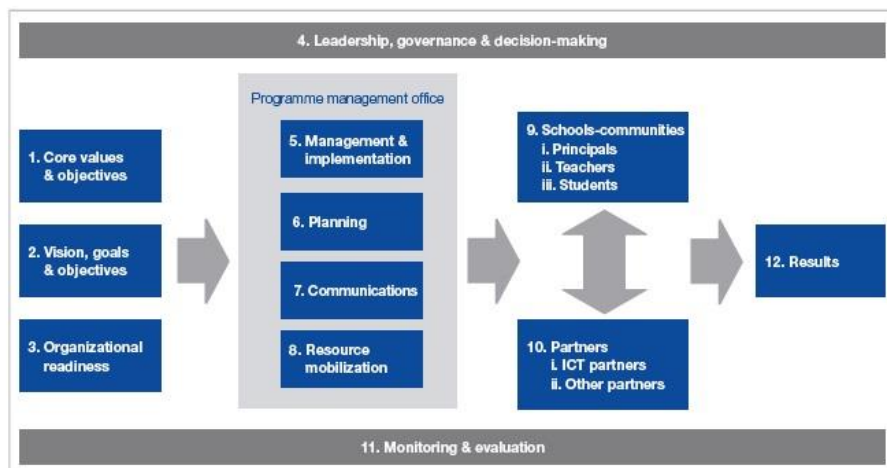


Figure A2. Cassidy's Model of GEIs Partnerships

Source: Cassidy (2007)

The GEI was launched in 2003 and focused initially on improving the development and delivery of education to Jordan's citizens through the use of ICTs, in what became known as the Jordan Education Initiative (JEI). Bringing together government agencies, global ICT companies such as Cisco, Microsoft and Intel, as well as local companies, it

developed content in the core subject areas of mathematics, science, Arabic, English and ICTs, and implemented its roll out through 100 Discovery Schools that were provided with ICTs by the partners. Following the perceived success of the JEI, the Governments of Rajasthan in India and the Government of the Palestinian Territories both expressed interest in launching similar initiatives in 2005, and the government of Egypt likewise followed suit in 2006. Each initiative had different objectives, and a varying set of partners, although the core companies mentioned above played a leading role in shaping all of the initiatives.

As the GEI developed, four emergent principles became evident in catalysing effective ICT-enabled, action-oriented, and issue-based multi-stakeholder partnerships:

1. “Senior-level political ownership is critical in providing the long-term stability and vision that stakeholders require in any multi-stakeholder partnership initiative”;
2. “Alignment with national education sector plans ensures that an initiative aligns with the day-to-day activities and bureaucracy of the government, and the activities of the bilateral and multilateral donor community”;
3. “Maintaining overall programme management and keeping stakeholders aligned and informed are crucial tasks that cannot be underestimated, both in terms of resources and technical skills required”; and
4. “A neutral partnership broker that creates a platform of transparency and trust allows stakeholders to meet on a consistent basis at the senior levels to discuss progress, remove barriers and reaffirm commitments” (World Economic Forum, 2012, p.22).

The World Economic Forum’s (2012) final review of the GEI’s achievements, based upon interviews with many of those involved, highlighted three key lessons learned about crafting ICT partnerships for education:

1. Careful project management is essential for the success of an educational partnership;
2. Individuals play a critical role; and

3. Visibility through external and internal communication strategies is important.

It also noted six critical challenges that needed to be overcome in future initiatives:

1. Ensuring long-term sustainability, including maintaining the excitement and interest;
2. The underestimated difficulty of reaching common agreement on the goals and activities to be undertaken in an initiative;
3. The importance of balancing the different interests of the stakeholders, and determining what levels of contribution are expected from particular partners;
4. Identifying resources and focus;
5. Cooperation between private sector partners and relevant national bodies; and
6. Timely monitoring and evaluation (not leaving them until the end, when there is often little money left).

These are all important pointers to what can help make ICT partnership interventions successful. It is, though, highly pertinent for this book on delivering the SDGs that the most important challenge identified in the GEI was the first of these, ensuring long-term sustainability. Following previous examples of good practices in partnership implementation can indeed help to ensure success, but partnerships are difficult to implement successfully, and they must above all focus on ensuring that their interventions are indeed sustainable (see also Geldof *et al.*, 2011).

References

- Cassidy, T. (2007). The Global Education Initiative (GEI) Model of Effective Partnership Initiatives for Education. Geneva: World Economic Forum.
- Geldof, M., Grimshaw, D., Kleine, D. and Unwin, T. (2011). What are the key lessons for ICT4D partnerships for poverty reduction? Systematic review report, London: Department for International Development.
- Tennyson, R. (2011). *The Partnering Toolkit*. Oxford: The Partnering Initiative in Association with the International Business Leaders Forum. 3rd edition.

ICT-centric economic growth, innovation and job creation

Unwin, T. (2005). *Partnerships in Development Practice: Evidence from Multi-Stakeholder ICT4D Partnership Practice in Africa*, Paris: UNESCO for the World Summit on the Information Society.

World Economic Forum. (2012). *Global Education Initiative: Retrospective on Partnerships for Education Development 2003-2011*, Geneva: World Economic Forum.

Biography

Tim Unwin is UNESCO Chair in ICT for Development (ICT4D) and Emeritus Professor of Geography at Royal Holloway, University of London. He was Secretary General of the Commonwealth Telecommunications Organisation (CTO) from 2011-2015, and Chair of the Commonwealth Scholarship Commission from 2009-2014. He serves on the ITU's m-Powering Development Advisory Board, the UK Department for International Development's Digital Advisory Panel, the UN University – Computing and Society International Advisory Board, the Steering Committee of the World Economic Forum's Internet for All initiative, and is Honorary Professor at Lanzhou University in China. He has written or edited 15 books and more than 200 academic papers and chapters, many of which focus on the use of technology for development. His edited book *Information and Communication Technologies for Development*, is published by Cambridge University Press, and his book *Reclaiming ICT4D* is published by Oxford University Press. He was appointed a Companion of the Distinguished Order of St. Michael and St George (CMG) in the Queen's 90 birthday Honours list in 2016 for his services to the Commonwealth.

Chapter 3

Digital Divide and Digital Multiplier: A Paradigm Shift through Innovation

*Emanuele Giovannetti**

This chapter discusses the key factors that facilitate and support the creation of an environment in which innovations are more likely to succeed, and highlights recommendations to make Information and Communication Technologies (ICTs) key enablers in realizing the Sustainable Development Goals (SDGs). These recommendations arise from adopting a multi-stakeholder approach to support innovations. The stakeholders' roles are analyzed by focusing on how they interact through ICT-enabled platforms that allow establishing new and previously unachievable interconnections in the development of innovations. Examples of such ICT-enabled platforms are discussed by focusing on their potential benefits and associated risks, which ultimately depend on the existence of proper technologies as well as an enabling policy, regulatory and economic environment to support different pillars in the innovation ecosystem, including the role of gender in innovation, and the potential for positive spillovers to create digital multipliers that foster useful innovations and enhance productivity.

3.1 Introduction

This chapter identifies the key elements that facilitate and support the creation of an environment in which innovations are more likely to

* Anglia Ruskin University and Hughes Hall College, University of Cambridge, Cambridge, United Kingdom

succeed, and highlights the policies that need to be set and implemented so that Information and Communication Technologies (ICTs) may become vital enablers in realizing the Sustainable Development Goals (SDGs). When properly applied, ICT-centric innovations can act as digital multipliers, providing digital dividends for the billions of disconnected or poorly connected people in many regions of the world (World Bank, 2016). By facilitating ICT-centric innovations, the digital revolution plays a key role in reaching many of the SDGs discussed in Chapter 1.

We broadly define innovation as "a previously non-adopted modality to satisfy a specific need in a given context."⁴⁰ This high-level characterization encompasses the traditional distinctions between process, product and organisational innovations, between radical and incremental innovations, and includes the diffusion and adoption of innovations in new contexts. For example, product innovations may satisfy the need for an intermediate product or service within a production chain in a B2B framework, or increase service variety for the end user in a B2C setting. Our definition also encompasses processes and organizational innovations associated with structuring and managing resources and outputs within enterprises and markets. Our definition of innovation also includes the adoption of techniques that may be well-established in other contexts but may find new applications in new contexts. Thus, technological adoptions and adaptations, often through recombination, are also regarded as innovations.

This chapter focuses on the entire *innovation ecosystem* (Adner, 2006), which includes interactions between different stakeholders participating in the innovation process and the forces and feedbacks that drive such interactions. In this ecosystem, ICTs play a key role in clarifying how the linkages operate, and facilitate interactions to expand and enhance opportunities as discussed in detail below. ICTs enable stakeholders to develop and share new knowledge, impacting all aspects of innovation

⁴⁰ The literature is rife with multiple characterizations of what constitute innovations. For example, the pioneering work by Pavitt (1984) and Archibugi (2001) provide useful frameworks for understanding innovation processes.

processes from the original discovery through their implementation in the operation of markets and enterprises. This chapter also addresses the conditions required for the innovation ecosystem to transform digital divides into digital multipliers. The focus is on the building blocks forming the innovation ecosystem that benefits from the full set of implicit and explicit interactions between different stakeholders. In this framework, *ICT-centric platforms* are simultaneously organizational innovations in their own right as well as innovation enablers. As such, they play a pivotal role in generating digital multipliers.

3.2 Innovation Ecosystems

The study of the drivers of innovation was radically transformed in the late 20th century by the emergence of evolutionary economics (Nelson and Winter, 1982; Dosi, 1982) whose focus was on understanding innovations as *organisational learning processes* leading to creative and disruptive effects on markets and industries (Schumpeter, 1934). In this paradigm, the focus shifted to modeling the processes governing a firm's production decisions and considering innovations as the process by which the production processes mutated. This led to the concept of *national innovation systems* (Lundvall, 1992) based on the notion that understanding the linkages among key supply chain actors leads to understanding how innovations contribute to the enhancement of the overall economic performance. This is due to the fact that innovation and technical progress emanate from a complex set of interactions among multiple actors engaged in producing, distributing and applying different kinds of knowledge, and "the innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use, as well as the technologies they use." (OECD, 1997, page 9).

The functioning of *innovation ecosystems* depends on how their multiple stakeholders are linked through a set of cooperative interactions that form an *open innovation network* (Chesbrough, 2003). Open innovation networks enhance digital multipliers, and generate additional indirect benefits by expanding the effects of innovations to an even wider set of stakeholders through positive spillovers and network externalities. By including these indirect spillovers and

unintentional benefits, an *innovation ecosystem* (our focus here) represents a more encompassing concept than the set of explicit cooperative interactions forming the *open innovation network*.

The following sections build on this conceptual framework, and consider innovations as part of a dynamic process of collective learning, leading to changes in the way products and services are made, refined and delivered.

3.2.1 Collaborations as Building Blocks of Innovation Ecosystems

In order to understand how the *innovation ecosystem* works, one needs to focus on the interactions between different stakeholders (Figure 3.1). These interactions represent *collaborations* that enable the *innovation ecosystem* to develop, share, and implement innovations. Our focus on the modalities of collaboration among stakeholders is based on the large body of theoretical and empirical research developed to measure innovative activities and outputs, as discussed in the *Oslo Manual* (OECD/Eurostat, 2005) which is a key reference on the design of the *Community Innovation Surveys* (CISs), conducted by Eurostat.⁴¹

The CISs provide valuable data for assessing the degree of *innovativeness* in European countries, regions and sectors and identify the data needed to assess the economy's capacity for innovation. The CISs focus on the process, product and organisational innovations and the interdependencies among the many stakeholders that jointly contribute to the development of innovations. These innovation surveys allow a detailed decomposition of a firm's innovation expenditures into different intangible assets (Corrado et al., 2006) that contribute to building its capacity for absorbing knowledge (Cohen and Levinthal, 1990). The CISs also provide evidence about the many *intentional* cooperation activities, set up by firms as part of their innovation processes. These activities are categorized according to the types of interactions among stakeholders. The CISs list the set of stakeholders

⁴¹ Eurostat (2017). <http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>.

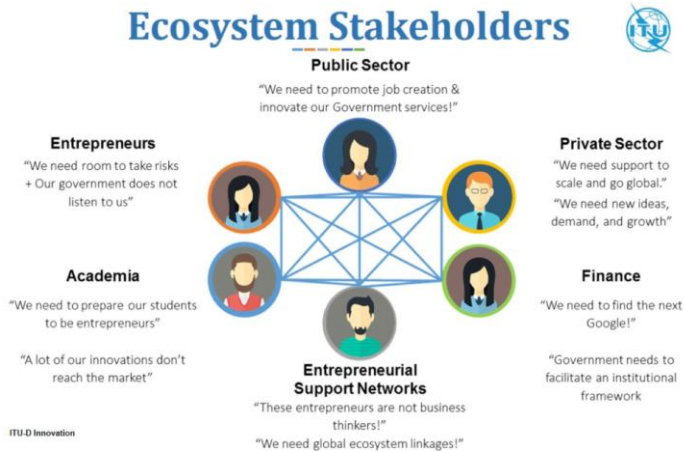


Figure 1. Stakeholders in Innovation Ecosystem

Source: ITU (2017)

with whom an innovating firm can set up cooperative interactions in one of the following categories: 1) other businesses within the same enterprise group, 2) suppliers of equipment, materials, services or software, 3) clients, customers or end users, 4) competitors or other businesses in the same industry, 5) consultants, commercial laboratories, or private R&D institutes, 6) universities or other institutions of higher education, and 7) Government or public research institutes.⁴²

The role of intentional cooperation for innovation has been the focus of Management, Innovation and Regional Studies using survey data. In separate studies, De Propriis (2002), Freel and Harrison (2006), Tomlinson and Jackson (2013) and Giovannetti and Piga (2017) have all identified the facilitating role of stakeholders' cooperation for the realization of successful innovations. The positive role of explicit cooperation on innovation is also one of the key insights that has emerged from the literature on *open innovation* processes (Chesbrough, 2003; Gassmann et al., 2010). This leads to Recommendation 1 below to develop a roadmap for supporting innovations:

⁴² See Mazzucato (2013) for a fascinating analysis of the role of governments in the innovation process.

Recommendation 1: Facilitate cooperation in innovative activities among different stakeholders by providing face-to-face and virtual meetings, and trust-enforcing mechanisms to increase the chances of success.

3.2.2 Collaboration Among Competitors Can Hamper Innovation

While the previous section stressed the importance of facilitating cooperative interactions between different stakeholders, a policy roadmap also needs to focus on the potential for conflicting economic objectives among different stakeholders in the *innovation ecosystem*. For example, innovations in goods and services when introduced by competitors intensify both price and quality competition, exerting a negative effect on profitability. Anticipation of this adverse impact can reduce the incentives to innovate (Giovannetti, 2013; Katz et al., 1990). Insiti and Levien (2004) coined the term “*dominator strategy*” to capture how this might adversely affect an open innovation ecosystem and reduce its innovation output. Furthermore, building on the Schumpeterian notion of *creative destruction*, Aghion and Howitt (1992) incorporated these ideas into an endogenous growth model, and pioneered the *Neo-Schumpeterian* approach to the relationship between innovations and economic growth (See Aghion et al., 2014 for a recent survey). A problem may arise when innovation policies support industrial consortia for developing systems such as online booking systems or e-commerce platforms. While cooperation in such consortia can help with cost sharing and the dissemination of best practices, there is also a risk that such consortia can be used to reduce competition that might otherwise be a strong incentive. Such negative aspects of cooperation among competitors within an *innovation ecosystem* should, therefore, be taken into account when assessing potential obstacles in introducing innovations.

Recommendation 2: Monitor cooperation between stakeholders that are also product competitors as this may reduce rivalry and reduce innovation.

3.2.3 ICTs, Spillovers and Soft Boundaries in Innovation Ecosystem

CISs capture explicit collaborations among stakeholders, but are less successful in capturing implicit or unintentional interactions that can also facilitate knowledge spillovers. Marshall (1890) was the first to note the role of knowledge spillovers by way of face-to-face interaction and informal contacts (Polanyi, 1958) that can take place when parties are in physical proximity (Jaffe, 1989; Acs et al., 2002; Audretsch and Feldman, 1996). Due to the de-localising effect of ICTs, such spillovers can now take place without requiring physical proximity⁴³. This unintentional form of cooperation is what characterizes the holistic nature of *innovation ecosystem*, where intentional collaborations as well as unintentional knowledge spillovers facilitate innovations.

To deliver tangible benefits, these spillovers require potential beneficiaries to appreciate and take advantage of the shared knowledge. Cohen and Levinthal (1990) noted that knowledge produced elsewhere is a key component of a company's *intangible capital* (Corrado et al., 2006) and is considered as an enabler of innovation. Such knowledge spillovers that can occur because ICTs reduce the need for physical proximity are beneficial simply because trade between firms can be increased because of such spillovers.⁴⁴ Hence, the increasing importance of e-commerce platforms for *Business to Business* (B2B) interactions makes ICTs a key enabler for facilitating and absorption of unintentional cooperation.

⁴³ ICTs make it feasible to distribute the organization of decision-making and production in multiple dimensions: geographically (e.g., software running on a remote server can implement functionality that previously had to be hosted on hardware in a specific location); time (e.g., store-and-forward service); and context (e.g., software-controlled machines can customize production on a per-unit basis).

⁴⁴ A research paper on these themes, published by the UK Department for Business, Innovation and Skills (BIS, 2014), for example, measured the *unintentional cooperation* effects arising from proximity in production space by using metrics based on weights derived from inter and intra-sector trade exchange flows.

3.2.4 ICT-Centric Innovation Ecosystems

Having considered the importance of intentional and unintentional collaborations in the *innovation ecosystem*, we now focus on the role of ICTs in facilitating open collaboration and introducing innovations. By allowing virtual communications that do not require physical co-location of collaborators, ICTs play a key role in forming virtual R&D teams, promoting creativity, exchanging technical information, and coordinating decentralized activities, as shown by Boutellier et al. (1998) in their study of IBM's transnational R&D activities. The literature also attests to the importance of investing on ICTs as a key enabler in firms' *innovative activities* leading to better productivity (Hall et al., 2012). ICTs may simultaneously be the cause and the effect of innovations, which complicates the analysis of their impact. Different authors have addressed this problem by proposing different estimation or modeling schemes (Brynjolfsson and Hitt, 1995; Hempell, 2005; Röller and Waverman, 2001; Czernich et al., 2011).

The concept of innovation ecosystem has also been used in framing policies in developing countries (ITU, 2016a). When assessing the impact of ICTs in fostering innovation in developing countries, the key problem is that the innovation ecosystem often suffers from the absence of reliable ICT infrastructure needed by advanced ICT-based platforms.

Recommendation 3: As the innovation ecosystem benefits also from unintentional collaboration, arising from spillovers in intangible innovative activities, innovation policy should encourage the use and diffusion of all platforms that facilitate the process of knowledge absorption for the formation of human capital and ICT access infrastructure required by these platforms.

Another major impediment often experienced in flourishing innovations is the lack of sufficient funds to transform innovative ideas into successful products and services. In some economies, venture capital comes to the rescue, where risk-taking investors are prepared to invest in activities that in their own judgment are worthy of investment. However, when venture capital is unavailable, a new concept called crowdfunding, as described further in Section 3.3.3, can be used where many investors provide small amounts and the risk is distributed to

many funders. Crowdfunding uses web-based interfaces to match lenders and borrowers to finance micro-entrepreneurship and innovation projects, and is an example of ICT-enabled platforms that can play an important role in strengthening the innovation ecosystem (Kromidha and Robson, 2016; Davies and Giovannetti 2016).

There are many other examples of ICT-enabled concepts, such as *Innovation Hubs* (World Bank, 2016, Box 4.29 page 229; Firestone and Kelly, 2015) that match innovators with entrepreneurs and financiers; Internet exchange points (World Bank, 2016, page 220) that facilitate exchanging Internet traffic in a cost effective manner, E-commerce platforms (ITC, 2016) that match sellers and buyers, and national research and education networks that connect researchers and universities in different locations to achieve WSIS Target 3 "Connect all scientific and research centers with ICTs" (ITU, 2011; World Bank 2010; Foley, 2016), all of which can facilitate innovation by linking key stakeholders. Each of these ICT-enabled platforms is both an ICT-innovation in its own right, as well as a facilitator of additional innovations. When extant, such platforms can serve as digital multipliers, amplifying the effects of innovations by expanding their accessibility, while stimulating more innovations. However, the success of such platforms is not assured and depends on the existence of proper technologies as well as the enabling policy, regulatory and economic environment to support the pillars of innovation ecosystem.

An important element for ensuring that such platforms can serve as digital multipliers is the need to provide access to disconnected populations. This is in line with Target *c* of SDG 9: "*Significantly increase access to information and communications technology (ICT) and strive to provide universal and affordable access to the Internet in least developed countries by 2020.*" At present, this is mainly achieved via wireless networks as the preferred way to reach the unreached in an affordable manner and provide them with digital content and connectivity (ITU, 2016). Hence, affordability, quality and availability of mobile services are vital for these platforms to reach critical masses of users. For innovation to be economically viable, there needs to be an addressable market that exceeds a critical mass, which once achieved can set off a self-reinforcing adoption cycle (Katz and Shapiro, 1985).

Public policy can help jumpstart such adoption bandwagons by helping to form the critical mass through demand aggregation, education, and/or subsidy programs. Such policy stimulus is especially important when social returns greatly exceed private returns.

Bricks and mortar shops and physical market places are examples of market platforms that enable buyers and sellers to engage in the trade of goods and services. The formation of micro-shops addresses gender equality (SDG 5) as their absence forces consumers, predominantly women and girls, to walk for kilometers to purchase and exchange essential livelihood items, preventing them from engaging in educational tasks. Establishing micro-shops to meet these needs often requires micro-entrepreneurship that, in turn, needs the availability of more advanced digital platforms, such as mobile banking. In many rural areas, it can be difficult for financial institutions to find economic incentives to provide physical banking services to the population (UNCTAD, 2015; ITU, 2016; McKinsey, 2016).

In each of such platforms, the key elements are *partnership and cooperation* that also require conscious decisions based on human and business interactions, for which ICT infrastructure is a prerequisite.

Recommendation 4: As an ICT-centric innovation ecosystem is formed by developing and utilizing multiple ICT-enabled platforms by different stakeholders, there is a need for holistic and gender aware policies to ensure that such platforms are developed and used for attaining a vibrant and successful innovation ecosystem.

3.3 Examples of ICT-Centric Innovation Ecosystem and Their Relevance to SDGs

3.3.1 Incubators, Digital Hubs and Mobile Application Development⁴⁵

The development of *Mobile Applications* is typically associated with the emergence of digital hubs and incubators, of which some 314 were

⁴⁵ Parts of this section draw on Unwin (2017).

active in Africa in 2016 (Du Boucher, 2016). The *iHub* in Nairobi was hailed as a successful example of African innovation, after launching *Ushahidi*, a crowd sourcing mapping software and the *BRCK*, a rugged, self-powered, mobile Wi-Fi device that connects people and things to the Internet with inadequate infrastructure. Incubator initiatives have been promoted by international organizations to support entrepreneurship in developing countries (Firestone and Kelly, 2015). A potential problem arising from such initiatives is that large (and often foreign-based) companies that can play an important role in promoting the success of such hubs and incubators may also take advantage of their superior resources to hire or acquire the assets of some of the best emerging talents and resources available in such hubs, starving smaller firms of talent and potentially reducing future competitive threats by preventing smaller firms from growing to critical mass (Unwin, 2017). This is a clear example whereby rivalry among competitors may stifle innovation.

Similarly, the failure to successfully cooperate with other stakeholders who embody entrepreneurial competencies and resources in the innovation ecosystem may cause the incubator to fail in providing the necessary business skills needed by such potential entrepreneurs to succeed, as indicated in Recommendation 1.

Recommendation 5: Governments should protect smaller firms by discouraging larger companies from hiring talents of smaller firms.

3.3.2 Gig Economy

Gig economies are systems where temporary employment positions are dominant and organizations tend to use short-term or zero hour labour contracts. The gig economies are enabled by *ICT platforms* generating new demand and supply for material and digital goods and services through ICT-based *matching mechanisms*. However, the typical innovation ecosystem surrounding the gig economy presents both opportunities and threats. Some of the problems posed by these digital platforms are due to the fact that gig economy workers often miss out on the social protection systems such as unemployment benefits, sick pay and pensions. The World Bank and the International Labour Organization (ILO) recommend that countries should adopt the same

The Availability of Online Work in Relation to Wealth

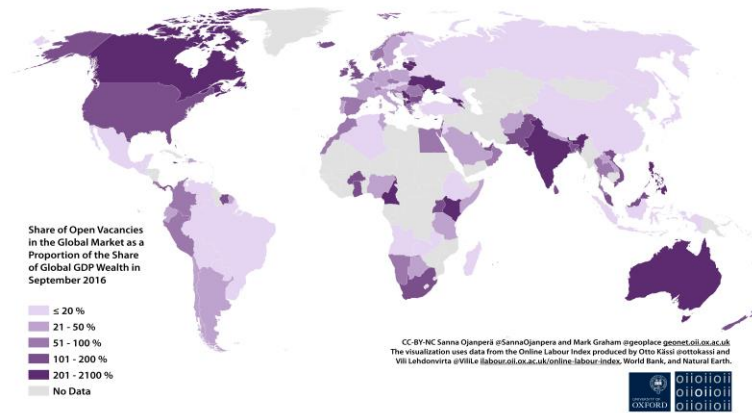


Figure 2. The relationship between availability of online work and wealth

<http://ilabour.oii.ox.ac.uk/mapping-the-demand-for-online-labour>

digital technologies to extend social and labour legislation to protect gig economy workers (Kuddo et al., 2015).

The importance of ICT-centric innovation ecosystems sustaining the gig economy is becoming increasingly evident for developing countries. India, the Philippines and Bangladesh, for example, all have large shares of *online labour*, as shown in Figure 3.2. However, the data also show that many countries in Sub-Saharan Africa such as Cameroon, Kenya, and in South America such as Guyana and Panama, are experiencing significant rates of employment linked to the gig economy.

In October 2016, digital platforms such as Uber, Lyft, TaskRabbit, Upwork, Freelancer, Thumbtack, and Airbnb, were used by about 4 percent of the working-age population to earn income (McKinsey Global Institute, 2016). The report also found that most independent sellers of goods do so by joining e-commerce market platforms, such as eBay and Etsy, while 25 and 40 percent of those who earn independently by leasing assets use digital platforms such as

HomeAway, Airbnb, or VRBO (McKinsey Global Institute, 2016, page 12). The ICT-platforms underlying the gig economy present unmatched opportunities for introducing innovations by providing services and goods in new areas. But their development also poses key policy and regulatory questions that need to be addressed if ICT-centric innovation ecosystems, based on these platforms, are to achieve the relevant SDGs.

Recommendation 6: ICT-centric innovation ecosystems in the gig economy present unmatched job opportunities, but may disregard employees' rights. Hence, while labour policies and laws should support innovations, they should also protect such rights.

3.3.3 ICT-Centric Crowdfunding

ICT-centric crowdfunding can alleviate the shortage of funds for transforming innovations into successful and marketable products and services. It can also be used to address a number of other challenges, such as provision of low-cost microfinance, helping in particular the participation of women whose gendered perspectives and contributions are important in developing new products and services or meeting users' needs.⁴⁶ However, an ICT-centric crowdfunding platform can only be useful if all its users are provided with affordable and ubiquitous ICT connectivity.

One famous example of pre-ICTs crowdfunding is the call by a New York newspaper to its readers for funds to build the pedestal of the Statue of Liberty (BBC News, 2013). ICTs have transformed this old idea into crowdfunding platforms capable of raising a substantial amount of money from a large number of entrepreneurs as an alternative form of funding.

Crowdfunding has been classified into different types depending on the participation rights of those funding the projects. Giudici et al. (2013)

⁴⁶ See, for example the WISET and Portia report edited by Lee and Pollitzer (2015) "The Role of Gender-based Innovations for the UN Sustainable Development Goals Toward 2030: Better Science and Technology for All". http://gender-summit.com/images/GS6Docs/SDG_Report_FINAL.Jan13.pdf

identified the following four categories:

- *Equity-based* crowdfunding, where a backer is entitled to own a portion of the company shares or the product they are backing.
- *Lending-based* crowdfunding, where backers are given an interest payment for their backing.
- *Donation-based* crowdfunding, where no physical return is given to the backer.
- *Reward-based* crowdfunding, in which the backer is given a reward, based on the size of his donation which can be a product, artwork, or other rewards.

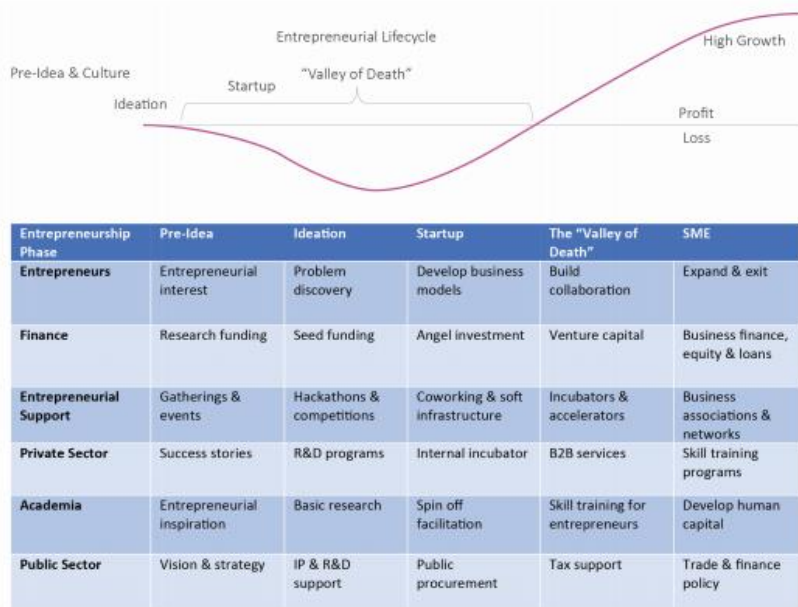
Crowdfunding platforms are complex ICT-enabled applications and their success in delivering innovations depends on the interplay of many stakeholders, not only the lenders and borrowers. One key group of stakeholders is represented by the *social network* built around a given innovation project (Colombo et al., 2015). In some developing countries, the *geographical location* of a project is an important factor that affects its probability of success, and plays a key role towards financial inclusion and driving micro-entrepreneurship. However, ICTs enable the crowdfunding platforms to bypass the physical distance between funders and proposers, and facilitate achieving SDG 8, Target 10 "*Strengthen the capacity of domestic financial institutions to encourage and to expand access to banking, insurance and financial services for all*".

Recommendation 7: ICT-centric innovation ecosystem thrives through reciprocity. Innovation policy should support the formation of social capital by facilitating meeting and interaction and enforcing rights and guarantees. These are key elements in the ecosystems' finances comprising its crowd-funders and stakeholders.

In general, and for crowdfunding in particular, *timing* is another key dimension in determining the success of innovative projects. Such path-dependency (Arthur, 1994) reflects the aspects of categorizations inspired by Rogers (2003) in the more general context of the theory of diffusion of innovations. The timing of innovation processes, as depicted in Figure 3, includes a portion that is commonly called the

Valley of Death, defined as a period after an innovative concept is proved to be functional when innovators require significant investment and support, and there is a high risk of failure as a business. This is possibly the most critical period to provide the necessary and critical support, though support throughout the lifecycle is also critically important. Similar to the need for support from all pillars of the ecosystem, if any part of the entrepreneurial lifecycle fails, it will vastly reduce the chances of success for similar ventures (ITU, 2016a, p. 59).

Recommendation 8: The initial phase is very important in an innovative activity, and providing early financial support is critical to surviving the Valley of Death. Early access to finance can be achieved by disseminating information, creating accountability, and increasing trust in ICT- enabled crowdfunding platforms.



Source: ITU

Figure 3. The Valley of Death and phases of Stakeholders' involvement

3.4 Roadmap to Enhance Digital Multipliers

ITU estimates that over 4.5 billion people were “connected” worldwide in 2016. However, many are still unable to enjoy new products or services to satisfy their actual or potential needs, mainly due to lack of proper platforms for matching those needs with either existing or innovative products or services. Even more worrisome, the cost to connect the next 1.5 billion people by 2020 is estimated to be \$450 billion (Broadband Commission for Sustainable Development, 2016) and this would not include those at the “bottom” of this list. Clearly, policies aimed at attaining SDGs should move far beyond this threshold and focus on innovations that could reach the “bottom” billion.

Using appropriate ICT metrics is a prerequisite for the success of any agenda that aims at fostering innovations for the benefit of the society. Metrics are necessary to monitor and evaluate capabilities and progress toward specific goals and outcomes. Policies targeting “Innovation Divides” should use appropriate ICT metrics, such as *Network Readiness Index* provided by World Economic Forum, Akamai's speed of connectivity indexes (Figure 4) and ITU's ICT Development Index (IDI),⁴⁷ each capturing, benchmarking and comparing different aspects of ICT development and readiness, at country and regional levels.

In the ITU report on *Measuring the Information Society* (ITU, 2016), regional comparisons of the IDI index show significant disparities across the globe. However, while essential in concisely capturing and allowing the visualisation of digital divides across countries, the IDI index also shows the relevance of policies for removing the obstacles faced by ICT-based innovations. The IDI index has three separate sub-indices, namely, *Access*, *Use* and *Skills*. The disaggregate analysis of these sub-indices is of particular interest, especially when these vary greatly among countries and regions, as they provide a clear picture of

⁴⁷ For additional metrics based on crowd-sourced *Internet Periphery* methods see, for example, Giovannetti and Sigloch (2015), Gupta et al. (2014) and the series of *Active Internet Measurement Systems (AIMS)* workshops hosted by the Center for Applied Internet Data Analysis (CAIDA).
<https://www.caida.org/workshops/aims/1703/>

ICT-centric economic growth, innovation and job creation

the multi-dimensionality of the digital divides. Of particular interest are the countries that perform very differently in the world ranking in different sub-indices, allowing for the disentanglement of the different country-specific bottlenecks and barriers. These sub-indices can be used to identify specific deficiencies in the physical and human capital resources needed by appropriate ICT infrastructure underlying the innovation ecosystem system.

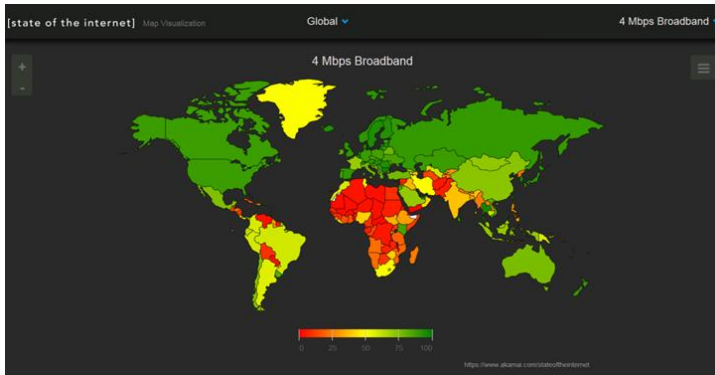


Figure 4. State of the Internet: a heat map displaying worldwide rate of access to 4 Mbps broadband

Source: Akamai (2016)

The *Access index* can be used in developing a policy roadmap for the ICT-centric *innovation ecosystem* for addressing the *digital gap* that prevents the less connected and totally disconnected from enjoying the potential transformative benefits of digital platforms (ITU, 2016a). However, while ICT policies that focus on physical ICT infrastructure, as captured by the *Access index* are essential, it is equally important (especially for developing countries) to also focus on the other key elements in the *ICT-centric innovation ecosystem*. The *Use* and *Skills* indices may provide a better indication of the innovation capacity associated with social and intangible capital, both essential components of the overall growth and productivity that are needed for inclusive and sustainable development through innovations.

Moving from the digital divide to the innovation divide also implies shifting from lack of connectivity to lack of services, platforms and

products that hold back consumers' and producers' needs. Digital platforms are the backbone of different types of impactful but low-cost, or *frugal* (Radjou and Prabhu, 2015) innovations, which can be developed by recombining and adapting existing tools and applications to specific needs and contents that have local and gender relevance. These are considered as innovations, as they satisfy given needs in a new context. The main obstacles associated with these innovations are largely due to the coordination required for sustaining ecosystems to work smoothly through the full innovation cycle, including the possibility of crowdfunding to overcome the *Valley of Death*.

Different Recommendations developed in this chapter add further elements and suggestions to improve some critical aspects of the internal workings of the *ICT-centric innovation ecosystem*. These insights were derived by focusing on building blocks of the ecosystem: the set and timing of the intentional and unintentional interactions among different stakeholders. As an exemplar case of successful innovation ecosystem, the Research Park (IITMRP) and its Incubation Cell (IITMIC) at Indian Institute of Technology Madras in Chennai is presented in Appendix 1, where we discuss practical implications, and lessons learned. This case-study focuses on the nature of interactions between key stakeholders, and on the IITMRP's actions to coordinate and leverage the synergies in driving innovation and entrepreneurship through cooperation between academia, industry and other stakeholders.

3.5 Concluding Remarks

The presence of significant barriers for developing and enhancing ICT-centric innovation leads to missed opportunities in satisfying the unfulfilled needs for services and products, and to obstacles in enhancing productivity and efficiency. These pose major impediments for achieving SDGs.⁴⁸ A set of policies and guidelines needs to be put in place to establish an *ICT-centric innovation ecosystem* for achieving SDGs in an efficient and cost effective manner. The ICT-centric

⁴⁸ Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors.

innovation ecosystem has a number of separate, yet interlinked elements. It is essential for all stakeholders to have a common understanding of the objectives and agree on efficient methods to achieve those objectives. There is also a need to have political support and determination in removing the obstacles and bottlenecks. In some instances, the stakeholders and players in the ICT-centric ecosystem are unaware of the adopted policies and expectations.⁴⁹ This lack of awareness impedes innovation and stifles growth and productivity. In this respect, the human and social capital, ICT infrastructure, platforms and institutions are all key elements of the *ICT-centric innovation ecosystem* that need to be coordinated and harmonized.

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References

Acs, Z., Anselin, L. and Varga, A. (2002), Patents and innovation counts as measures of regional production of new knowledge. *Research Policy*, 31, pp. 1069–1085.

⁴⁹ See Cornell University et al. (2015) for an overview of country level innovation policies.

ICT-centric economic growth, innovation and job creation

- Adner R. (2006), Match your innovation strategy to your innovation ecosystem. *Harvard Business Review*, 84(4), pp. 98-107.
- Aghion, P. and Howitt, P. (1992), A model of growth through creative destruction. *Econometrica*, 60(2), pp. 323-35.
- Aghion, P., Akcigit, U. and Howitt, P. (2014), What do we learn from Schumpeterian growth theory? in Aghion, P. and Durlauf, S. N. Editor(s), *Handbook of Economic Growth*, Elsevier, 2014, pp. 515-563.
- Akamai (2016) State of the Internet, Q1 2016 Report, available at <https://www.akamai.com/stateoftheinternet/>.
- Archibugi, D. (2001), Pavitt's taxonomy 16 years on: a review article. *Economics of Innovation and New Technology*, 10, pp. 415-425.
- Arthur, W. Brian (1994), *Increasing Returns and Path Dependence in the Economy*, Ann Arbor, Michigan: University of Michigan Press.
- Audretsch, D. B. and Feldman, M. P. (1996), R&D spillovers and the geography of innovation and production. *American Economic Review*, 86(3), pp. 630-40.
- BBC News (2013), The Statue of Liberty and America's Crowd funding pioneer. <http://www.bbc.co.uk/news/magazine-21932675>.
- BIS (2014), Private and external benefits from investment in intangible assets, UK Department for Business, Innovation and Skills, *Research Paper No. 203*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/384345/bis-14-1270-private-and-external-benefits-from-investment-in-intangible-assets.pdf.
- Boutellier, R., et al. (1998), Management of dispersed product development teams: the role of information technologies. *R&D Management*, 28, pp. 13-25.
- Broadband Commission for Sustainable Development (2016), UN Joint Statement, *Working Together to Provide Internet Access to the Next 1.5 Billion by 2020*, 21 January 2016.
- Brynjolfsson, E. and Hitt, L. M. (1995), Information technology as a factor of production: the role of differences among firms. *Economics of Innovation and New Technology*, 3(3), pp. 183-200.
- Chesbrough, H. (2003), Open innovation: the new imperative for creating and profiting from technology. *Harvard Business School Press*, Cambridge, MA.
- Cohen, W.M. and Levinthal, A. (1990), Absorptive capacity: A new perspective on learning and innovation, *Administrative Science Quarterly*, 35, pp. 128-152.
- Colombo, M., Franzoni, C. and Rossi-Lamastra, C. (2015), Internal social capital and the attraction of early contributions in crowdfunding. *Entrepreneurship Theory and Practice*, 39(1), pp. 75-100.

ICT-centric economic growth, innovation and job creation

- Cornell University, INSEAD, and WIPO (2015), *The Global Innovation Index 2015: Effective Innovation, Policies for Development*.
http://www.wipo.int/edocs/pubdocs/en/wipo_gii_2015.pdf.
- Corrado, C., Hulten, C. and Sichel, D. (2006), Intangible capital and economic growth, NBER Working Paper No. 11948.
- Czernich, N., Falck, O., Kretschmer, T. and Woessmann, L. (2011), Broadband infrastructure and economic growth. *The Economic Journal* 121(552), pp. 505–532.
- Davies, W. and Giovannetti, E. (2016), These are the things that successful crowd funding projects do, *World Economic Forum*. <https://www.weforum.org/agenda/2016/11/these-are-the-things-that-successful-Crowdfunding-projects-do>
- De Propriis, L. (2002), Types of innovation and inter-firm co-operation, *Entrepreneurship & Regional Development*.144, pp. 337-353.
- Dosi, G. (1982), Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change, *Research Policy*, 11(3), pp. 147-162.
- Du Boucher (2016), A few things we learned about tech hubs in Africa and Asia.
<http://www.gsma.com/mobilefordevelopment/programme/ecosystem-accelerator/things-learned-tech-hubs-africa-asia>.
- Eurostat (2017), *Community Innovation Survey (CIS)*.
<http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>.
- Firestone, R. and Kelly, T. (2015), Africa's thriving tech hubs. *Background Paper for the World Development Report 2016*, World Bank, Washington, DC.
- Foley, M. (2016), The role and status of national research and education networks (NRENs) in Africa.
<https://www.ubuntunet.net/sites/default/files/RoleAndStatusOfNRENsInAfrica.pdf>.
- Freel, M., S. and Harrison, R. T. (2006), Innovation and cooperation in the small firm sector: Evidence from 'Northern Britain'. *Regional Studies*.404, pp. 289-305.
- Gassmann, O., Enkel, E. and Chesbrough, H. (2010), The future of open innovation. *R&D Management*, 40(3), pp. 213-22
- Giovannetti, E. and Piga, C. (2017), The contrasting effects of active and passive cooperation on innovation and productivity: evidence from British local innovation networks, *International Journal of Production Economics*, 187, pp. 102–112.
- Giovannetti, E. and Sigloch S. (2015), An Internet periphery study: network centrality and clustering for mobile access in Bhutan. *Telecommunications Policy*, 39(7), pp. 608-622.

ICT-centric economic growth, innovation and job creation

- Giovannetti, E. (2013), Catching up, leapfrogging or forging ahead? Exploring the effects of integration and history on spatial technological adoptions. *Environment and Planning A*. 45(4), pp. 930-946.
- Giudici, G., Guerini, M. and Rossi Lamastra, C. (2013), Why crowd funding projects can succeed: The role of proponents' individual and territorial social capital. *SSRN Electronic Journal*.
- Gupta, A., et al. (2014), Peering at the Internet's frontier: A first look at ISP interconnectivity in Africa. In *International Conference on Passive and Active Network Measurement*: pp. 204-213. Springer.
- Hall, B.H., Lotti, F. and Mairesse J. (2012), Evidence on the impact of R&D and ICT investment on innovation and productivity in Italian firms. *NBER Working Paper No.* 18053.
- Hempell, T. (2005), What's spurious, what's Real? Measuring the productivity impacts of ICT at the firm-level. *Empirical Economics* 30(2), pp. 427-464.
- Insiti, M. and Levien, R., (2004), The Keystone Advantage: What the New Dynamics of Business Ecosystem Mean for Strategy, Innovation, and Sustainability. Harvard Business School Press, Cambridge, MA.
- ITC (2016), Bringing SMEs onto the e-commerce highway. Geneva.
<http://www.intracen.org/publication/Bringing-SMEs-onto-the-e-Commerce-Highway/>.
- ITU (2011), Measuring the WSIS targets: A statistical framework. Geneva.
- ITU (2016), Measuring the information society. Geneva.
- ITU (2016a), ICT centric innovation ecosystem: Country review – Albania. Geneva.
- ITU (2017), Bridging the digital innovation divide: A toolkit for strengthening ICT centric ecosystems. Geneva
- Jaffe, A. (1989), Real effect of academic research. *American Economic Review*. 79, pp. 957-70.
- Katz, M., et al. (1990), R&D Cooperation and competition. *Brookings Papers on Economic Activity. Microeconomics*, 1990, pp. 137-203.
- Katz, M.L., and Shapiro, C. (1985), Network externalities, competition, and compatibility, *The American Economic Review*. 75(3), pp. 424-440.
- Kromidha, E. and Robson, P. (2016), Social identity and signaling success factors in online Crowd funding, *Entrepreneurship & Regional Develop.* 28(9-10), pp. 605-629.
- Kuddo, A.; Robalino, D. A.; Weber, M. (2015), Balancing regulations to promote jobs: from employment contracts to unemployment benefits. World Bank Group.
- Lundvall, B.-Å. (ed.) (1992), National Innovation Systems: Towards a Theory of Innovation and Interactive Learning, Pinter, London.

ICT-centric economic growth, innovation and job creation

Marshall, A. (1890), *Principles of Economics*, Macmillan, London.

Mazzucato, M. (2013), *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, Anthem Press, London, UK.

McKinsey Global Institute (2016), *Independent work: Choice, necessity, and the gig economy*. <http://www.mckinsey.com/global-themes/employment-and-growth/independent-work-choice-necessity-and-the-gig-economy>

Nelson, R.R. and Winter S.G. (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.

OECD (1997), *National innovation systems*.
<https://www.oecd.org/science/inno/2101733.pdf>.

OECD/Eurostat (2005), *Oslo manual: Guidelines for collecting and interpreting innovation data*, 3rd Edition, OECD Publishing, Paris.

Pavitt, K. (1984), Patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13, pp. 343–374.

Polanyi, M. (1958), *Personal Knowledge: Towards a Post-Critical Philosophy*. University of Chicago Press, Chicago.

Radjou, N., and Prabhu, J. (2015), *Frugal Innovation: How to Do Better with Less*. Hachette Book Publishing, India.

Rogers, E. (2003), *Diffusion of Innovations*, 5th edition. Free Press.

Röller, L.H. and Waverman, L. (2001), Telecommunications infrastructure and economic development: A simultaneous approach. *American Economic Review*, 91(4), pp. 909–923.

Schumpeter, J. A. (1934), *Theory of Economic Development*. Harvard University Press, Cambridge, MA.

Tomlinson, P. R. and Jackson, I. (2013), Co-operative ties and the impact of external factors upon innovation in an industrial district: some insights from the North Staffordshire table and giftware sector. *Regional Studies*, 47(4), pp. 580–596.

UNCTAD (2015), *Access to Financial Services as a Driver for the Post-2015 Development Agenda*, Policy Brief, September, No. 35. Geneva.

Unwin, T. (2017), *Reclaiming Information and Communication Technologies for Development*, Oxford University Press, Oxford.

World Bank (2010), *A program of the South-South experience exchange facility*.
<https://openknowledge.worldbank.org/handle/10986/12367>.

World Bank (2016), *World Development Report 2016*, Washington, DC.

Appendix A

Fostering Innovation in Indian Institute of Technology Madras Research Park

Emanuele Giovannetti (Anglia Ruskin University)
and
Shailaja Fennell (University of Cambridge)

1 Introduction

The Indian Institute of Technology Madras (IITM) has established a Research Park (IITMRP) where an *ICT-centric innovation ecosystem* is at work by creating and enhancing successful collaboration between industry, research community, academia and public bodies. IITMRP's focus on facilitating partnerships between IITM and industry has not only fostered collaboration towards research and development, but also resulted in spinning-off innovative business ventures that have further generated innovations for fostering economic development in Chennai.

IITMRP was first conceptualized to create a bridge between the academia and the industry for transforming innovations into products, applications and services. The key notion was that “the rewards of R&D will be significantly higher if the academia and industry work together on new ideas.” The central identifying feature of IITMRP's *innovation ecosystem* is the sharing of physical space (the research park), where research-oriented companies interact formally and informally with faculty members and other scientists and technicians at IITM.

IITMRP rewards collaborative interaction through its “knowledge and innovation ecosystem,” and has produced solid and tangible results: By 2015, over 60 patents were filed for the work done at IITMRP. This shows a successful way to overcome the traditional obstacles faced by

individual innovators in transforming their new ideas and concepts into successful new products and services by way of creating, recombining, integrating, and applying new knowledge and insights into successful technological innovations.

2 Fostering Innovation in IITMRP Innovation Ecosystem

IITMRP was opened in March 2010, and is directly linked to the main campus of IITM. It covers an area of 11.42-acre, and is in the proximity of one of the largest IT parks in Asia, the *Tidel Park*⁵⁰. The Tidel Park was set up in 2000, and employs more than 12,000 software professionals. High speed data/voice services are provided by multiple service providers to customers in Tidel Park.

IITMRP's basic approach to fostering innovation includes:

1. Creating a collaborative environment between the industry and academia through joint R&D projects and consulting assignments
2. Developing a self-sustaining and technologically fertile environment
3. Aligning R&D activities in the academia to the potential needs of the industry
4. Providing world class infrastructure for R&D activities
5. Educating and training high-quality technical staff and motivating them to grow professionally through part-time Masters and PhD Programs
6. Sharing technology and business skills between academia and industry tenants

IITMRP's objective is to create a space that reproduces the characteristics of the best innovating research parks, for example, that of Stanford Research Park: "... a community of and for people who seek to invent the future. We support innovative companies in their R&D pursuits by providing modern facilities in a beautiful natural landscape, offering sustainable transportation programs, forging connections with Stanford University's talent and resources, and fostering collaboration"⁵¹. Clearly, given the different national context,

⁵⁰ <http://www.tidelpark.com/index.asp>

⁵¹ <http://stanfordresearchpark.com/about>

a key success of IITMRP has been in showing that some of these ideas, initially developed in the US, could be adapted to the local contexts of Tamil Nadu and India.

IITMRP's focus is not only on business incubation but also on supporting innovation in already established R&D intensive companies. This is done by connecting the industry to the “innovation inputs” of knowledge and being the catalyst for high-tech development. Collaboration amongst industry *R&D staff, faculty members* and *students* is the key element for increasing the probability of success via introducing thriving and sustainable innovations. These three key pillars are brought together by being co-located at IITMRP, and have been identified as the following *Golden Triad* forming the ecosystem:

- R&D staff: bringing the rich insights of the industry and market
- Faculty: repositories of a wealth of knowledge from multiple domains and departments
- Students: different but key stakeholders, able to work relentlessly and oblivious to risk.

The benefits of becoming a tenant company in IITMRP include high-quality ICT and research infrastructure, and a collaborative relationship with IITM, so that tenant companies will have the opportunity to tap into its research resources. In other words, by moving into IITMRP, a company will have the potential to leverage the expertise of the faculty, utilise their research facilities, while providing part-time jobs and work experience to IITM students. IITMRP now has 29 corporate clients⁵² and 16 smaller “incubates”⁵³, and has developed and deployed effective mechanisms to foster cooperation between different stakeholders.

2.1 CREDIT: Fostering Cooperation in Innovation Ecosystem

Collaboration between the industry and academia has been “formalised” so that companies residing in IITMRP are expected to seek active collaboration with the university, for which they receive “points”.

⁵² http://respark.iitm.ac.in/our_clients/corporate_clients.php

⁵³ http://respark.iitm.ac.in/our_clients/incubatees.php

Every company is required to earn a minimum number of points each year, depending on its area of activity. IITMRP's Credit Points System, called "*Collaboration in Research and Engagement with Departments in IIT Madras*" (CREDIT⁵⁴) measures collaboration between a company and IITM. The key motivation lies in the fact that a successful innovation ecosystem has a high level of collaboration in R&D and innovation activities among different stakeholders, which in this case are the resident companies and IITM. The CREDIT system rewards collaboration and discourages opportunistic behaviour.

2.2 Incubation in IITMRP: A Pillar of Entrepreneurship in the Innovation Ecosystem

IITMRP promotes entrepreneurship and innovation by way of incubation, which include provision of work space, *seed funding*, *branding* through IITM's worldwide reputation, *academic mentoring*, collaboration based *networking*, and other support services such as patent application. IITMRP has developed a system of *topic-specific* incubators that include *Rural Technology Business Incubator* and *Bio Incubator*. The incubators are coordinated by the *Incubation Cell*, and have incubated more than 100 companies. In the sequel, we briefly review the main features and roles of the Incubation Cell, the Rural Technology Business Incubator, and the Bio Incubator.

IITM Incubation Cell (IITMIC)⁵⁵ coordinates and supports the two Incubators to ensure innovation and entrepreneurship at IITM. It supports cutting-edge research and facilitates collaboration between academia and industry. IITMIC was the first university-driven research-park-based incubator in India and has a strong record of incubation in rural, social and industrial technologies. Its success is based on establishing collaboration between different stakeholders: the State, the private sector (local companies and outside firms), and IITM's students, faculty members, staff & alumni. It supports tech start-ups that can disrupt markets and industries via innovative solutions while providing benefits to the wider society.

⁵⁴ http://respark.iitm.ac.in/collaborate_with_us/credits.php

⁵⁵ <http://www.incubation.iitm.ac.in/>

*IITM Bio Incubator*⁵⁶ was established by the *Biotechnology Industry Research Assistance Council*⁵⁷(BIRAC), a public sector enterprise in the Department of Biotechnology (DBT). BIRAC was set up as a platform to empower emerging biotech enterprises to undertake strategic research and innovation, while addressing the nation's needs for new products. Through the Bio Incubator Support Scheme (BISS)⁵⁸, BIRAC has established several bio incubators around the country, including one at IITM. The objective of IITM's Bio Incubator is to promote Indian biotech innovation and entrepreneurship by enhancing R&D capabilities in start-ups and SMEs.

Rural Technology and Business Incubator (RTBI)⁵⁹ is the IITM's incubator for rural-inclusive technology and business innovation. Its mission is to design, pilot and incubate scalable business ventures with a rural focus. It provides leadership, funding, and an incubation ecosystem for entrepreneurs at any phase in their venture including the early conceptual stage. RTBI's incubation areas include education, health, agriculture, financial inclusion, vocational training, and micro-enterprise development and technologies for rural needs.

The faculty members at IITM are shareholders in 19 start-ups. Besides, collaboration between faculty members and their current and former students for translating research into commercial ventures/companies is on the rise.

2.3 Patents and Intellectual Property Rights in IITMRP

Intellectual Property Rights (IPRs) for joint activities performed in IITMRP are negotiated between the companies and the university. IITM normally assigns all IPRs to the respective company, and in return receives a portion of revenue generated from the work. In the legal framework governing IPRs, the involvement of other governmental departments and institutions is also essential. For example, the National

⁵⁶ <http://www.bioincubator-iitm.in/>

⁵⁷ http://www.birac.nic.in/description_new.php?id=89

⁵⁸ http://www.birac.nic.in/desc_new.php?id=84

⁵⁹ <http://www.rtbi.in/>

Science & Technology Entrepreneurship Development Board (NSTEDB), which is part of the Indian Department of Science & Technology played an important role in establishing IITMIC and certifying the IIPMRP's Technology Business Incubator. This is of vital importance in securing additional resources.

2.4 IITM Research Centres in Innovation Ecosystem

In what follows, we provide a brief overview of some of the more active IITM research centres together with their respective focus.

Centre of Excellence in Wireless Technology (CEWiT)⁶⁰ is a Public Private Partnership (PPP) focussing on research, development and deployment of wireless technology. CEWiT supports public institutions in policy making, spectrum management, and regulation with research on 5G technologies; and participates in global standardisation of wireless networks and systems. CEWiT also provides simulators and test beds needed in R&D projects.

*Healthcare Technology Innovation Centre*⁶¹ (HTIC) was established with the support of Indian Department of Biotechnology (DBT). It is a multi-disciplinary centre for facilitating collaboration among technologists, engineers, doctors and healthcare professionals in industry and government with a view to developing healthcare technologies. HTIC collaborates with the leading medical institutions and many industry players in different areas, such as ophthalmology, ultrasonography, orthopaedics, neonatal care, and patient monitoring. As an example, a project developed at HTIC in collaboration with Sasken is the *Remote Intensive Care Units* (ICU), which provides continuous monitoring of clinical data from patients by utilizing multiple pieces of equipment connected to a network of strategically located phone-based cameras. The technology was piloted in Mehta Children Hospital, Chennai

⁶⁰ <http://cewit.org.in/#>

⁶¹ <https://htic.iitm.ac.in/newsite/>

*Centre for Technology and Policy*⁶² (CTaP) addresses key questions on innovation policy. Examples of such questions are how IITM's R&D work can be leveraged to address public policy challenges, and how science and technology can be made an integral part of policy-making processes? CTaP focuses on energy, water, healthcare, telecom, and education, and advocates an inter-disciplinary approach by working with other incubation centres.

2.5 IITMRP Corporate Clients

Figure A1 shows a breakdown of the areas of activity for tenant companies in IITMRP, and in Annex 1, we briefly describe areas of activity and focus of 29 corporate clients in IITMRP.

2.6 Success Stories

As a direct impact of IITMRP on creating new jobs, circa 15% of students graduating from IITM venture into entrepreneurship, and more than 40% of faculty members are involved in entrepreneurship activities. However, this has some negative consequences, such as increasing the students' stress levels and reducing academic performance when their ventures pick steam. To deal with such problems, students are allowed to take a semester off to cope better. In what follows, we briefly mention 5 success stories that have emanated from the IITMRP's innovation ecosystem.

2.6.1 Public Transport

RAFT is an App developed by the start-up *Geotagg*, which helps commuters in mastering public transports timing in Chennai by suggesting the best route to take between any two points in the city, with up-to-date timing of buses and trains. It experienced more than 30,000 downloads in a very short time⁶³.

⁶² <https://ctap.iitm.ac.in/>

⁶³ *Geotagg*, incubated at IITM, (Deccan Chronicle, May 2, 2015)

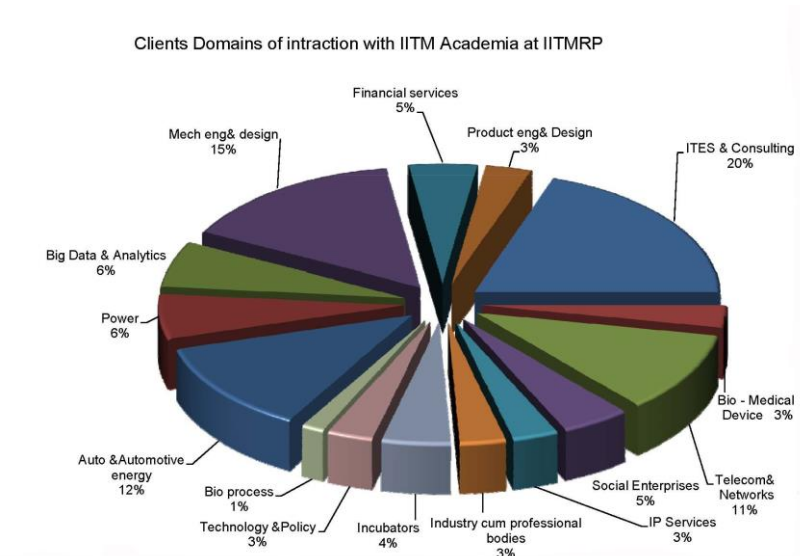


Figure A1. Areas of activity of tenant companies in IITMRP

Source: http://respark.iitm.ac.in/our_clients.php

2.6.2 Brain Games

Edsix Brain Lab was incubated in the Rural Technology and Business Incubator, which was instrumental in seeking collateral-free loans through the government's Technology Incubation and Development of Entrepreneurs programme. *Edsix* was provided with working space, and received mentorship, loans and grants in exchange for some equity in the company. The work resulted in *Skills Angels*⁶⁴, which is a gaming platform to assess and enhance brain skills that include logic and memory, featuring animation and images to different versions of modifiable games. During the development phase, it was recognized that there is a need to consult with developmental paediatricians and clinical psychologists as well. *Skills Angels* was featured in Startup India 2016, was the finalist at the CavinKare-MMA Chinnikrishnan Innovation Awards in 2015, and has received numerous other awards, including the Best Start-up Award in 2014 by the Department of

⁶⁴ <http://skillangels.com/>

Electronics & IT, Ministry of Commerce & IT, the Hot100 Technology Award and People's Choice Best Startup Award. Applications for local and international patents have been filed for *Skills Angeles*.

2.6.3 Solar ATM

Vortex Engineering, one of the “top 10 startups that could change your life” according to Time Magazine in 2010^{65,66}, worked on financial inclusion by developing disruptive innovations to extend the reach of Automated Teller Machines (ATMs) to rural areas. Among them, was the first commercially viable solar ATM. As reported by CNBC⁶⁷ “A small startup, a frugal mindset and a disruptive technology are shaking up the rural banking scene in India, giving 300 million dwellers a chance to get a bank account”. These ATMs use solar power that works even at extremely high temperatures without requiring air-conditioning, and are designed to minimise breakdowns. Vortex ATM is customized to the India's case where electricity is scarce, accessibility is poor, crisp bank notes are hard to get and the language and dialects vary.” The research has resulted in nine patents related to Vortex ATM.

2.6.4 Micro-Spinning

Microspin has developed another impactful innovation⁶⁸ that involves a new method of spinning for small scale production, which is the dominant reality of cotton farmers in the Vidarbha region in the Indian State of Maharashtra. This was achieved by integrating separate activities of weaving and dyeing, thereby allowing cotton farmers to bypass intermediate stages and eliminating unnecessary costs.

⁶⁵ <http://www.thehindubusinessline.com/economy/spinning-success-from-diverse-opportunities/article4541988.ece>

⁶⁶ http://content.time.com/time/specials/packages/article/0,28804,2017050_2017049_2017042,00.html

⁶⁷ CNBC “Solar ATMs changing the face of banking in India”, by Neerja Jetley Tuesday, 1 Apr 2014 <http://www.cnbc.com/2014/03/28/solar-atms-changing-the-face-of-banking-in-india.html>

⁶⁸ Chennai tech firm spins a solution for farmers in Vidarbha, by SHILPA ELIZABETH. <http://economictimes.indiatimes.com/news/economy/agriculture/chennai-tech-firm-spins-a-solution-for-farmers-in-vidarbha/articleshow/46185407.cms?intenttarget=no>

2.6.5 Stellapps Technologies - IoT Wearables for Cows

Stellapps Technologies was incubated at IITMRP and was ranked second in the in 2016 Deloitte Technology Fast 50 in the India's fastest growing tech companies after having reached a growth rate of 1278%. Stellapps innovations are based on a combination of the Internet of Things (IoT), cloud computing, data analytics and wearables applied to the dairy sector. The work is of critical relevance to the India's 75 million dairy farms that suffer from some of the worst productivity levels. The SmartMoo IoT router and in-premise IoT controller obtain data via sensors that are embedded in the milking system, animal wearables, milk chilling equipment and peripherals, and transmit the same to the Stellapps SmartMoo Big Data Cloud Service Delivery Platform (SDP) where data are analyzed before disseminating the analytics to various stakeholders⁶⁹. This work has differentiated Stellapps from others and led to its enormous growth in the past few years. The startup was bootstrapped with the founders' corpus contributions in April 2011. Subsequently, in 2012 it was angel funded/incubated by IIT-Madras Rural Technology Business Incubator.

2.7 Conclusion

IITMRP is a case of successful innovation ecosystem and provides clear lessons to be learned. It validates that the prescribed recommendations in Chapter 3 form a basis for creating and establishing a successful ecosystem for fostering innovations that create new jobs and lead to sustainable economic development. One can clearly observe the relevance and applicability of the recommendations in Chapter 3 to successful cases that have emerged from IITMRP's innovation ecosystem. However, we wish to emphasize that solutions to some problems may not be universal, and implementation of Recommendations needs to be carefully adapted to the conditions that are specific to each case.

⁶⁹ The Economic Times: Wearables for cows: How Stellapps Technologies is 'Milking' its way to success by MAMTA SHARMA, Nov. 16, 2016. Read more at: http://economictimes.indiatimes.com/articleshow/55350970.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Annex 1: Corporate Clients at IITMRP⁷⁰

1. Altiscale: Offers cloud service to develop a fast, reliable, easy to use, and affordable infrastructure.
2. AMADA Soft India: Provides engineering solutions to customers in the CAD/ CAM domain.
3. ARCI: Is a R&D entity in advanced materials and the associated processing technologies.
4. BHEL R&D Gateway: Is engaged in the design, engineering, manufacture, construction, testing & commissioning of a wide range of products, systems and services.
5. BigCat Wireless: Focuses on developing innovative wireless solutions that encompass algorithm development and Implementation.
6. Cognizant Technology: Works in virtualization, machine learning, bots, semantic web and text mining.
7. The Confederation of Indian Industry (CII): Works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government through advisory and consulting.
8. DesiCrew: Utilizes information technology to build a new outsourcing model and provide employment opportunities in rural India, ideally suited to digitization of high volume data such as data base compilation, mailing list compilation, keying from images, data mining from web, electronic publication and file translation.
9. D Espot: Is engaged in the design and development of Lithium-Ion & Lithium Polymer battery products for niche industrial and defence applications in India
10. Dhvani R&D solution: Works on technologies related to non-destructive testing, manufacturing diagnostics, materials characterization, structure monitoring, simulation and visualization tools.

⁷⁰ http://respark.iitm.ac.in/our_clients/corporate_clients.php.

11. FEV: Works on the design and development of internal combustion engines, conventional, electric, and alternative vehicle drive systems, energy technology
12. Forbes Marshall: Is the India's largest steam engineering and process energy company. Its products include steam boilers, steam distribution accessories, process heat utilization systems, controls, condensate and flash steam recovery systems, plant diagnostics, process automation systems, solar heating systems and renewable energy systems, DCS systems, field sensors for critical process parameters, flow and level measurement and a whole range of process plant solutions.
13. Guidanz Systems: Provides products, services, and solutions focused on databases, analytics, and big data.
14. Helyxon Healthcare Solutions: Is in the business of connected healthcare, building platforms, devices and services for an affordable effective healthcare. It specialises in integrating smart medical sensors/devices, data science and automation.
15. Invention Labs: Was incubated by IIT Madras Rural Technology and Business Incubator (RTBI) and funded by RTBI. Their product, Avaz, provides solutions for assisted speech in children with disabilities.
16. MaxVal: Provides comprehensive intellectual property services covering the entire patent lifecycle. With experience in innovation, IP management and monetization, as well as legal expertise, they offer invention analysis (including patentability), patent filing and prosecution in India, US and other countries.
17. Myeasydocs.com: Provides services of online storage, verification & sharing of paper based documents, linking document owners, document issuers and document seeking entities into a single portal.
18. Net Access (India): Is a provider of IT infrastructure solutions and services, focussing on reducing complexity and barriers across their IT infrastructure.
19. NMS Works Software: Focuses on network management framework, vertical-specific applications and mediation adapters to integrate many third party EMS and network elements.

20. ROPE: Manufactures environment friendly home decor and life style products, focusing on sustainability and environmental responsibility.
21. Saggezza: Provides consulting, systems integration, and outsourcing solutions, focussing on being a trusted technology services partner in key industry verticals.
22. Sconce Solutions: Is a provider of engineering solutions and services and has launched a web based search environment, “Bingo!”, which uses shape indexing technology to effectively search 3D component models (assemblies/parts/drawings) based on 3D geometry or 2D input sketches.
23. Stratus Environmental: Specializes in the assessment and clean-up of soil and groundwater that has been impacted by petroleum products, pesticides, solvents and heavy metals.
24. Tata Consultancy Services: Has its own research and development wing known as the innovation labs. The broad area of interests include sensor networks, semantic web, web 2.0, software tools, etc.
25. TATA Elxsi: Is a design company whose services include embedded product design, industrial design, animation & visual effects and systems integration.
26. Uniphore Software Systems: Is engaged in-depth research to understand the dynamics of information needs, linguistic modelling, impact creation, demand of information, etc. for rural India and is creating value by developing innovative applications on its patent pending VoiceNet system. Uniphore supports increased scope in bridging the rural information divide and add value by providing automated services in various verticals such as healthcare, agriculture, education, livelihood, banking, etc.
27. Villgro: Focuses on rural development by actively identifying and incubating innovative models and ideas to promote rural based social enterprises. Villgro works with different stakeholders to create and support an eco-system that incubates and empowers social entrepreneurship.
28. Vortex Engineering: Is the pioneer of rural ATM in India. With its patented and innovative, low power consuming ATMs, Vortex now

has the world's largest number of solar ATM installations.

29. Yalamanchili: Focuses on technologies in the authentication and transactional security systems to provide self-sufficiency and self-help to organizations, and remove dependency on complex technologies.

Biography

Emanuele Giovannetti is Professor of Economics at Anglia Ruskin University, and Fellow at Hughes Hall, University of Cambridge. He has also taught at the University of Cape Town and the University of Verona. His research focuses on the diffusion of mobile social networking, market power in the Internet, mobile Internet access and adoption of new technologies. Prof. Giovannetti has advised governments, competition authorities and businesses in Europe, Africa and Asia on Internet access and competition policy, and has led multidisciplinary and multinational projects focusing on network competition, Internet infrastructure and mobile access in developing countries. He has published numerous academic articles in leading academic journals, edited a special issue of Telecommunications Policy on "Peering and Roaming in the Internet" and co-edited "The Internet Revolution: A Global Perspective" published by Cambridge University Press. He holds a PhD and MPhil in Economics from Trinity College, University of Cambridge.

Chapter 4

The Role of Governments in ICT-Based Sustainable Development

*George R. Barker**,
*Prasit Prapinmongkolkarn** and Supavadee Aramwith***

This chapter explores how governments can harness ICTs to promote sustainable development. To do so, we will identify two important focal points for governments in charting the way forward. First, within the ICT sector itself, governments should focus upon removing policies that prevent competition and limit innovation. Instead they need to encourage and facilitate the introduction of innovative ICT-based products and solutions. Second, in non-ICT sectors of the economy (agriculture, health, energy, transportation, commerce, etc.), governments need to actively identify barriers to the development of ICT-based products and services. Policies that constrain competition and innovation in non-ICT sectors can be particularly detrimental, indirectly limiting and distorting demand for ICT solutions: thus preventing the most efficient use of ICTs. In many countries, and across most non-ICT sectors, existing regulatory regimes are frozen in time. General reforms of non-ICT markets will thus be complementary or synergistic with reforms that are directly ICT-related, and *vice versa*. Hence governments need to adapt their vision and objectives of their regulatory regimes. In doing so, they can avoid and remove all barriers to the introduction of innovative ICT-based products and solutions across a wide range of sectors.

* London School of Economics, London, United Kingdom, and Australian National University, Canberra, Australia

** Chulalongkorn University, Bangkok, Thailand

4.1 Introduction

This chapter discusses the role (and limits) of governments in establishing a legal, budgetary, policy and regulatory frameworks for information and communication technologies (ICTs) to ensure they can make an optimal contribution to the UN's objective of sustainable development. We will identify and briefly assess key policy choices affecting ICTs and how best to ensure that government policy optimizes the role of ICTs in sustainable development.

Government policy takes various forms, such as acts of legislatures (including general law, and fiscal or budgetary measure including tax and expenditure), regulations and rules made by ministers and/or regulators, and decisions taken by courts, fiscal and regulatory agencies, and state-owned enterprises (SOE). Government influence also extends to co-regulation, social marketing/advertising, and collective action for non-market production by private individuals.⁷¹ The aim of these policies is fundamentally the same: influencing the behaviour of individuals and organizations to promote sustainable development.

Our focus will be on government decisions on policies pertaining to budget (tax and expenditure), law and regulation (including e-government), and how this in turn affects the contribution of ICTs to sustainable development.

4.2 Outline

The remainder of this chapter is broken into four sections. Section 4.3 focuses on defining the objectives, with a review of the UN's seventeen sustainable development goals (SDGs). It will show how all of these goals are related. In the remaining three sections, we turn our attention to the means which could be used by the government to achieve these objectives, focusing particularly on the government's role in three areas:

1. First, in Section 4.4, we focus on the organization of government

⁷¹ We recognise, of course, that the extent and nature of public or state production provides a major context for the regulation of other activities.

itself, and the importance of more open, accountable and transparent processes as a pre-condition for sustainable development. In this endeavour, the role of ICTs is critical. This is particularly relevant to two fundamental UN goals: SDG 16 – Peace and Justice for all – and SDG 17 calling for global partnerships. In this section we explore how ICT-enabled systems such as e-Government offer considerable scope for creating peaceful, just and inclusive societies by facilitating more open, accountable and transparent governments.

2. Second, in Section 4.5, we assess how government policy on ICT markets impacts the role of ICTs in sustainable development. This includes government policy on two key ICT markets:
 - ICT infrastructure markets, including state ownership of legacy ICT network assets, spectrum licensing, competition law and access-price regulation, as well as the government's role in universal service obligations.
 - ICT applications and content markets, focusing upon the government's role in intellectual property and privacy law.
3. Finally, in Section 4.6, we consider how government policy on non-ICT markets is shaping the role of ICTs in sustainable development. Government policy on non-ICT markets (including food, water, energy, urban and human-settlement services, education services, health, etc.) can indirectly affect the demand for ICTs, either enabling or limiting opportunities for ICTs to contribute to sustainable development. In particular, we focus on the unforeseen effects of government policy on non-ICT markets. Designed for the pre-Internet era, these policies remain largely frozen in time and may now be limiting the beneficial effects of ICTs. Indirectly, they are preventing the rise of the internet of things (IoT), ⁷² or smart

⁷² Internet of Things (IoT) is when the Internet and networks expand to places such as manufacturing floors, energy grids, healthcare facilities, and transportation by networking relevant physical devices, vehicles, buildings and other items - embedded with electronics, software, sensors, actuators, and network connectivity, enabling these objects to collect and exchange data.

markets.⁷³

4.3 Objectives and Goals

In this section, we first review and define sustainable development; review how the UN's seventeen SDGs relate to each other; and seek to isolate the role of ICTs and government policy in their achievement for further analysis.

4.3.1 Sustainable Development

The overarching objective of *sustainable development* has been defined by the UN as: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”⁷⁴ The two key elements of this definition are

- a focus on the needs of the people, or more broadly their *well-being*;
- a concern with the factor of time – that is, with the needs, or well-being of people *over time*.

Sustainable development is a question of striking the right balance between the well-being and needs of people in the present, and the well-being and needs of people in the future, including future generations. The above definition implies that the test for any new sustainable development policy is whether it will enhance the well-being of those in the present, *without* harming those in the future.

For the vast majority of today's world population, it appears possible to both enhance the well-being of people today, and people in the future, striking a win-win balance over time. This is presumably what governments should focus on to achieve sustainable development. As we shall see, to optimize the well-being of the population over time,

⁷³ A type of auction in which transactions are made to and from a pool of participants rather than bilaterally between one buyer and one seller. It is cleared using operations research techniques and mathematical optimization, such as linear programming, operated by a market manager. A smart market can assist market operation when trades would otherwise have significant transaction costs or externalities.

⁷⁴ See “What is sustainable development” www.un.org/sustainabledevelopment/development-agenda.

sustainable development involving such win/win outcomes over time requires three things:

1. Resources need to be allocated to their best uses or activities in terms of people's needs or wellbeing over time.
2. The most productive use of allocated resources is required over time.
3. Dynamic innovation, adaptation and adoption of new and better ways to allocate and productively use resources over time so as to continuously enhance what is achievable in terms of people's needs or well-being.

As we shall see, policies directly and indirectly affecting ICTs offer such possibilities. At the same time, we may face inter-temporal trade-offs, in the well-being of people over time. In such cases, it is important to strike the right balance. Climate change is a much cited case of a potential *win-lose* outcome over time, and therefore unsustainable development. It is also, however, possible to go too far in the opposite direction, adopting policies that hurt those in the present more than they benefit those in the future. These kinds of trade-offs lead to *lose-win* outcomes over time, making them equally "unsustainable policies". This might arise, for example, where current carbon emissions are restricted too much to improve future environmental outcomes.

Occasionally, one might allow a policy with adverse future consequences (a win-lose outcome), so long as it has *offsetting* present-day benefits. These gains can be drawn upon to make active investments in the future and compensate for future losses. The contentious question is whether such win-lose policies should be allowed in the absence of actual inter-temporal compensation or compensatory action. Where there is a risk of catastrophic consequences in the future/present that can't be mitigated or compensated for adequately, it makes sense to adopt a more precautionary approach.

To ensure sustainable development, decision-makers should prioritize policy alternatives where, compared to the *status quo*, *benefits outweigh costs over time*. Furthermore, they need to be certain that the chosen alternative is the one that has the greatest *net benefits over time*

compared to every other feasible alternative. Cost–benefit analysis (CBA) offers a helpful methodology for collective decision making that promotes sustainable development by enabling decision makers:

- To determine if a decision’s benefits outweigh the costs, and by how much;
- To compare alternatives by weighing the total expected cost of each option against its total expected benefits.

Environmental impacts can also be factored into CBA.⁷⁵ Recently, one has seen the development of an “ecosystem approach” which focuses consideration on “ecosystem services” as a generalization of the idea of “environmental goods”. Ecosystem services can be defined as “the benefits that humans obtain from ecosystems”.⁷⁶ The UN identifies three key ecosystems for sustainable development: the terrestrial ecosystem (SDG 15), the marine ecosystem (SDG 14) and the atmospheric ecosystem (SDG 13). All three provide ecosystem services. Environmental impacts can thus be factored into CBA using ecosystem service valuation (ESV), which values the benefits we derive from ecosystems, and the costs and benefits of alternative uses for scarce ecosystem services or environment resources, including future costs arising from climate change, habitat degradation, pollution, ocean acidification, de-oxygenation, etc.

⁷⁵ See Borger et al (2014) p. 163. In the UK, cost-benefit analysis that factored in environmental impacts gained moment as early as 1984 with HM Treasury's “Green Book” which noted that non-market impacts may not be directly measured in money terms, but might “sometimes still sensibly be given money values” (Pearce et al 1989 p. 124). In its 2003 edition, “Green Book” specifically referred to the need to capture “social and environmental costs and benefits for which there is no market price” (Treasury HM 2003 p. 19) and included a separate annex dealing with non-market assessment. In the EU environmental assessment came into focus in the EU Water Framework Directive (EC Directive 2000/60/EC), and recently in the EU Marine Strategy Framework Directive (EC Directive 2018/56/EC).

⁷⁶ See Borger et al (2014) p. 162.

4.3.2 Sustainable Development Goals

The General Assembly 2030 Agenda for Sustainable Development adopted seventeen detailed sustainable development goals (SDGs) for the post-2015 era (RIO+20, 2012).⁷⁷ Figure 1 summarizes these goals, depicting the ways in which they relate to each other as well as the ultimate objective of sustainable development. The central dial in the figure identifies key *outcome-related* SDGs that help address trade-offs between individuals' well-being over time – or equity problems – including: poverty reduction (SDG 1), gender balance (SDG 5), inequality reduction (SDG 10) and economic growth (SDG 8). The SDGs on poverty, gender and inequality indicate the focus of the UN's equity concerns, indicating that greater weight is to be given to the well-being of some of the most disadvantaged portions of the population. SDG 8 (economic growth), on the other hand, helps address equity concerns in a different way: by ensuring government policies seek to grow the size of the pie. Reducing financial hardship helps to potentially avoid other trade-offs and, over time, offers greater capacity to finance compensatory transfers to those most in need.

Later in the chapter, we shall not discuss in detail how to measure, reconcile or balance these key *outcome-related* SDGs (1,5,8 and 10) identified in the central dial. We take these as given criteria for evaluating the outcome of government policy and choosing between alternatives. Instead, we will focus our attention on the SDGs highlighted in the remainder of the diagram. These are best thought of as the means to achieve the outcomes sought by the SDGs in the central dial. Further, our focus will be on the role of governments and ICTs affecting these remaining thirteen 13 SDGs over time.

We start in the next section with the core role of governments encapsulated in the pyramid at the bottom of Figure 1, as to ensure peace, and justice for all (SDG 16), and global partnerships (SDG 17). As we shall see, these form key preconditions for sustainable development, and ICTs have a critical role to play here.

⁷⁷ See Chapter 1: ICT Engines for Sustainable Development. The 2030 Agenda also announced a total of 169 specific targets to accompany the seventeen SDGs.



Figure 1. UN Sustainable Development Goals

We then move up the diagram to discuss the role of government policy in the two SDGs shown in large ovals. In particular, we shall examine the role of government policy in sustainable infrastructure, industrialization and innovation (SDG 9), and in sustainable production and consumption (SDG 12). Our focus in this section will be on the role of government policy directly affecting ICT markets, given that ICTs

are a key platform for infrastructure, industrialization and innovation (SDG 9), and key inputs and outputs in sustainable production and consumption (SDG 12).

Finally, we shall move to the top of the diagram, to consider how government policy is directed at the nine remaining SDGs. Shown in smaller circles surrounding the central dial, these SDGs relate to needs shared by people of all generations and fall into three categories:

1. Basic needs, or goods and services, including: food (SDG 2), water (SDG 6), energy (SDG 7) and cities and settlements (SDG 11), shown in the bottom portion of the outer ring of circles;
2. Fundamental human capital, or human needs or services: including health (SDG 3) and education (SDG 4), identified in small circles at middle level;
3. Fundamental environmental needs, or goods and services: including climate (SDG13), oceans and seas (SDG 14) and terrestrial ecosystems (SDG 15), identified at the top of the outer ring of circles.

These nine UN SDGs thus specifically relate to key non-ICTs markets, including markets for basic goods and services (food, water, energy, cities and settlements); markets for human services (health and education); and (often missing) markets for environmental goods and services. We shall thus examine how government policy directly regulating these non-ICT markets can indirectly affect the demand for ICTs, enabling or limiting the opportunities for ICTs to contribute to sustainable development. In this final section, we shall particularly focus on how government policy on these non-ICT markets may have unforeseen effects, limiting the beneficial effects of ICTs. As we shall see, in market after market, policy designed for the pre-Internet era appears to be preventing the development of smart agriculture and food markets, smart water markets, smart energy markets, smart cities, smart transport, smart health, smart education and smart manufacturing. For this reason, governments urgently need to review and adapt their existing policies on non-ICT markets to ensure that they better suit the Internet era, thereby enabling cutting-edge ICTs to play their role in sustainable development.

In what follows, we begin by focusing on the organization of government itself. Next we explore the impact of government policy on sustainable development through the two main transmission mechanisms shown in Figure 2, namely, ICT markets and non-ICT markets that directly relate to key SDGs, such as food (SDG2), water (SDG6), and energy (SDG 7).

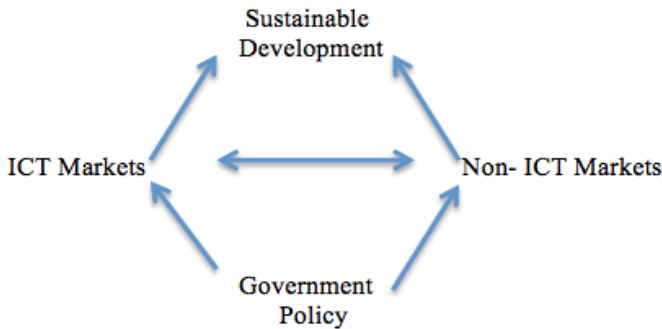


Figure 2. Transmission of Government Policy to Sustainable Development

Government policy on ICT markets (on the left) can directly impact upon sustainable development, since ICT markets are a source of employment and income for many people. Also ICT market outputs are directly measured in GDP and therefore affect key outcomes like economic growth, poverty, gender balance and inequality. A key additional point for this chapter, however, is the two-way interaction (shown in the horizontal link) between both ICT and non-ICT markets. This captures the fact that policy on non-ICT markets (right) can affect ICT markets (left) – particularly in terms of demand – and *vice versa*: policy on ICT markets can affect non-ICT markets – particularly in terms of the supply of ICTs. These cross-effects are a key overlooked strategic issue facing governments in the twenty-first century which we shall address in this chapter. But we begin with the organization of government itself, and the role of ICTs therein.

4.4 The Organization of Governments and ICTs

4.4.1 Peace and Justice for All

UN SDG 16 seeks to “promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels” (UN, 2016). Establishing peace and justice is a key foundation for sustainable development and requires the establishment of an open, accountable and transparent state, and government institutions.

Nobel Prize-winning economist, Douglas North, highlighted the state and the organization of governments as a key determinant not only of peace, but also of the performance of economies through time.⁷⁸ North defined the state as the contestable monopolist⁷⁹ of violence, or of coercive powers within a jurisdiction, the geographic boundaries of which are set by the limits of the state’s ability to tax. North argued that the centralization, and limitation of the use of violence or coercion within a state not only lays the foundation for peace, but also for economic growth, largely because it enables the definition and allocation of property rights. This in turn supports both the development of markets, and investment in production of goods and services required to meet the needs of people over time.

The centralisation of the use of violence in the state, however, only lays the foundation for better economic and social outcomes. There needs to be more than centralisation of coercive power. There also needs to be appropriate institutions that sustain and guide a state to better progress the well-being of its citizens.⁸⁰ Otherwise, as North notes, the state’s coercive powers can be diverted to promote only the narrow interests of a power elite and encourage unproductive rent seeking.

⁷⁸ See North (1983, 1990 and 1995).

⁷⁹ North (1983) points out the reason a state holds only a contestable monopoly of violence is because it faces both the threat of internal overthrow by revolution, and the threat of external overthrow by other states.

⁸⁰ Acemoglu D. and. Robinson J.A. (2012) document the need not only for centralisation of power but inclusive institutions governing its use.

As noted by the UN, achieving sustainable development is extremely difficult in the absence of effective, accountable and inclusive institutions, and ICTs offer considerable scope for creating peaceful, just and inclusive societies by facilitating more open, accountable and transparent governments (UN, 2016). The role of ICTs in achieving SDG 16 can extend from making information more accessible – to enabling citizens to hold governments to account and to express their preferences or demand for government services (e.g., through voting) – ensuring more efficient and responsive supply, access and delivery of government services, including legal and social welfare systems designed to offer justice for all.

E-government is the term given to the use of ICTs in facilitating online registration, online service delivery, e-public services, e-revenue and one-stop service, or integration of all government services to citizens and businesses. The 2016 United Nations E-Government Survey highlights a positive global trend towards higher levels of e-government development commenting:

Countries in all regions are increasingly embracing innovation and utilizing ICTs to deliver services and engage people in decision-making processes. One of the most important new trends is the advancement of people-driven services. It addresses the growing demand for more personalized services that react to individual needs, as well as people's aspiration to be more closely engaged in the design and delivery of services. These new demands are transforming the way the public sector operates. (UN, 2016, p. 3)

The survey provided insight into global indicators and comprehensive data showing the status of 193 countries in e-government development. Its aim was to deepen understanding of the extent of interoperability and implementation of WoG (Whole of Government). These indicators relate to the following:

- One-stop service platform;
- Advanced search features (indexing contents and government websites);
- Digital features that enable different systems to seamlessly exchange information; and

- Online tracking systems that permit citizens and representatives of civil society to check on the status of on-line transactions. (UN, 2012)

E-government and e-participation, including access to social media, have enabled people to get involved and this has led to increased transparency and participatory decision-making at countrywide and local level relating to implementing government and public policy. Since e-government can also enable delivery of services through ICT-enabled platforms, transacting with the government can become easier and more straightforward (from filing taxes and expenditure program applications, to applications for licenses and other regulatory approvals). This can include consent-based platforms for residents to manage their personal data for electronic government transactions.

4.4.2 Global Partnership

UN SDG 17 seeks to “strengthen the means of implementation and revitalize global partnership for sustainable development”. This is another key foundation for sustainable development, for the simple reason that, (as North’s definition of state highlights), states tend to be delineated by boundaries, or be limited in geography, and in scale. One does not have just one global super state, but many states of differing sizes. Whilst this can be a good thing, it also necessitates state cooperation.

While it may be both common – and helpful – for a state to monopolize/centralize control of violence in a geographic area to safeguard peace and economic growth, it has also historically been uncommon, and generally unhelpful, for just one state to try and control all populations on the planet. Multiple competing states have been both a fact and a beneficial feature of history. In the famous Tiebout model (Charles M. Tiebout, 1956), multiple competing jurisdictions enable households to “vote with their feet” and choose a jurisdiction that provides the fiscal package best suited to their requirements. Besides enabling such “assortative matching” of citizens to states, competition

between states can also facilitate policy and legal experimentation by states, and shared learning from success and failure.⁸¹

Despite these benefits from competing small states, there are also potential costs to be considered. Three key cost issues are likely. First, there may be loss of economies of scale in the production, and/or consumption of collective goods produced by the state. This can occur where there is declining marginal cost of production and/or non-rivalry in consumption of collective goods produced by the state. Second, there may be increased scope for inter-jurisdictional “externalities” (e.g., climate change), or situations where (a) decisions made in one jurisdiction impact another (an external effect); and (b) these external effects are not factored into the original decision making (i.e., an externality). Third, there is the serious threat of war between states. As North notes, two thirds of all changes in government since World War II did not occur peacefully, but rather as the result of external invasion by another state, or internal revolution, with the latter often fermented by another state.

Global partnerships and cooperation (SDG 17) can thus help to address or minimise these costs of competing states. Such global partnerships and cooperation can, in turn, be supported through ICT-based solutions. ICTs, for example, can be used to facilitate communication, monitoring and enforcement of inter-state cooperation agreements, to exploit economies of scale and address inter-jurisdictional externalities at a transnational level, fostering positive cross-border transactions (e.g. trade) and better regulating negative ones (e.g. climate change).

A key challenge, however, is global cooperation between states to address cybersecurity. This stands out as an increasingly pertinent issue with many countries now including cybersecurity in their national policy priorities. (CCDCOE, 2017). Priority has been given to cybersecurity for two reasons: first, the Internet and ICTs are considered as vital infrastructure for driving economic and social development; and second, the increasing severity and pace of cyber

⁸¹ See Oates (1999) pp. 1130ff for a discussion of potential gains from experimentation with greater decentralization within a federal system.

threats. While policy makers might seek to promote the Internet as an open platform for innovation and growth (OECD, 2012) at the same time they need to provide efficient protection against cyber threats. The International Telecommunication Union (ITU) launched Global Cybersecurity Agenda (GCA) in 2007 to develop a framework and strategies to respond to global challenges in cybersecurity (ITU, 2011 p19). Analysis of ITU Global Cybersecurity Index (GCI) in the ITU Cybersecurity Index and Cyberwellness Profiles Report (ITU, 2015) shown in Table 1a below reveals that Europe is the region with the highest index. Africa rates lowest.

Table 1a: Global cybersecurity index and cyberwellness profiles

Global	Africa	Americas	Arab	Asia Pacific	CIS	Europe
0.28	0.16	0.26	0.27	0.29	0.27	0.45

Table 1b shows additional ITU cybersecurity index analysis by five work areas: (1) legal measures; (2) technical and procedural measures; (3) organizational structures; (4) capacity building; and (5) international cooperation. The five work areas are seen to be important to battling cybercrime (ITU, 2014). The highest sub-index is Europe for legal aspects and the lowest is Africa for capacity building. Besides enacting and enforcing cybersecurity legislation and setting up a national cybersecurity framework, government priorities include setting up national cybersecurity entities, including a computer incident response team (CIRT), organizing public–private partnerships, strengthening countries’ cybersecurity skills through training, and fostering international cooperation.

4.5 ICT Market Policy

We now focus on the direct impact of government policy upon two key ICT markets:

1. ICT infrastructure markets; and
2. ICT applications and content markets.

In Section 4.4.1 below on ICT infrastructure markets, we focus on the impact of state ownership of legacy ICT network assets, spectrum

ICT-centric economic growth, innovation and job creation

licensing, competition law, access regulation and universal service obligations (USO). In Section 4.4.2, we focus on the government's role in intellectual-property rights (IPR) and privacy law.

Table 1b: Global cybersecurity index and cyberwellness profiles work areas

Area	Legal	Technology	Organizational	Capacity Building	Cooperation
Africa	0.31	0.13	0.17	0.11	0.16
Americas	0.44	0.24	0.24	0.25	0.20
Arab	0.42	0.24	0.27	0.26	0.23
Asia pacific	0.41	0.30	0.30	0.27	0.25
CIS	0.73	0.31	0.19	0.13	0.26
Europe	0.79	0.42	0.45	0.37	0.34

Source: ABI research report (ITU, 2015, p. 17).

Before proceeding to the above mentioned sections, we will first briefly identify the significant contribution made by ICT markets to two key SDGs:

- SDG 9 which aims to “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”;
- and
- SDG 12 which aims to “ensure sustainable consumption and production patterns”;

and briefly discuss the role of governments at a high level in ICT markets to provide context.

ICT infrastructure is a key direct contributor to SDG 9. ICT infrastructure investment involves decisions on investment in, and use of the underlying communications technology used to intelligent devices such as computers, smart phones, tablets, etc. It includes the backbone of the telecommunication infrastructure (wired, wireless, fixed and mobile). A considerable amount of capital investment is required to create and maintain this ICT infrastructure. Indeed, investment in ICT infrastructure is typically among the largest of the

key infrastructures in some developed economies. For example, Table 2 presents data on investment in private non-residential assets in the US.⁸² As shown in the second to last column in Table 2, from 1995–2015, investment in total ICT infrastructure⁸³ was on average higher than investment in all utilities combined over the same period ⁸⁴ – and also higher than investment in all transport combined.

Indeed, as shown in the last column of Table 2 by 2015, despite falls in ICT prices over the prior twenty years, total ICT infrastructure investment in the US was 63% higher than the total investment in utilities and 53% higher than investment in transportation.⁸⁵ ICT infrastructure in this case thus directly and significantly affects SDG 9 more than any other infrastructure, and for that reason alone, it is important that ICT investment is sustainable. As we explore later, however, ICT infrastructure also indirectly affects the achievement of SDG 9 by impacting on the sustainability of other infrastructure platforms, i.e., by supporting more efficient “smart” energy, water, sanitation, and transport infrastructures.

Applications and contents delivered over ICT infrastructure are also significant components of both the firm’s production processes and consumer’s consumption bundles. Applications are software programs that run on devices, smartphones and tablets, which are typically

⁸² The data in the table is taken from Bureau of Economic Activity analysis of Investment in Private Non-Residential Fixed Assets <https://bea.gov/national/FA2004/Details/Index.htm>. For further data see Table 4a US Annual Capital expenditure survey. For detailed 2015 data www.census.gov/data/tables/2015/econ/aces/2015-aces-summary.html.

⁸³ Including broadcasting and telecommunications (codes 515, and 517 in the North American Industry Classification System (NAICS)) and information and data processing services (NAICS 518,519).

⁸⁴ All utilities combined (NAICS 22) includes electric power generation, transmission, and distribution, natural gas distribution water, sewage, and other systems.

⁸⁵ All forms of transportation and warehousing (NAICS 48-49) include air, rail, water, truck, transit and ground passenger, pipeline of crude oil, refined petroleum, and miscellaneous products, natural gas, scenic and sightseeing, support activities for transportation couriers and messengers, warehousing and storage.

Table 2: US investment in private non-residential fixed assets

Structures, equipment and intellectual property (millions of USD)			
	NAICS ⁸⁶ Codes	Average 1995-2015	2015
Total ICT infrastructure		139,855	201,717
Broadcasting and telecommunications	515, 517	114,271	132,576
Information and data processing services	518, 519	25,584	69,141
Utilities	22	81,650	123,536
Transportation and warehousing	48-49	74,493	131,587
ICT applications and content			
Publishing industries (including software)	511	27,871	40,227
Motion picture and sound recording industries	512	33,427	36,725
ICT grand total		201,152	278,669

connected to mobile or fixed phone networks. The rapid growth of mobile devices has been accompanied by an equally rapid growth in app development, in substantial part because platform providers (Apple, Google, etc.) have lowered the costs of development and distribution of mobile applications.⁸⁷ Contents refer to digitized audio and visual material such as music, film and television, books, video games, etc.

⁸⁶ North American Industry Classification System (NAICS).

⁸⁷ Bresnahan, T., Davis, J.P., Yin. P., (2015) p. 233.

Recent studies indicate that real-time entertainment (comprised of streaming video and audio) continues to be the largest traffic category on virtually every network (mobile and fixed) and the key driver of network growth.⁸⁸ The last four rows of Table 2 further show investment related to ICT applications and content, relevant to the Internet, namely publishing (including software), motion picture and sound recording. As shown, investment in this form of applications and contents adds around another 40% to total ICT infrastructure investment, making the grand total of investment in ICTs shown in the last row of Table 2 higher than investment in both utilities and transport combined. ICT applications and contents thus form a direct component of SDG 12 sustainable consumption and production. As we shall see, ICT applications and contents also indirectly affect consumption and production of other goods and services related to other key SDGs, including food (SDG 2), water (SDG 6), energy (SDG 7), cities and settlements (SDG 11), health (SDG 3), education (SDG 4), climate (SDG 13), oceans and seas (SDG 14) and terrestrial ecosystems (SDG 15).

As summarised in Chapter 1, the research literature on the higher-level socio-economic impacts of ICTs is extensive and provides ample evidence that ICTs can contribute significantly to sustainable development. For example, the World Bank (2016) concluded that “the accumulation of ICT capital accounted for almost 20% of global growth between 1995 and 2014.”⁸⁹ Although the empirical evidence is less extensive, ICTs have been generally found to produce similarly positive economic impacts in studies that focus on less developed countries.⁹⁰ The great part of this contribution is through the effect of ICTs on non-ICT markets – to which we turn in the next section.

To realize the full benefits of ICTs, however, requires properly functioning markets and competition, in particular ICT infrastructure

⁸⁸ Sandvine 2016.

⁸⁹ World Bank (2016), p. 55.

⁹⁰ For references see Chapter 1 of this book: ICT Engines for Sustainable Development

markets and ICT applications and contents markets. In any economy, the supply and exchange of services from businesses to businesses (B2B), businesses to households as consumers (B2C) and businesses to government (B2G) involve markets - where markets are merely institutions for consummating such exchanges. For markets to work well, however, requires a legal framework that ensures a sustainable open, pro-competitive trading environment. Otherwise, ICT markets can fail in classic ways; if, for example, they become dominated by monopolies, or exhibit externalities that remain uncorrected. ICTs can further contribute to positive externalities – for example, through better access to knowledge – although this potential benefit may remain underexploited if this access to knowledge involves free riding on the investment in knowledge creation, which reduces the reward and therefore the incentive for knowledge creation.

The government clearly plays a pivotal role in market exchange relationships between households and the businesses that provide services to meet their needs, including ICT – whether the businesses are for profit, non-profit, private or state owned. The broad rationale behind any kind of government intervention should be to correct “market failures” or situations where markets fail to deliver sustainable development. An equally important consideration, however, is the risk of “government” or “regulatory” failures that do not deliver sustainable development. This highlights the importance of detailed comparative institutional analysis, and avoiding the assumption that heavy reliance on either markets or government is better. One inevitably needs an optimal blend of both to achieve sustainable development, and this requires comparing feasible alternative policy options.

In what follows, we address key policy issues and challenges in greater detail, and try to identify practical guidance on key government roles, highlighting several key practical areas of advice for development professionals in relation to ICT markets focusing in more details.

4.5.1 ICT Infrastructure Markets

As shown above, the underlying ICT infrastructure (mobile and fixed line telephony) can be the most capital-intensive infrastructure in any economy. For a country to benefit from ICT-supported sustainable

development, therefore, it requires major ICT infrastructure investment. A central policy problem to be solved by governments interested in ICT-supported sustainable development then is that they must convince potential domestic or foreign ICT-market entrants as new investors that neither government policy nor the regulatory environment will expose them to excessive regulatory risk or uncertainty.

This poses a so-called credible commitment problem for governments.⁹¹ There will always be temptation for governments to intervene in politically expedient ways after large ICT capital investments have been made by firms.⁹² This will typically involve a transfer of wealth from investors who have become locked into an investment in “stranded assets”, to a consumer group, or a particular local competitor who may be important to short-term political objectives. This will lead to unsustainable developments, with the well-being of future citizens being compromised by the political opportunism of governments in the present. Hence, investors – particularly foreign ones – will have “outside” options before investing (*ex ante*) and will foresee the sovereign government risk to stranded assets posed after they invest (*ex post*). They will therefore demand compensation for this risk, or not invest at all. Thus, a simple way to attract foreign investment at a lower cost of capital is for governments to make credible commitments *ex ante*, to safeguard investors’ legitimate investment expectations *ex post*.

The design of institutional arrangements then becomes critical to ensuring sustainable development, ensuring that the well-being of future generations is not compromised by the opportunism of present-day governments. Next, we will explore this problem and its implications for ownership of legacy ICT network assets, spectrum licensing, competition law, access regulation and universal service obligations (USO).

⁹¹ See North D.C and Weingast B. R. (1989) for a seminal article on the credible commitment problem for governments.

⁹² See Levy, Brian; Spiller, Pablo T. (1994) for seminal application of credible commitment problem to telecommunications.

State Ownership of Legacy ICT Assets

The world's first telecommunication network, supporting telephone services, began in the US under largely private ownership in 1877.⁹³ By mid-1880s, the company had built telephone exchanges in every major city in the country along with inter-city lines to connect them. Elsewhere in the world, however, the state assumed ownership of telecommunications service, often locating them in a state-owned agency along with post and telegraph. There remains a significant element of state ownership of telecommunication assets today, despite the global trend for privatization from the 1980s when steps were slowly taken to privatize fixed-line incumbent telecommunication operators around the world. By 2011, 60% of OECD countries had at least partly privatized their fixed-line operators: leaving a significant portion under state ownership.⁹⁴ This was, however, twice the level of privatization as the average recorded in non-OECD countries. Latin America and the Caribbean, African resource-rich and African resource-scarce coastal countries have only privatized between 30 and 40% of their fixed-line operators – and this number falls to 10% in African resource-scarce landlocked countries.⁹⁵

⁹³ Principally owned by the Bell Telephone Company, a common law joint stock company formed in Boston, Massachusetts on July 9, 1877, by Alexander Graham Bell and his father-in-law Gardiner Greene Hubbard, which later evolved into American Telephone & Telegraph (AT&T).

⁹⁴ Gasmi et al 2013.

⁹⁵ *ibid.* The fixed telecommunication infrastructure has no doubt faced increasing competition from the mobile-cellular worldwide. Data on the extent of state ownership of the mobile networks globally is not readily available, however it seems likely that state owned fixed line incumbent operators have been involved in the roll out of mobile networks – particularly the early 2G networks. It is worth noting however that the proportion of the world's population covered by at least 2G mobile network is about 95%, with mobile-broadband 3G network reaching 84 per cent in 2016, but only 67 per cent in the case of the rural population (see ITU 2016 p88). The ITU notes however that it is impossible to draw conclusions on mobile- phone usage in the world's poorest nations due to lack of data (See ITU 2016 p162). The World Economic Forum notes however the gap between coverage and penetration is 30-50% in many developed countries, and this difference jumps to 55-75% in emerging markets World Economic Forum (2015) p. 19.

A key policy issue for many countries then remains state ownership of legacy telecommunication infrastructure. Telecommunication infrastructure is a critical driver of ICT-based sustainable development, as it remains a key input into all downstream ICT market activities. State ownership of the telecommunication network, however, poses serious credible commitment problems for governments. Unfettered state ownership of key ICT assets like the telecommunication network poses the risk of political opportunism by future governments which may opt to raise prices or limit investment – thus compromising service quality – for short-term fiscal or political gains. This would be to the detriment of both domestic and foreign private investors in ICTs reliant on such state-owned assets. The problem is how to credibly commit future governments, and encourage domestic and foreign direct investment in ICT infrastructures today, when state ownership of critical ICT assets means that governments will control price and quality of key ICT services available to downstream users and investors, after private sector investments are made. Once an ICT investment becomes a sunk cost, it is also at risk of becoming a “stranded asset”, open to misappropriation by government for short-term political gain.

Besides credible commitment, or the need for the government not to abuse its control of assets, there is also the problem of the effect of state-owned firms’ incentives on efficiency. So far as sustainable development is concerned, the effect of state ownership on three conditions for economic efficiency are primarily relevant.⁹⁶ These are:

1. Allocative efficiency: if economic growth in a country is to be sustainable, resources within that economy need to be allocated to their highest return uses at the margin.

⁹⁶ Empirical evidence suggests a positive fiscal impact of privatization. This is mainly due to the cessation of state capital injections to public sector enterprises, as well as due to the collection of privatization proceeds and taxes derived from the profits of privatised firms. See Gupta, Schiller and Ma (1999, pp. 10–11). Davis et al. (2000) and Kikeri and Nellis (2002, pp. 13–14). Other secondary effects may include the promotion of capital markets and the enhancement of public ownership of shares.

2. Technical efficiency: this requires the use of least-cost production methods to produce outputs using the lowest amount of labour, capital and other possible resources.
3. Dynamic efficiency: both allocative and technical efficiency need to be maintained on a dynamic basis, or continuously through time, by way of constant innovation.

These three conditions require that enterprises do not absorb resources that might earn a higher return elsewhere, and at the same time that any resources absorbed by an enterprise are also allocated internally to their most highly valued uses and used efficiently on a dynamic basis. This requires systems of management that eliminate relatively low-return investment activities, build ones with higher returns at the margin, and foster innovation subject to the constraint of available funds. Ideally this would be done to equalize returns to investment at the margin, and thereby maximise total value added over time.

A key problem undermining efficiency in any state or private-owned organization, however, is commonly known as the principal agent problem. This problem arises when agents within a firm pursue goals that are not aligned to the wider interests of other parties, such as contributors of capital and consumers. Individual members of an organization have a tendency to pursue their own goals. Owners typically aim at maximizing their profits (dividends and capital growth), while managers and workers remain primarily focused on the fulfilment of their personal goals (e.g., increased income and higher social status).⁹⁷ Internal firm decision making about the allocation and use of resources which are owned by the “organisation” may lead to insufficient investment, innovation, or care, and so called shirking, or featherbedding, having a negative influence on corporate performance. Theoretically, with clearly defined property (or decision) rights and zero costs of contracting to structure agents’ incentives, these incentive problems could be overcome through contracting. In the presence of

⁹⁷ Williamson (1963), Jensen and Meckling (1976) and Fama (1980). W Galal (1991, pp. 2–6), Shleifer and Vishny (1994), Boycko, Shleifer and Vishny (1996), King and Pitchford (1998), Nestor and Mahboobi (1999, pp. 3–10), Shirley and Walsh (2000, pp. 22–24, 28–36), Corneo and Rob (2002) and Cragg and Dyck (2003).

information costs, however, transaction costs of negotiating, monitoring and enforcing contracts emerge, and lead to scope for inefficiency, or wasted resources within firms.

The “agency problem” is common in both private and public sectors, yet, it is exacerbated in the case of state-owned firms for a number of reasons, including, *inter alia*:

- Manipulation of state-owned enterprises (SOEs) by the government for political objectives (e.g., appointment of political friends in managerial positions, use of SOEs to employ redundant workers), as opposed to clear and stable profit objectives;
- The existence of a complex structure of delegation by voters to ministers and by ministers to managers who are monitored by ministers; this, in turn, displays “agency problems” at multiple levels and is tainted by political, or distributional criteria, as opposed to wealth maximization criteria;
- Increased monitoring difficulties by citizens-voters-owners in the case of state-owned firms, due to the fact that ownership is highly diffused and there is the possibility of free riding on the monitoring efforts of others;
- The lack of market for management teams, analogous to market for corporate control (takeover threat) in the private sector; that is, in the case of state-owned enterprises, managers are appointed and removed by the government.
- The absence of the threat of bankruptcy and market discipline, since state-owned enterprises are frequently bailed-out by the government when things go wrong.⁹⁸

A key reason for privatizing large trading entities in particular (e.g. telecommunication firms) is that in the absence of doing so, the beneficial effects of the threat of competition – including product market entry by other firms, takeover and bankruptcy – are diluted, and incentives for superior performance weakened. In the context of residual government ownership, or special legislative and/or fiscal

⁹⁸ Staikouras P. K. (2004) p. 375.

interventions, there is always the potential for the company to focus its energies on maintaining or deepening regulatory or fiscal advantages (creating barriers to entry), or to feel that it can always fall back on implicit government guarantees against financial failure, which are hard for governments to avoid given their power to raise taxes. The consequence of resisting privatization then is weaker economic performance. Having said that, how privatization is implemented is also important.

One of the key events that helped kick-start the growth of ICTs and the spread of the Internet worldwide in the 1990s were steps to increase competitive conditions in telecommunications. These focused on reform of ownership arrangements from the early 1980s. This began in the US, with the break-up of Ma Bell into AT&T providing long-distance service, and the so called “Baby Bells” or Regional Bell Operating companies providing local services, which was finally mandated in 1982. These moves to enhance competitive conditions through ownership reforms were mirrored elsewhere in the world into the 1990s and beyond, with the retreat of state ownership of telecommunications.

The superiority of private firms over their state-owned counterparts can be confirmed by looking at productive efficiency that is the relationship between quantity of goods produced/service provided and resources employed.⁹⁹ Historically, there was a debate between researchers who asserted that private firms do better than SOEs given the same market structure¹⁰⁰ and others who argued liberalization and competition policies affecting market structure are more important to increased efficiency.¹⁰¹ It appears safe to conclude, however, that privatization

⁹⁹ Kay and Thompson (1986, p. 20).

¹⁰⁰ Boardman and Vinning (1989), Megginson, Nash and Van Randenborgh (1994), Haskel and Sanchis (1995), Jones and . & Mygind, N. (2000) Estache and Gonzalez (2002), all conclude that privatization increases firms’ efficiency, with Jones and Mygind (2001), estimating that private ownership is 13–22% more efficient than public ownership.

¹⁰¹ Kay and Thompson (1986), Parker and Hartley (1991), De Fraja (1993), Martin and Parker (1995), Durant, Legge and Moussios (1998), Estrin and Rosevear (1999), Liu and Garino (2001).

and liberalization, or promotion of market competition are complementary rather than competing policies.¹⁰² While private firms tend to perform better than SOEs given the same market structure, privatization realizes its full potential when market competition is also promoted.¹⁰³ Privatization of telecommunications from the 1980s has thus also tended to include the liberalization of the telecommunication sector, in particular, the opening to competition of the fixed and cellular segments of the industry typically accompanied by the creation of regulatory agencies independent from the political administration in a sector where regulation and competition policy have been playing an increasingly important role in the functioning of markets.

Spectrum Licensing

Spectrum is a critical input to a networked and digital economy and society. It supports a wide range of services that promote economic growth and enhance social well-being. Its role, as an economic driver and the value it returns to society, is increasing. Wireless services can support more efficient processes and delivery of existing services, enabling improvements in productivity. Yet, according to data compiled by the ITU at the end of 2013, many emerging markets had only released one-third or less of the spectrum that will be required to meet mobile demands alone in 2020.¹⁰⁴ Some countries will need up to ten times more spectrum than what is now available.¹⁰⁵

A critical constraint on efficient outcomes will be the nature of government decisions on spectrum policy. Spectrum licensing reform on a global scale is necessary to unleash the potential sustainable development dividend offered by ICTs. In this way, it would be possible to satisfy the growing demand for access rights associated with the growth of all types of wireless service, which are critical to the

¹⁰² Fershtman (1990), Boubakri, Cosset and Guedhami (2001), Debande (2001), Smith and Trebilcock (2001), Ng and Seabright (2001) and Angelucci et al. (2002).

¹⁰³ Shirley and Walsh (2000), pp. 50–52, Kikeri and Nellis (2002), pp. 21–25, Nicoletti and Scarpetta (2003), pp. 7–11.

¹⁰⁴ ITU (2013a).

¹⁰⁵ World Economic Forum (2015).

continued growth of the ICT value chain and the overall economy. Besides, reform is needed to ensure that available spectrum is used efficiently.

One can characterize spectrum policy globally along two dimensions:

1. The first is the nature of the access model, and the resulting use of the spectrum: exclusive use (the traditional model), shared use and the commons.
2. The second is a more conventional breakdown of spectrum management models into command and control, and market-based methods.

The combinations of these access and management models are not mutually exclusive; regulators can combine them – often in the same band and even for the same services – and market outcomes differ depending upon the conditions of demand and supply.

Historically, around the world, the typical approach to managing the radio spectrum has been highly prescriptive, or based on command and control. More recently a number of spectrum agencies have modernized spectrum management policy to accommodate the use of increasingly market-based methods and promote flexibility in use. This contrasts with the approach thirty years ago when command and control were the universal management practice. Most of the innovations unveiled in recent years revolve around flexibility and the use of market-based methods. Many countries have introduced some degree of market-based methods, usually via competitive assignments of some kind, or auctions for certain classes of licenses (chiefly cellular telephony spectrum licenses).

Only a handful of countries, however, have gone beyond auctions and introduced serious measures to address flexibility and accommodate spectrum trading. These are the United States (US), Australia, New Zealand (NZ) and the United Kingdom (UK). Ambitious reforms in these countries have been associated with different degrees of technology and service neutrality and the (re)definition of spectrum-property rights. Only the US has adopted elements of the commons access model. Otherwise, current arrangements elsewhere in the world are generally biased in favour of a command and control approach in

relation to decisions about spectrum use and regulatory models. While this approach works in so much as it licenses spectrum to particular users and ensures that excessive interference is avoided, it is unlikely that it achieves the full objective of maximising the economic value derived from the spectrum.

Thus it is currently the case in most countries that a large amount of spectrum remains directly under government control, or within the public sector, and has not even been released into private hands. This is unlikely to lead to maximizing the economic value derived from spectrum. A market-based process can be extended, however, to public sector spectrum where government-funded agencies compete for spectrum with private users, and therefore pay the opportunity cost of spectrum in private use. One way to move towards more market-based systems for government-held spectrum would be to allow and encourage government agencies to participate in market activity such as spectrum trading. Government agencies would also be required to meet their new spectrum needs through the market in all but exceptional circumstances.¹⁰⁶ Emergency services such as the police, however, are extremely reluctant to share their spectrum with other users, as their radio networks need to have sufficient “headroom” above traffic patterns in normal times to be able to cope with the rapid increase in traffic levels whenever an emergency arises. For such users, the development of robust sharing protocols would be useful. Re-farming of spectrum in land-mobile bands to enable the dedication of a significant spectrum block for a national government radio network would also be a major step forward in emergency services communications. In addition, it should be possible to explore ways of providing greater incentives for spectrum sharing, with license fee relief and other measures. Public sector spectrum use is, often for good reason, swathed in secrecy. Whenever possible, however, information needed by potential users to make decisions on purchasing, leasing or sharing of such spectrum should be made available.

¹⁰⁶ Cave M. (2005) UK Independent Audit of Spectrum Holdings.
<http://www.spectrumaudit.org.uk>

Where spectrum has been allocated to private hands under command and control systems, much of it is under protected or restricted use, for example, a significant amount of spectrum is often restricted to only broadcasting uses. Technology has, however, made it increasingly feasible to unbundle services from specific technologies and frequency bands, enabling new business models and service architectures that hold the promise of new services, expanded markets, and more robust competition.

Much of the debate in relation to spectrum placed in private use has been around a move from command and control exclusive access to market-based exclusive access. It is widely accepted that appropriately supervised markets can yield superior outcomes to the command and control methods. Market-based mechanisms have to date been used to grant licenses (principally through auctions) and to accommodate secondary trading of licenses. Spectrum trading is arguably the most potent market-based mechanism available, yet, in practice its impact has been minimal to date. To increase spectrum trading activity, regulators and governments can help satisfy key efficiency criteria including to ensure that there are well-defined property rights, thick markets with limits on abuse of market power, better information and limitations on unforeseen externalities.

Perhaps the key factor limiting outcomes in global spectrum management has been the widespread failure to adopt well-defined property rights. In general, market-based mechanisms work effectively when property rights are well defined and clearly assigned. The idea that the right to use a radio spectrum should be a private property right — an approach that has its origins in ground-breaking economic work by Nobel Prize-winning economist, Ronald Coase ¹⁰⁷, — regards frequencies as a resource that should be exclusive to individual owners. Even in economies with better designed systems like US, Australia and NZ, however, spectrum licenses lack key features that are important to incentives for investors and traders. Spectrum license terms, for example, are often severely limited by governments. In general, longer

¹⁰⁷ Coase, R.H. (1959).

tenure for spectrum licenses would lead to an improvement in their utility and help to make network development a much more enticing proposition to investors: thus removing a significant impediment to the trade and development of efficient secondary spectrum markets. By comparison, property rights in land are in perpetuity which serves to support both significant long-term investment and trade in real estate.

The property rights model – which lies at the heart of market-based mechanisms – contrasts with the commons approach. Several influential authors, such as Noam¹⁰⁸ and Benkler¹⁰⁹, have promoted the idea of substituting the traditional regime of exclusive access to spectrum, under either market or command and control methods, with an alternative commons approach based on non-exclusive access. The commons is a part of the spectrum where anyone can transmit without a license. For that reason it is sometimes called license-exempt, or unlicensed spectrum. In the past and today, a small portion of spectrum sat alongside licensed spectrum to provide unlicensed access to users of certified equipment; but their approach has attracted little interest. Since the late 1990s, some authors, however, have proposed an alternative radical regime change in which command and control methods are replaced not by markets and property rights but by a universal commons. As Noam envisions, sharing of spectrum would be policed by the market. In advocating “deregulation of spectrum”, Werbach contends that courts can ensure that individuals and firms use commons access spectrum without unduly interfering with one another.¹¹⁰

The ideas of these pioneers of the commons were initially embraced by an increasing number of commentators, who pointed to successful innovations such as WiFi communications¹¹¹ (in the 2.4 GHz band) — which rely on utilizing resources controlled by no one — to strengthen their support in favor of the commons, and against exclusive use of the

¹⁰⁸ Noam, E. M., 1998,

¹⁰⁹ Benkler, Y. (1998); and Benkler, Y., (2002,)

¹¹⁰ Werbach, K.

¹¹¹ Weiser, P.J. and Hatfield, D.N. (2005). The authors claim that the “success of the 802.11 standard, popularly known as WiFi, has demonstrated that unlicensed spectrum can be big business” (p. 1). See also Lessig, L. (2001),.

radio frequency spectrum. For instance, the US Federal Communications Commission (FCC) has shown some interest in these arguments and has made more license-exempt spectrum available as a sort of commons, leading many to question whether further unlicensed allocations would result in more innovation and deployments.

However, after a stage that has been dubbed ideology¹¹², in the current stage of implementation and problem solving, the case for the commons seems generally tougher to defend – at least as a “one-size-fits-all” model for spectrum management. It is difficult to regard spectrum that is in high demand as one where open access may be justified on economic grounds. A commons regime may work more effectively if there is an owner (possibly a collective) who can determine the amount of spectrum to be assigned to the commons. Indeed, spectrum commons might be allocated by market forces; the owner(s) – both private and public – could buy, sell, trade, aggregate, disaggregate, and share their spectrum.

More recently spectrum policy debate has shifted away from the polarization seen in academic papers and considered the possibility of combining the commons with market-based methods.¹¹³ Designating a band as suitable for unlicensed use relaxes some constraints on entry and use, but almost invariably introduces new ones, e.g., restrictions on power and requirements for interference mitigation. Hence, the costs and benefits of decisions concerning the allocation of spectrum to licensed versus unlicensed need to be assessed on a case-by-case basis. In general, however, worldwide, an approach based on risk analysis involving a more aggressive expansion of property rights together with

¹¹² Faulhaber, G.R. (2005), WiFi is an example of an application that is known to many consumers. However, there are many other applications that use licensed spectrum and that consumers do not use directly. Hazlett (2006) observes that success of unlicensed applications does not mean that more unlicensed spectrum is needed.

¹¹³ The two approaches are not mutually exclusive. In practice the commons approach will require some element of property rights (usually held by either a private band manager or public spectrum manager), see Brito J (2007) .

a modest expansion of the commons would seem to be an appropriate model to pursue.

There is an ongoing need for examination of government spectrum and other “protected” spectrum, and of the appropriate balance between this and other spectrum. Full-scale, across-the-board liberalization with a wholesale redefinition of property rights has not been achieved in any country. This raises continuing questions about the feasibility of major reforms in spectrum management. A concerted push is needed to get the reform process moving again, and to capitalize on the early gains that have been made. To pursue a more rapid introduction of market-based and flexible spectrum regulation, governments need to devise and adopt transformational reform strategies. The precise nature of these reform programs, and importantly what spectrum would be implicated in the early stages, would require further detailed study. The use of an incremental adjustment strategy could avoid, or minimize, the need for significant disruption and compensation for displaced users when compared to a “big bang” approach to reform. Under an incremental or transformational reform model, existing users (in most cases) could be given notice before they are required to relinquish their existing licenses. Two-sided auctions could also be another way of reducing compensation demands, by placing the responsibility for deciding whether to move out of a band on the incumbent rather than the government imposing such a move.

Recommendation 1: Wherever possible, a wholesale transition to a property rights regime for spectrum is recommended.

Recommendation 2: There is also scope for a modest expansion of the spectrum commons. Governments should consider whether existing licensing arrangements are adequate for the development of a private commons and other shared use of spectrum. New licensing arrangements should be implemented if necessary. Goals could be set for the reservation of public park commons (perhaps paid for from auction proceeds from the transition to a property rights regime). Governments should also explore ways of providing greater incentives for sharing of spectrum through licence-fee relief or other measures.

Recommendation 3: Reforms to spectrum management should also include the removal of all designated or protected commercial services band (e.g., remove the designated, protected or dedicated uses afforded to such categories as broadcasting where no longer required).

Recommendation 4: Additional incentives are needed for government agencies to use spectrum more efficiently and to acquire and dispose of spectrum in the market. Even where spectrum use is deemed to be in the public interest, an agency could still enter into the market to acquire additional spectrum. This spectrum could be leased out (if not required in the immediate future), or sold on (in case where it is surplus to requirements). Government agencies could thus be allowed and encouraged (though not forced) to participate in market activity such as spectrum trading. Government agencies should be expected to meet their new spectrum needs through the market in all but exceptional circumstances.¹¹⁴ Market approaches and provision of spectrum for public use need not be mutually exclusive.

Recommendation 5: On balance we would not support the introduction of use-it-or-lose-it provisions as a means of addressing the problem of under-used spectrum. This would only increase uncertainty and insecurity of title; instead rather greater reliance should be placed on developing a market in tradable rights.

Competition Laws and ICT Access Regulation

It is generally accepted that, while ICT markets can perform well in delivering economic growth, government action to foster competition is critical to ensure this growth delivers sustainable development. The promotion of an open and pro-competitive market environment within a legal framework that ensures sustainability is essential. For many countries hoping to foster competition, this would be achievable through structural reform in the major areas of policy affecting ICTs, including:

- Trade and foreign investment policy;

¹¹⁴ Cave (2005) UK Independent Audit of Spectrum Holdings.

ICT-centric economic growth, innovation and job creation

- Government procurement policy;
- State-ownership policy; and
- State licensing policy.

Fostering an open, competitive economy through reform in the areas outlined above – to lower barriers to trade and investment, increase economic integration, and enlarge the size of markets – would facilitate exploitation of available economic efficiencies in ICT markets and foster sustainable development. However, literature suggests that, in addition to structural reforms, there is a need to both adopt and then effectively implement competition and consumer regulation. Effective competition and consumer protection laws are appropriate to complement structural reform measures in ICTs owing particularly to:

- The existence of a large and non-tradable ICT sector in any economy (e.g., telecommunication infrastructure in local exchanges)
- The inevitably significant, albeit residual, legal barriers to market entry which will exist in any economy (e.g., due to ICT infrastructure licensing); and
- Information problems undermining efficient consumer markets in any economy.

For these reasons, one needs a two-pronged approach to sustainable development, involving structural reform and laws to directly foster competition and consumer protection; otherwise, structural economic policies may operate at cross-purposes to competition and consumer protection laws by overly protecting domestic markets from beneficial import competition, promoting concentration in certain markets, distorting competitive conditions or creating market power.

Two key elements of any competition laws are: rules against cartel or anticompetitive collusive behaviour, and rules against unilateral abuse of market power. This may extend further to direct regulation of access to any residual monopoly elements in ICT infrastructure. The four key decision variables in the regulation of any ICT infrastructure market in terms of their economic consequences are:

1. Entry;
2. Price, including retail and wholesale prices;

3. Access obligations, to sets the terms of access to infrastructure; and
4. Quality or conditions of service.¹¹⁵

In order to ensure sustainable development – and to avoid, or at least minimize, the risk of law enforcement being distorted to meet the political demands of the day – effective economic regulation calls for not only effective substantive rules written into the legislation on the above concerns, but also effective procedural and institutional rules governing administration and enforcement. The critical question then is: can governments solve their credible commitment problems by putting institutional arrangements in place that prevent harmful government interference in regulatory decisions and promote sustainable development? This question is critical: both for prospective investors in newly liberalized industries, and policy makers concerned with encouraging new investment and stimulating sustainable development.

As noted earlier, theoretical and empirical work in economic history and development literature concur that a government's ability to credibly commit not to interfere with investors' legitimate private property rights is vital for countries to attract long-term capital investment and experience sustained economic growth. Much of this literature emphasizes the importance of independent institutions ensuring regulatory commitment.¹¹⁶ To maintain credible commitment to the promotion of economic welfare, the agency charged with enforcing the rules governing ICTs will need to be independent of government. Two main options then offer themselves:

- Independent court-based administration: This requires, at root, an independent judiciary. The enforcement of competition and consumer regulation may then be vested in an ordinary court system through civil actions to ensure the independence of the administration of justice. Court oversight of the operation of any economic regulation will be inevitable and necessary, at least on

¹¹⁵ Quality of service regulation can be driven by competition concerns, information asymmetry concerns, or externality concerns, including safety, and environment impact.

¹¹⁶ See Henisz (2000 and 2002) for good reviews of this literature.

appeal, but they could also be made the place of hearing in the first instance.

- Independent commission: The common alternative approach is the creation of an independent National Regulatory Authority (NRA) subject to court supervision.

In addition, it is important to distinguish between nuanced scenarios. One option is to separate the decision on *whether* to regulate a component of ICT infrastructure into a separate agency from that tasked with the decision on *how* to regulate in a particular case. This may place a check on the tendency for regulatory creep, where regulatory agencies may have incentives, and even a psychological bias to see the need for regulation, when unregulated markets might operate better.

Universal Service Obligations

The imposition of universal service obligations (USO) is a specific example of regulation of quality, or conditions of service that needs to be carefully designed to achieve sustainable development. USO seek to ensure that basic ICT services are available at an affordable price to all citizens and customers. USO, therefore, are likely to impose additional costs on infrastructure service providers requiring them to provide ICT access to high-cost users at below cost, for example, to poor people living in rural and arid areas. USO may be imposed by a telecommunication/ICT regulator, or a ministry responsible for ICT development. USO began with basic telephone services and have since moved on to cover Internet and broadband WiFi and advanced mobile technology (4G and 5G) access as an alternative for broadband optical fibre.

Around the world, USO policies have faced political challenges and problems. So far, there have been more failures than successes (GSMA, 2013). The two critical problems have been confusion over the objectives of USO, and second poorly designed means to achieve them. The basic underlying objective of USO applied to any ICT service is typically to provide access to the ICT service at below cost for high cost users who might not be serviced at all through pure market-based delivery. This suggests three key questions: (i) what services?

(including what volume, and quality); (ii) For whom?; and iii) how are the services to be funded? ¹¹⁷

Clearly the funding problem will increase with the range, volume and quality of the services, and the number of people targeted in USO. Given the limited resources of most developing countries, there will be a need to prioritize through careful social cost–benefit analysis, and some candidate services may need to be excluded. Decisions will thus need to be made as to whether, for example, USO be extended from traditional phone calls to Internet video streaming – and even Internet protocol television (IPTV)?

Limited USO funds should be focused on uses and users where there are the greatest net social benefits. A key threshold question in any case is whether any service under consideration would have been provided by the market anyway, in which case USO would only crowd out private enterprise and innovation. A policy of encouraging competition in fixed and mobile markets appears more likely to lead to a high degree of availability, quality and affordability for the basic connection and services – thus making separate USO unnecessary. This may then imply a narrow emphasis on ICTs for education only, both traditional classroom type (formal), education and distance learning or online classroom; or ICTs for healthcare services only, such as access to specialists for remote patients and applying broadband imaging of patients for diagnostic purposes. Thus, although broadband communications empowered by computer and animation technology can provide opportunities for new ICT start-ups in urban areas, it is not clear whether this would have a high enough net social benefit to justify relocating USO funding from, for example, education or health, to poor people in remote regions.

¹¹⁷ See papers in Symposium on Universal Service Obligation and Competition in Information Economics and Policy 12 pp. 205-300 – especially Panzar (2000) who explains the underlying logical exercise one must go through when attempting to measure the cost of fulfilling any specified USO; and Gasmia F., Laffont, J. J., Sharkey W. W. (2000) who discuss the relevance of USO to developing countries. More recently see Chone, Flochel, and Perrot 2002; Mirabel, Poudou, and Roland 2009 and Hoernig 2006.

Once the objective is clear, in terms of the service and target population involved, the best means to fulfil the objective needs to be used. This implies the need to find a service provider who is willing to deliver the designated services to a satisfactory standard, to the targeted customers at least cost. A potentially efficient way to secure such a provider would be to auction the USO to the lowest bidder.¹¹⁸ Such an auction would seek to establish who is the least cost provider of any USO service at the required standard to a target population, in terms of the cost of service delivery, including related administrative, and enforcement costs.

Having determined how best to establish the price of USO service provision, the question that remains is how best to fund it. It would seem reasonable for funding to be approached in the same way as for any other public good, particularly given its largely redistributive purpose, and fund the USO out of general taxation, preferably drawing on a broad base and low-rate tax system that minimizes distortions and the costs of financing. The funds raised could then be paid either to the service provider directly, or to the target populations to enable them to buy services from the provider – or a mixture of both. There may also be some user co-payments to ensure efficient use.

In reality, the problem, however, has been the way the USO funded which is a budget and regulation issue. In early regulated telecommunication business between 1990 and 2010, the common approach was for government or regulatory bodies to collect a percentage of the gross revenues of telecommunication operators to cover the expense of USO implementation. It is not clear why this is the best tax base. A second major problem with most of these early funding approaches has been the funds, which, although collected, have not been disbursed in many countries.

¹¹⁸ Paul Milgrom delivered the Nobel Lecture in Stockholm, in December, 1996, in which he provided an overview of the application of auctions to universal service. See Milgrom (1996) and Weller (1999).

Recommendation 6: Funding for USO should ideally be provided from general taxation; where industry levies are applied, it should be spread across a wide range of contributors benefitting from the availability of networks.

Recommendation 7: Auction mechanisms should be used for the allocation of available funding for USO subsidies aimed at stimulating competition among several subsidized carriers, with due care being given to minimizing the extent such auctions are vulnerable to collusion.

4.5.2 Application and Content Markets

In total, applications and contents streamed as audio visual in downstream retail consumer markets – including software, databases, computer games, books, press, music, radio; video, motion picture, television; visual photography, and graphic arts – already now make up between 7 and 8% of GDP in developed countries, and provide equivalent numbers of employment. The latest Internet trends in Asia-Pacific, Africa, and the Middle East also indicate the growing importance of ICT applications and contents.

The latest data on Internet trends in North America and Latin America suggest that in future, most countries will see a growing importance of consumer retail markets for applications and contents. In North America, real-time entertainment (comprised of streaming video and audio) is now responsible for over 71% of downstream bytes during peak period – a modest increase over the 70% in 2015.¹¹⁹ As streaming audio and video adoption continues to expand, and emerging video technologies such as 4K resolution, high-dynamic-range (HDR) video, and virtual reality increase in adoption, it is expected that North America will be the first region to surpass the 80% of downstream traffic streaming threshold by the end of 2020.¹²⁰

On the source of this traffic, the data suggests:

¹¹⁹ Sandvine (2006) p. 1.

¹²⁰ *ibid*, p. 1.

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- Even with these improvements in video streaming efficiency, Netflix represented 35.2% of traffic on North American fixed networks, a modest decline from the 37.1% of traffic it represented six months ago. Netflix's traffic share on fixed networks in Latin America by comparison increased from 6.6% to 8.3%. Amazon Video is now the third ranked downstream application (up from eighth a year ago) in North America, accounting for 4.3% of fixed traffic. Sling TV now appears among the top twenty applications on most US networks, but still accounts for less than 1% of traffic.
- Cloud storage (Dropbox, iCloud, Google Drive, etc.) has surpassed filesharing as the largest source of upstream traffic during peak period on North American fixed access networks. BitTorrent now accounts for less than 5% of total daily traffic in the region.
- The addition of video and voice calling is driving growth in communication apps on mobile networks in both Latin America and North America. In Latin America, WhatsApp traffic share is now 7.4% – more than triple what it was two years ago.
- In Latin America, Facebook and Google account for over 70% of total mobile traffic in the region – up from 60% reported last year.
- Over 60% of mobile traffic in both Latin America and North America is now encrypted and Sandvine predicts some networks will surpass 80% this year.

The latest Internet trends in Asia-Pacific, Africa, and the Middle East also indicate the growing importance of ICT applications and contents. Thus, in 2016:

- Video on mobile networks in Africa has more than doubled in one year, increasing from 8.6% to 18.1%.
- YouTube continues to top the mobile application in both Asia-Pacific and the Middle East, with Sandvine predicting the rapid growth of video in Africa will make it the top application in Africa within the next eighteen months.
- Filesharing still accounted for almost 30% of total traffic on fixed networks in Asia-Pacific, although it did experience a small decline from the figures observed last year. Last year, Sandvine predicted that filesharing traffic share had peaked in the region.

- Facebook properties (Facebook, Instagram, and WhatsApp) continue to account for almost a quarter of all traffic on mobile networks in the Middle East.
- WAP browsing, typically associated with feature phone use, has seen its traffic share cut in half in Africa over the past two years. This is indicative of increasing smartphone adoption in the region

Intellectual Property Rights

Application and content markets depend critically on government policy and regulation, in particular intellectual property law and policy. The main value created by application and content businesses discussed above derives from investment in intangible capital, or intellectual property that is generated by innovation, creativity and inventiveness. The main way in which such investment in intangible capital is protected is through the intellectual property law, including copyright, design, patent and trademark law, that create different types of intellectual property rights (IPR).

IPR act as the key enabler of innovation, creativity and inventiveness. This is because of two key underlying economic characteristics of innovation, creativity and inventiveness:

- First, innovation, creativity and inventiveness require creation costs. These are the costs to creating any new work. As Demsetz notes, standard economic theory does not contemplate creative activity: “standard economic theory does not allow for two classes of goods, newly created and already existing. All goods are presumed to already exist in these models”.¹²¹
- Second, the outcomes of innovation, creativity and inventiveness are easy to copy and appropriate, yet, difficult and costly to protect. As Demsetz observed, economic theory “deals only with production of an existing, known good . . . [t]his denies opportunities to engage in the sort of free-riding . . . which is based on the ability of a copier to avoid the cost of creating the new work”.¹²²

¹²¹ Harold Demsetz, 2009, p. 9.

¹²² Harold Demsetz, 2009, p. 8.

This creates the problem of free-riding. The free-rider lets others incur the risks and costs of innovation, creativity and inventiveness, and simply imitates and appropriates their successful practices. Free-riders can then undercut the innovators', creators' or inventors' price to market, and thereby prevent them from earning a return on their investment in innovation. This will lead to suboptimal levels of innovation, creativity and inventiveness, as innovators, creators or inventors are not rewarded for their contributions.

IPR serve to reduce free-riding. IPR are thus critical to ensuring sustainable development or ensuring the well-being of those in the future is not compromised by free-riding on innovation, creativity and inventiveness in the present. The value of investment in intangible capital associated with innovation, creativity and inventiveness protected by IPR is ever increasing, accounting for the largest portion of business investment and a key contributor to growth in advanced economies.¹²³ Copyright law is, in turn, the most important IPR in terms of the value of creative and inventive investment, and output it protects – including applications and contents. The World Intellectual Property Office (WIPO) has developed a methodology that identifies eight groups of core creative industries protected by copyright, according to product or service including 1) software, databases, and computer games; 2) press and literature; 3) music, theatrical productions, operas; 4) motion picture and video; 5) radio and television; 6) photography; 7) visual and graphic arts; 8) advertising services.¹²⁴ In total, these industries make up between 7 and 8% of GDP and provide an equivalent percentage of total employment. This role only seems likely to increase for two main reasons: First, if as seems likely, more economies of the world progress from lower to middle income, and poverty worldwide continues to decline, demand for creative and innovative output will increase. In addition, to the extent ICTs displace the demand for unskilled work, creative industries will be offering more jobs, and becoming more important to ensuring sustainable development that benefits all.

¹²³ OECD (2013a), p. 12.

¹²⁴ WIPO Guide, para 123, pp. 49–50.

There tends to be an assumption that developments in digital technologies and the spread of the Internet over the past twenty to twenty-five years have facilitated a dramatic increase in fortunes for the innovative and creative sector. This hypothesis is based on the assumption that digitization and the spread of the Internet have reduced the costs of creating and distributing creative works that are protected by copyright. A key problem, however, is that ICTs are also having negative, as well as positive effects on creative industries. Greater access to ICTs, digitization of creative works and the spread of the Internet have enabled greater unauthorized appropriation or piracy of copyright works. The question, then, is whether the predicted positive effects of ICTs have been offset by the negative effects of greater unauthorized appropriation of copyrighted works that are also enabled by digitization and the spread of the Internet.

Recent empirical research¹²⁵ suggests that, even if digitization and the spread of the Internet have reduced the costs of creating and distributing creative works protected by copyright, these positive effects have been offset by the negative effects of greater unauthorized appropriation of copyright works that is enabled by digitization and the spread of the internet. This supports the need to move to stronger copyright to restore copyright protection and deter unauthorized appropriation, and limit market bypass. This would enhance the extent of market transactions in copyright-protected works along with the total reward and incentive for creativity, stem the loss of economic value, employment and investment to the benefit of the wider community in the future.

Privacy Law and Policy

Privacy concerns are increasingly important in the online world. Users of online services clearly place value on their information being kept private and safe¹²⁶, and view use of their personal data without explicit consent, adequate safeguards and compensation as a form of coerced exchange. Consumer access to applications and contents online, however, is often subsidized in so-called two-sided markets, where

¹²⁵ Barker G. R. (2017a) and (2017b).

¹²⁶ Horrigan, J. (2008).

third-party advertisers pay for consumers' access, in return for use of consumer data, and placement of advertising. This poses significant issues relating to privacy, or control and ownership of personal data and potential abuse of market power in information markets. Internet intermediary firms are using information about firms and individuals:

- “sell” online services to users, such as search, and simultaneously;
- sell advertising services to third parties based on individual users' revealed behaviour.

This is a form of bundling. Users may want to use services to search for information - but not simultaneously “advertise” their interest.

The widespread and increasing use of cloud computing also raises a number of privacy and security questions. At the beginning of the millennium people stored data on private fixed hard drives located in offices and homes, and used portable private discs and then memory sticks when mobile. Now companies, individuals and governments are all increasingly turning to cloud computing. Cloud computing refers to the ability to access and manipulate information stored on remote servers, using any Internet-enabled platform, including smartphones. Originally used for applications like emails, computing facilities and applications are increasingly being delivered as a service, over the Internet. The three cloud service delivery models are: application/software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS).¹²⁷

As early as September 2008, a Pew survey¹²⁸ showed that 69% of Americans had stored data online or using a web-based software application involving six forms of common cloud computing, at least once.¹²⁹ Users of the six cloud computing services further reported high

¹²⁷ ITU-T Technology Watch Report (2009).

¹²⁸ Horrigan, J. (2008) based on a survey of 2,251 adults between April 8, 2008 and May 11, 2008. Some 1,553 respondents in the survey were internet users and the margin of error is plus or minus 3 percentage points for results based on internet users.

¹²⁹ The six activities and percentage usage included 1) use of webmail services, 56% e.g., Hotmail, Gmail or Yahoo!; (2) storing personal photos online, 34% e.g.,

levels of concern when presented with scenarios in which companies may put their data to uses of which they may not be aware.

- 90% of cloud application users said they would be very concerned if the company at which their data were stored sold it to another party.
- 80% said they would be very concerned if companies used their photos or other data in marketing campaigns.
- 68% of users of at least one of the six cloud applications said they would be very concerned if companies who provided these services analyzed their information and then displayed ads to them based on their actions.

Data in the cloud is easier to manipulate, but also easier to lose control of. Without knowledge of the physical location of the server or how the processing of personal data is configured, end-users consume cloud services without any information about the processes involved. Can cloud providers be trusted? Are cloud servers reliable enough? What happens if data gets lost? What about privacy and lock-in? Will switching to another cloud be difficult?

It is generally accepted that due consideration of privacy issues promotes user confidence in the online world and can contribute to sustainable economic development. Indeed, privacy is enshrined in Article 12 of the Universal Declaration of Human Rights which states that: “No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks.”¹³⁰ A number of basic privacy principles are further common in various countries’ legislation on the matter and enjoy wide consensus. The Madrid Resolution¹³¹, for example, was approved by data protection authorities from fifty

Flickr; (3) using online applications, 29% e.g., Google Documents and Adobe Photoshop express; (4) Storing personal videos online, 7% e.g., YouTube; (5) Paying for store computer files on line, 5%; (6) Backing up hard drive to an online site, 5%.

¹³⁰ <http://www.un.org/en/universal-declaration-human-rights/index.html>.

¹³¹ Madrid Resolution (2009).

countries, gathered in Madrid in 2009 within the framework of the 31st International Conference of Data Protection and Privacy. Its purpose was to define a set of principles¹³² and rights guaranteeing the effective and internationally uniform protection of privacy with regard to the processing of personal data, and to facilitate the international flows of personal data inherent in a globalized world. Privacy principles are also to be found in other organizations and countries.¹³³ In Europe, the Charter of Fundamental Rights of the European Union (2000) became legally binding in European Union as part of the Lisbon Treaty (in force since December 2009). The main legal instruments in Europe covering privacy and the processing of personal data are the EU Directive 95/46/EC, and e-privacy and electronic communications Directive 2002/58/EC covering also data retention.¹³⁴ The US does not have an overarching governmental regulation but follows a sectoral approach, while countries in the developing world (e.g. on the African continent, India and China) have introduced, or are currently planning, privacy and data protection laws.

In general, promoting sustainable development requires not only access but also confidence in the online world. This requires users' consent to use of their personal data online, and that adequate mechanisms exist to ensure that their data is protected and kept safe. The global differences in privacy legislation may, however, become a trade barrier and prevent innovation. Adoption of privacy enhancing technologies (PETs)¹³⁵ to

¹³² The basic principles identified in the Madrid Resolution for the use of personal data include those of lawfulness and fairness, proportionality, purpose specification, data quality, openness and accountability see Madrid Resolution (2009).

¹³³ Some examples of other privacy principles: OECD (Privacy Principles 1980), Generally Accepted Privacy Principles (GAPP) from AICPA, FTC Fair Information Practice Principles (FIPPs) (United States Privacy Act of 1974), Consumer Privacy Protection Principles (CPPPS), Asia-Pacific Economic Cooperation (APEC) Privacy Framework - Information Privacy Principles (2005) and International Security, Trust & Privacy Alliance (ISTPA) Privacy Principles.

¹³⁴ 27 Member States have implemented the 1995 EU Directive

¹³⁵ In general PETs are viewed as technologies that: a) Reduce the risk of contravening privacy principles and legislation. b) Minimize the amount of data

support the secure processing of personal data in the cloud will increasingly depend upon government policy, including the existence of uniform ways of handling personal data at international level and on technical standards which can help demonstrate compliance with legal and regulatory frameworks.

4.6 Non-ICT Markets Policy

As noted, nine of the UN's SDGs relate to specific key needs of people, and relevant goods and services that fall into three categories:

- Basic needs, including goods and services such as food (SDG 2), water (SDG 6), energy (SDG 7) and cities and settlements (SDG 11);
- Fundamental human capital or human services needs including health (SDG 3) and education (SDG 4);
- Fundamental environmental needs or goods and services including climate (SDG 13), oceans and seas (SDG 14) and terrestrial ecosystems (SDG 15).

These nine UN SDG's in turn relate to three corresponding key non-ICTs markets, including (i) markets for basic goods and services (food, water, energy, cities and settlements); (ii) markets for human services (health and education); and (iii) markets for environmental goods and services (terrestrial, marine and atmospheric).

We shall examine how government policy directly regulating these three sets of non-ICT markets can affect the demand for ICTs, enabling or limiting the opportunities for ICTs to contribute to sustainable development. In particular, we shall explore the detrimental effects of the fact that regulation of non-ICT markets has been designed for the pre-Internet era, and remains frozen in time, thereby indirectly preventing the development of "smart non-ICT markets" including smart agriculture and food markets, smart water markets, smart energy markets, smart cities, smart transport, smart health, smart education, smart manufacturing and smart eco-systems.

held about individuals. c) Allow individuals to retain control of information about themselves at all times. See ITU-T Technology Watch Report (March 2012) p. 4.

ICT innovation enables a variety of new services, deployed through various ICT-enabled applications including big data analytics (Davenport and Kudybe, 2016), the Internet of Things (IoT), ubiquitous computing, artificial intelligence (AI), and robotics expected to occur by 2025. As outlined below, governments urgently need to review and adapt regulation of non-ICT markets to ensure they are not standing in the way of these developments, but are better suited to the Internet era, and thereby better enable the role of ICTs in sustainable development.

4.6.1 Basic Goods and Services Markets

Sustainable Food (SDG 2)

UN SDG 2 aims to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”. The challenge here is that demand for agricultural crops is expected to double as the world’s population reaches 9.1 billion by 2050. Increasing the quantity and quality of food in response to growing demand will require increased agricultural productivity. ICT-enabled applications permit more sustainable food production and distribution by enabling better production efficiency and product quality, through computer-controlled production and ICT-based quality inspecting sensor systems enabling laboratory quality inspection and testing. Regulation of food markets, however, may currently be preventing these developments and needs urgent review to exploit the opportunities for food productivity growth posed by ICTs.

The potential role of ICT-enabled systems in enhancing productive and allocative efficiency and sustainable development in food is well documented and demonstrates only a special case of ICTs’ economy-wide productivity effects. Since the 1960s, the Hazard Analysis and Critical Control Points (HACCP) system has been recognized internationally as a logical tool for adapting traditional inspection methods to a modern, science-based, food safety system.¹³⁶ ICT-

¹³⁶ HACCP was conceived in the 1960s when the US National Aeronautics and Space Administration (NASA) asked Pillsbury to design and manufacture the first foods for space flights. HACCP is however believed to have originated for production process monitoring during World War II because traditional “end of the pipe”

enabled HACCP systems can support safe food production practices and enhance food quality at lower cost, thereby increasing the supply of food to meet basic needs, while enabling businesses to better meet demands of a growing number of consumers, including health-conscious buyers interested, for example, in organic food and agricultural products. Web-based ICT devices and programs can be used to identify low cost and/or health promoting food, and provide supply chain transparency or visibility of how food is produced and promote confidence and trust.

ICT-enabled systems also enable accountability, and compliance with governmental food standards, regulations and codes, that impose requirements for foods such as additives, food safety, nutrition contents, labelling and genetically modified (GM) foods. The United Nations Food and Agricultural Organization (FAO) uses Good Agricultural Practices (GAP) as a set of principles to apply for on-farm production and post-production processes, to ensure safe and healthy food and non-food agricultural products that are economically, socially and environmentally sustainable. ICTs can be applied to facilitate GAP implementation, quality assurance and supply-chain integrity. This would create new market opportunities for farmers and exporters in developing countries, enhance the productivity of farmers in the supply chain, train farmers in sustainable practices and help to eradicate poverty. Improvements in producing economic food and cocoa tree crop varieties, for example, has enabled several hundred million people living in rural Africa to earn a living. (Chakravorti, 2015)

Sustainable Water (SDG 6)

SDG 6 seeks to “Ensure availability and sustainable management of water and sanitation for all”. Sanitation is the means of promoting hygiene through the prevention of human contact with hazardous waste (especially faeces), by proper treatment and disposal of such materials,

testing on artillery shell's firing mechanisms could not be performed, and a large percentage of the artillery shells made at the time were either duds or misfiring. The seven HACCP principles are included in the international standard ISO 22000 FSMS 2011.

often mixed into wastewater. Wastewater management, thus, has implications for water scarcity. Water scarcity is the lack of sufficient water resources to meet needs within a particular region. It affects every continent and around 2.8 billion people around the world at least one month out of every year. More than 1.2 billion people lack access to clean drinking water. Water scarcity can arise from inadequate natural water resources to supply a region's demand, but can also be exacerbated by poor management of available resources.

ICT-enabled applications provide opportunities for more sustainable water systems. Once again, poor regulation of water markets may currently be preventing these developments and need urgent review to exploit the opportunities for sustainable water posed by ICTs. ICT-enabled systems, for example, can better ensure production efficiency and product quality, with computer-controlled production and ICT-based quality inspecting sensor systems enabling laboratory quality inspection and testing.

Focusing on water quality, standards are determined by the intended use, be it human consumption, industrial use, or in the environment.¹³⁷ A number of water quality initiatives now apply HACCP principles and steps to control the spread of infectious water-borne disease, and HACCP provided the basis for the water safety plan (WSP) approach in the third edition of the World Health Organization (WHO) report.¹³⁸

Although water quality is usually sampled and analyzed at laboratories, nowadays, citizens demand real-time information about the water they are drinking. ICT-enabled systems can provide this via real-time remote monitoring systems for measuring water-quality worldwide (including pH, turbidity or dissolved oxygen levels).

Demand for such developments, however, is hindered by problems in the regulatory framework surrounding water globally. In particular, property rights in water and tradable markets in water rights have not

¹³⁷ The use of HACCP for water quality management was first proposed nearly 20 years ago. See Havelaar, A.H. (1994).

¹³⁸ "Guideline for Drinking-Quality Water" World Health Organization (WHO). 2004. http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf

been developed. This is undermining the scope for pricing water to reflect scarcity and quality, enabling more efficient use of water, and providing signals and incentives for more efficient investment, including investment in ICT-enabled water management.

Sustainable Energy (SDG 7)

SDG 7 seeks to “Ensure access to affordable, reliable, sustainable and modern energy for all”. ICT-enabled applications provide opportunities for more sustainable energy systems. ICT-enabled energy systems can ensure better investment and use of scarce energy resources. Computer controlled production and ICT-based monitoring systems enable improved allocative and productive efficiency, and reliability. Beyond the obvious supply-side engineering or systems management benefits of an ICT-based “smart grid”, ICTs can also ensure more efficient demand-side management through real-time pricing.

On the supply-side, ICT-based wholesale electricity markets have been developed worldwide from the late 1980s to enable real-time and “nodal pricing”, so that prices paid to suppliers of energy vary by time of day and region or geographic “node” based on real-time auctions that ensure prices reflected relative scarcity. Using ICT-enabled networks these “smart energy markets” sent better price signals by time period, and node to less efficient generators to reduce production and even shut down, and to more efficient generators to expand production, and further to investors on where and when to invest in new generation capacity. Any externalities including environmental costs of particular forms of energy generation and distribution have also been factored into ICT-enabled energy market prices – either through direct carbon-emission-related taxes, or through carbon emissions prices set in related “input” markets for tradable rights in carbon emissions, with total carbon emissions limited to meet regional and/or global caps.

ICT-based real-time energy pricing also encourages better demand-side management and conservation of energy by sending signals to energy retailers as to peak periods and bottleneck locations, alerting them to possible demand-shifting behaviours. More recently ICT-enabled applications have also led to “smart meters” located in households and businesses that encourage consumers to shift their usage from peak to

off-peak periods, and from high-cost supply to lower cost sources of supply - expanding the total system capacity with no further investment, just more efficient demand-side management.

A key issue with ICT infrastructure itself, and its growing ubiquity and use, however, is the additional demand for energy use that ICTs *per se* generate. This can lead to pressure on the power grid, and demand for greater investment in energy systems. This, of course, is addressed in part by the “smart energy systems” that ICTs enable outlined above, including energy pricing that factors in all costs. There are also many examples of innovative ways to develop ICT services that have lower energy-intensity, and which can be combined with low cost, and distributed or local alternative energy generation.

Sustainable Cities and Settlements (SDG 11)

SDG 11 seeks to “Make cities and human settlements inclusive, safe, resilient and sustainable”. The greatest change in human settlements over the past 200 years has been the growth of cities or urban areas. At the turn of the 20th century, just 15% of the world population lived in cities¹³⁹ increased to 30% by 1950, 54% by 2014, and is projected to reach 66% by 2050.¹⁴⁰ The urban population, thus, grew globally by more than five times from around 700,000 in 1950 to close to 3.9 billion in 2014, and is expected to grow by a further 2.4 billion to reach 6.3 billion by 2050, with nearly 90% of the increase concentrated in Asia and Africa.¹⁴¹

Table 3 presents data on urban population worldwide in total, and in percentages by size of city, together with the changing numbers of cities by size class. Growth in city populations occurs not just by growth of existing cities but also through the creation of whole new cities. Thus, as shown in the last column of Table 3, by 2030 the number of urban agglomerations larger than 300,000 is projected to increase across all

¹³⁹ Annez, P. C. and Buckley, R. M. (2009)

¹⁴⁰ UN 2014 (c) *World Urbanization Prospects*, p. 1.
<https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf>.

¹⁴¹ *ibid*, p. 1.

city sizes by over 30% on average, with around 530 more cities. As shown in the last three rows of Table 3, small urban settlements with fewer than 500,000 inhabitants in 2014 constituted over half of the world's urban population (around 2.3 billion of 3.9 billion total) but the share of the urban population living in these small cities is expected to fall by 2030 to around 45%, with larger cities expected to grow their share. By 2030 smaller scale cities of 500,000 to 1 million inhabitants are expected to grow in number by approximately 20, and host almost 150 million more people than in 2014, and incorporate around 10% of the world's urban population.¹⁴² Medium-sized cities of 1 to 5 million are projected to grow by a further 34% by 2030, or 141 reaching at total of 558 cities, hosting 1.1 billion people worldwide - or nearly a quarter of the world's urban population. The next size class of cities of 5 million to 10 million are projected to grow by 47% to 63 by 2030. Finally the number of megacities with 10 million or more inhabitants has also increased significantly: it tripled from three in 1970 to 10 in 1990, and tripled again to 28 in 2014. By 2030, this number is projected to reach 41 and to house 730 million people, representing one in seven (around 14 per cent) of the world's urban population.

These global developments pose major challenges. Rapid urban growth threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to ensure that the benefits of city life are equitably shared. An estimated 863 million people, representing nearly one third of urban residents in developing regions, lived in slums or informal settlements in 2012, characterized by housing that is non-durable or overcrowded, or that lacks access to improved water and sanitation or security against eviction (United Nations, 2014b).

Today's cities are further growing twice as fast in terms of land area as they are in terms of population (Angel et al., 2011). Consequently, projections indicate that future trends in urbanization could produce a near tripling in the global urban land area between 2000 and 2030 (Angel et al., 2011; Seto et al., 2012). Owing in part to their higher

¹⁴² *ibid.*, p. 79.

Table 3. Population distribution and number of urban agglomerations of the world by size class of urban settlement, 1970, 1990, 2014 and 2030

Area of residence and size class of urban settlement (number of inhabitants)	Population (millions)				Percentage distribution				Number of urban agglomerations			
	1970	1990	2014	2030	1970	1990	2014	2030	1970	1990	2014	2030
Total	3,691	5,321	7,244	8,425	100	100	100	100				
Rural area	2,341	3,036	3,364	3,367	63.4	57.1	46.4	40.0				
Urban area	1,350	2,285	3,880	5,058	36.6	42.9	53.6	60.0				
10 million or more	55	153	453	730	1.5	2.9	6.3	8.7	3	10	28	41
5 million to 10 million	106	157	301	434	2.9	3.0	4.1	5.2	15	21	43	63
1 million to 5 million	245	459	827	1,128	6.6	8.6	11.4	13.4	126	239	417	558
500,000 to 1 million	129	202	363	509	3.5	3.8	5.0	6.0	186	294	525	731
300,000 to 500,000	87	157	258	319	2.4	3.0	3.6	3.8	227	412	679	832
Fewer than 300,000	729	1,156	1,678	1,938	19.7	21.7	23.2	23.0				

incomes, urban dwellers tend to consume more per capita than rural dwellers. Today's cities consume more than two-thirds of the world's energy and account for more than 70% of global greenhouse gas emissions (UN-Habitat, 2011; IEA, 2008).

In the short run, given the rapid growth of cities, a key problem with current infrastructure is the cost of network congestion, and the lack of investment. According to a 2016 World Bank study, if one takes roads for example, many cities in developing countries are stuck in an “underfunding trap” for urban transport.¹⁴³ In these cities, the up-front investments that are needed for new transport infrastructure are huge, while revenue from their still small-scale and perhaps even poor-quality systems and other sources is insufficient to cover maintenance and operation expenses, let alone new investment projects. This problem of increasing urban transport congestion is global. In the US for example where we have better data, from 1982 to 2014, there has been a 233% increase in urban area congestion, measured as increases in the total hours of delay for each auto commuter.¹⁴⁴ Thus according to Texas AM Transportation Institute 2015 Urban Mobility Scorecard, in the US in 2015, travel delays due to traffic congestion kept travellers stuck in their cars forty-two hours per rush-hour commuter – up from eighteen hours in 1982 – or nearly 7 billion extra hours, at a cost of \$960 per commuter per annum, and caused drivers to waste more than 3 billion gallons of fuel involving a significant environmental cost. The total nationwide price tag in the US was estimated at \$160 billion.¹⁴⁵

As the UN notes, “with good planning and governance, the increasing concentration of people in urban settlements can facilitate economic and social development, while also offering opportunities to mitigate the adverse impact of consumption and production on the environment. However, rapid and unplanned urban growth threatens sustainable development when the necessary infrastructure is not developed or

¹⁴³ Ardila-Gomez, A. and A. Ortegon-Sanchez (2016), p. xiv.

¹⁴⁴ Schrank, et al. (2015), p. 1, DeGood and Madowitz (2014), p. 12.

¹⁴⁵ Schrank, et al. (2015), p. 1.

when policies are not implemented to protect the environment and ensure that the benefits of city life are equitably shared.”¹⁴⁶

ICT-enabled applications permit more sustainable cities and settlements that can better meet the above challenges. The “big” opportunity in cities and human settlements is to exploit ICT developments across utility or network industries, including energy, water, transport, etc. We have already elaborated the potential role of ICTs in assisting with “smarter” food, energy, water and waste management systems that are available to any city or human settlement. ICT-enabled systems also, however, offer cities and settlements advantages from computer monitoring and management of other key urban services or amenities, including transport, housing, public safety, education, health, retail services, parks, recreation and entertainment

An essential asset of a utility, for example, typically is the right of way it uses. Indeed, one can analytically conceive of all utilities as essentially involving transport of goods, services or people across fixed-cost rights of way – including transport of passengers, possessions, water, electricity, gas, signals, etc. Many utilities in fact share these rights of way over, under and on top of roads, but this could be done better to lower both investment and management costs. The government plays a critical role in the creation of these rights of way through its so-called “*eminent domain*” powers that enable the acquisition of property for a public purpose. It is important that *eminent domain* powers are used wisely, and that market compensation is paid to current owners of any rights “taken” or acquired, so as to safeguard underlying property rights. At the same time, government will inevitably need to make judgements about the design and use of any rights of way to ensure they make best use of the assets acquired. In this regard, the use of ICTs on all “rights of way” or “shared infrastructure platforms” to make them “smarter” offers considerable potential over the next ten years for better outcomes in cities. Already, the necessary systems and the data they collect are available. Some of it in private hands, with outsourcing and privatization likely to continue. Access to, and use of private data,

¹⁴⁶ *ibid*, p. 1.

however, are major issues to be grappled with, as discussed earlier in the section on privacy, including use of private data in enforcement

In what follows, we shall focus on recent developments in intelligent or “smart transportation” solutions across the various “modes” (road, rail and air) that provide an answer to the growing problem of congestion and underinvestment and, more generally, the basis for more efficient and “smart” cities. The core ICT-based opportunities we explore for transport systems are similarly available to other networks and are at least twofold, namely, better coordinated investment and better management of underlying scarce assets. Focusing on road, rail and air transport of passengers and goods to illustrate the opportunity, however – key ICT-enabled changes include:

- Increased power of the individual to capture and use information: Social media are altering how we think about service information asymmetries. The circumstances in which government has a useful role in dealing with such asymmetries is changing.
- Greater economies, and reduced investment requirements through sharing of excess capacity in existing private capital invested in transport (e.g., Uber).
- The development and uptake of automated vehicles or drones, on land, and in air and maritime applications; offering more efficient, safer and more inclusive systems for certain groups of users, e.g., persons with disabilities.
- Greater convergence, interconnectedness and intermodal competition can be foreseen. Changing boundaries between different transport “modes”, for example, is increasing competition between modes. For example, drones may become intermodal, (or be able to travel by land, air and sea), and be used to pick and deliver goods, and perhaps move them from point to point by land, air, and sea.
- Increased unbundling of services, e.g., information from service vehicles from infrastructure. Users can potentially access service on demand, design their own bundles, and switch back and forth between being users and providers. The same is happening in other sectors, especially media.

The above developments have implications not just for how we regulate the use of existing transport services but also for the regulation of transport rights of way or infrastructure across multiple utilities. The rise of “big data” and “big data analytics” is obviously front and centre for utility regulation and management, and widespread digitization has obviously made possible real-time accumulation of very finely grained and precise micro-data. Most utilities are by their nature composed of many individual transactions that are now amenable to direct physical measurement and can typically be monetized as well. This is probably the major ICT-driven innovation available to regulators. Government investment in, and use of ICTs to enable electronic pricing based on underlying transaction data, for example, in real time, on all utilities or networks, would enable better signals to guide infrastructure utilization, and investment decisions and alleviate congestion. There are large social costs from infrastructure not being priced properly. On the one hand, of course, if prices are too low there is the risk of over-use and congestion, while on the other hand, if the price of use is too high you have the risk of under-utilization. At the same time, prices that better reflect use and relative scarcities, can provide better signals for investment.

The problem is that current government policy is hindering innovative ICT-based developments. Focusing, for example, on transport infrastructure, current policy on financing arrangements designed for the pre-Internet era poses significant barriers to better ICT-based sustainable development. Currently the financing of transport is predominantly based on tax-funded infrastructure (using general income or sales tax, or petrol tax), together with state ownership and control of key assets. By comparison, a recent World Bank review of sustainable urban transport financing, however, concludes that instruments that charge the direct beneficiaries of urban transport investments, such as passengers or drivers, are most likely to efficiently achieve sustainable transport goals.¹⁴⁷ The current general tax, or petrol-tax based financing arrangements will increasingly fail on a number of fronts compared to

¹⁴⁷ Ardila-Gomez, A. and A. Ortegon-Sanchez (2016), p. xiv. See also DeGood and Madowitz (2014).

infrastructure that is funded using more explicit pricing systems that charge the direct beneficiaries of transport systems, and that are now becoming possible with new ICTs, including location-based (GPS) time of use pricing, paid for by using e-finance methods.

For example, while a petrol tax is related to road use, and paid by direct beneficiaries of transport systems, and has therefore been widely adopted as a better mechanism for funding road development than more blunt taxes like general income or sales taxes, it is still a blunt instrument. The petrol tax paid and collected does not vary sufficiently according to congestion. No doubt large commercial transport companies use the amount of petrol they can save for planning routes and monitoring performance, but the tax on top of the petrol price is a blunt signal even to them. Moreover, advances in fuel efficiency also mean the tax paid may fall, even though road development and usage costs are rising. In the US, for example, for more than five decades, gas tax revenues paid to the Highway Trust Fund (HTF) have been used to fund required highway and transit programs.¹⁴⁸ However, dramatic improvements in vehicle fuel efficiency have significantly reduced the amount of revenue owing into the fund. By 2025 increased fuel efficiency in the US is expected to double, cutting gas tax revenues in half and decimating the HTF in the process.¹⁴⁹

By comparison, pricing of transport services using new ICTs and e-payment methods involving advanced technologies in camera tag recognition, smart phones, automated billing and collection and a vast informatics network to process everything allows for more creative design of pricing methods that can better incentivize efficient use. Thus,

¹⁴⁸ DeGood and Madowitz (2014), p. 6. The Highway Trust Fund, or HTF, is capitalized by fuel taxes, a tire tax, a heavy vehicle use tax, and a fee on truck and trailer sales. Approximately 68 percent of HTF revenues come from the tax on gasoline and 25 percent from diesel. For purposes of simplicity, we refer to the “gas tax” as a shorthand for all of the various taxes that capitalize the fund.

¹⁴⁹ *ibid* (2014), p. 6.

states like Oregon¹⁵⁰, California¹⁵¹ and Washington in the US are leading the way as regards to electronic road pricing technologies. Optimal congestion pricing in the short run would reduce the congestion problems outlined above and internalize the external costs that additional network users are imposing on current network users, but also provide better price signals as to where more investment is justified by the benefits. Broad-based pricing across networks would also enable inter-modal competition by better revealing relative prices to users travelling on different modes. ICT-based pricing not only provides more efficient signals, and better incentives for investment, but can also better enable competitive entry, providing the basis for new investment of private capital in private infrastructure projects. It would also increase the ability to “unbundle” and “rebundle” individual services (e.g., pricing, vehicle, and infrastructure services) to optimize both user outcomes, administrative economy, and fiscal efficiency. Road pricing is further considered an equitable measure, especially in developing countries where private car users generally belong to higher-income populations. The measure might be progressive if the revenue collected from the charge is earmarked for public transport investments (as is the case in London) or non-motorized infrastructure.¹⁵²

Having said that, pricing or collecting fees for use is itself costly, so the objective has to be to minimize the sum of congestion and transaction costs. In the old days, in transport, for example, to collect a price for a road service, drivers had to stop to drop money into a “drop-box”. This was and remains a costly means of collection, because of the time lost and the congestion it causes. Prior to the lower cost pricing

¹⁵⁰ Oregon is the only state in the US with an operational road charge program. In 2013 the Oregon Legislature approved the Road Usage Charge Program [OREGo](#), which became operational July 1, 2015.

¹⁵¹ The California Road Charge Pilot Program, a multi-year pilot that commenced in the summer of 2016, has now concluded and the California State Transportation Agency (CalSTA) will submit a final findings report to the Legislature, the California Transportation Commission, and the Road Charge Technical Advisory Committee in summer of 2017. See http://www.dot.ca.gov/road_charge/index.html.

¹⁵² Ardila-Gomez, A. and A. Ortegón-Sánchez (2016), p. 55.

opportunities created by ICTs, the high transaction costs of collecting tolls using drop boxes justified limited use of tolls on largely uncongested roads at the time. Today, road pricing makes greater sense as the transaction costs of road pricing are lower with the new electronic road pricing technologies – and congestion costs are also higher. Policy, however, has failed to evolve to make road pricing more widespread. This is despite the fact that congestion or peak-period pricing using ICT-based electronic “congestion pricing” could be used to relieve congestion by encouraging users to shift to lower priced/less congested travel times, or travel modes.

London’s Congestion Zone, a so-called Cordon Price that wraps around the central business district (CBD), would not be possible without ICTs. Compared to simple flat-rate tolls or charges, even more sophisticated pricing methods are now possible¹⁵³, including vehicle kilometres travelled (VKT) and weight/distance charging. Similarly, “dynamic pricing” could be used in express lanes, where prices rise as speed of traffic falls, so as to maintain a constant speed of traffic flow by encouraging slower traffic to switch lanes. Private network operators who own their network, do active yield management of their capacity. So, too, do some public operators, especially in rail.

New technology has clearly expanded the scope for better transport pricing, enhanced competition, and increased transport privatizations, both within and across modes, and one can readily point to early adopters of regulatory approaches permitting better pricing, more competition, and greater private sector involvement, including early expansion of private providers in transit (e.g., Hong Kong), in roads (e.g., Spain), and in airports (e.g., Australia). In each case, increased competition and private involvement has resulted in and driven improvements in project delivery and oversight, price setting and collection, and identification and harvesting of new revenue streams that benefit users, private companies and the general public alike. For example, toll and fare collection systems have become increasingly efficient, in the case of transit especially allowing for faster and faster

¹⁵³ NZ has a road user charge system for heavy vehicles that has been operational for over 30 years that can be readily applied to passenger and other light vehicles.

loading and unloading of passengers and hence speedier system flows. The ability to sell and harvest data and put it under a brand has made some of these services not just self-funding, but revenue centres for government entities in some case. The simple privilege of data collection is worth money to a private company. An analogy can be made with Amazon.com, which uses its vast database of transactions to present users with “you may like” options that cross-market other goods and services, sometimes from third parties. Facebook’s core asset is the private information of its users it has access to.

There are some obvious concerns, of course, with attempts to support more efficient use and investment in transport networks by using new technology to enable greater competition and private sector involvement in such networks (road, rail, sea and air). Public-Private-Partnerships (PPPs) and privatizations have not been without glitches, such as poorly designed pricing or political fallout from users disliking prices applied to previously “free” goods or paying higher tolls. Technology is also not necessarily inexpensive. London's Cordon Price, for example, consumes 40% of its revenue in administration, and standard e-tolled roads average between 10 and 20% of total revenues consumed in collection costs in the US. Privacy is also a major concern, both in the unintended use of information (e.g., through hacking or technical faults) or intended misuse (e.g., licensing of private information to a third party without prior consent). More sophisticated technologically intensive pricing requires careful choices about technical means and ends often not easily reversible, that need to interact with a rapidly changing transport service delivery environment. But ongoing delays in adoption of ICT-based pricing are also very costly. There is a large knowledge base to draw upon to minimize known problems and design of contracts between users, providers and government, which can be optimized to ensure that when problems do occur, there is a ready, flexible and efficient recourse and resolution.

Government generally needs to do more with sophisticated pricing as a way of internalizing the costs new users of a network impose on others in increasingly congested networks, including through distance travelled and weight charges levied on users that also reflect congestion. One of the problems preventing such transitions in the past, however,

may be that current collective choice mechanisms based on broad-based tax funding of transport networks, in effect redistributes wealth across users and other groups, subsidising some at the expense of others. The resulting outcome may thus be difficult to change politically, even though inefficient. It may be politically entrenched to the extent that the outcome benefits a politically strong special interest group or the median voter at the expense of the wider society. Technological change, however, that enables more sophisticated pricing, and more efficient transport networks may also enable politically feasible transitions from current less efficient transport market equilibrium to better ones. It seems likely to be able to compensate losers out of the gains from more efficient and sustainable pricing systems, and/or grandparent those resistant to change through a time limited transition.

4.6.2 Human Services Markets

Health and education markets remain two of the most poorly regulated of any non-ICT markets (barring environmental markets), undermining the adoption of ICT systems that could enable more sustainable development of human service markets globally.

Sustainable Health (SDG 3)

UN SDG 3 aims to “Ensure healthy lives and promote well-being for all at all ages”. The health industry accounts for 4 to 8% of GDP in most emerging markets. In many countries, however, chronic disease rates are rising in tandem with economic development, while infectious diseases remain prevalent in rural areas. ICT-enabled applications provide opportunities for more sustainable health systems. ICT-enabled systems, for example, can better ensure low-cost access to health services, greater efficiency and service quality. ICTs can be used to improve healthcare services considerably. This includes so-called e-health, or healthcare practice supported by electronic processes and communications, and m-health, an abbreviation for mobile health, a term used for the practice of medicine and public health supported by mobile devices. Once again, however, poor government policy on health-service markets may currently be preventing these developments and need urgent review to exploit the opportunities for sustainable

health offered by ICTs. The policy problems exist both on the demand side and the supply side.

On the demand side, part of this problem is due to consumer ignorance about how to prevent poor health outcomes, and/or treat them, which ICT markets might help to address by making information available. There are, however, other severe problems facing the demand side of health markets that require government intervention based on its taxation powers. The need for tax funding stems from the fact the demand for health services is derived from a demand for human capital development. Health consumption for an individual is often unanticipated and in many cases people would prefer full coverage of costs resulting from random shocks to their health. Contracts to either insure, or service a loan against shocks to health or human capital, however, are not easy transactions to negotiate in private markets, presenting a classic case of market failure. The reason is that, unlike physical capital such as houses, asset valuations and securities over human capital for purposes of insurance or loan contracts are difficult to obtain. Whereas banks and insurance houses can, with relative ease, write contracts against future benefit or income streams derived from houses or cars because of active secondary markets in these assets, the same is not true for human capital.

The central point here, however, is that the taxation powers at the disposal of governments provide them with a comparatively more efficient enforcement or funding mechanism for health loans and health insurance enforce premium payments, loan repayments, and pool risk. In the absence of tax-funded government interventions, many countries suffer from very poorly developed health systems. Even poor countries, however, with adequate ICT-enabled tax systems could move to contributory health accounts, accessible by consumers using health smart cards, funded out of small tax contributions they would make to insure their health risks over their life cycle. Such health accounts placed within the direct control of health consumers would serve to create the demand side for a market in health services, enable competition on the supply side, and strengthen demand for ICT-based health solutions.

Very often however, taxation funded health systems are poorly designed, serve the interests of service providers, and need reforms to empower consumers and increase competition in the supply side of health services. There are four basic models of health service delivery: those that rely on trust; on command and control; on voice; and on choice and competition. All have their merits and demerits; but there are both theoretical and empirical arguments for preferring choice and competition in many situations.¹⁵⁴ However, the relevant policies do have to be properly designed.

On the supply side, the critical problem around the world is the lack of competition on the supply side of health services markets. Health markets tend to be subject to heavy licensing and regulatory burdens that create barriers to entry, and state ownership and management of heavily subsidised resources, such as hospitals, operating as regional monopolies that crowd out competition from the private sector. Government-set budgets are also often centrally determined historically and bear little relationship to performance or activities.¹⁵⁵ This form of budgeting tends to “lock in” traditional methods of delivering services, and lock out better performing, new and more cost effective ones, including ICT-based e-health and m-health service delivery systems. Although, on occasion, such institutional arrangements can work successfully, in many other cases they do not. In fact, typically, such budgeting schemes provide low-quality care, are inefficient in their use of resources, lack dynamism and innovation, are unresponsive to the needs and wishes of patients, and do not provide incentives for adopting innovative ICT-based healthcare solutions that can fix such problems.

Together, these demand- and supply-side problems create weak incentives for the adoption of ICT-based solutions. As a result, healthcare in remote rural areas is normally insufficient or not available

¹⁵⁴ Le Grand, J. (2009). See also Gaynor M. et al (2013), on the benefits of competition in health, a recent study showing that an English government policy in 2006 promoting competition between hospitals “led to an increase in quality without a commensurate increase in expenditure” p. 135, or “that the effect of competition is to save lives without raising costs”, p. 134.

¹⁵⁵ Le Grand, J. (2009), p. 479.

at all – and of inferior quality for lack of medical equipment and physicians, especially medical specialists. Healthcare and medical consultancy through ICTs could, however, obviously be provided at low cost so that these services are accessible to rural people, immobile senior citizens and persons with disabilities by appropriate funding and suitable competitive incentives driving innovation. For example, most of the sophisticated medical equipment using 3D medical imaging technology has provided opportunities for developing new services, by applying broadband imaging of patients. This can be used in the diagnosis of remote patients or immobile patients due to ageing or disability. In addition, broadband communications empowered by computer and animation technology can provide opportunities for new ICT start-ups in both urban and rural areas.

A 360° One-Stop Service concept using network connections, for example, between the remote community hospitals and major city hospitals could enable remote community physicians to use ICTs to access centrally connected medical devices, such as X-rays, ECG and blood tests, to consult with medical specialists, diagnose patients and make appointments in case of repeated medical check-up or patient care delivery. Scarce pharmaceutical products could be requested, registered and ready for pick-up or airborne delivery by drone to the patient, if there were allied ICT-based reforms to transport networks. Such exploitation of economies of scale, and streamlined operational processes, would shorten the waiting time for an appointment with a medical specialist and provide better access for rural inhabitants and people living in mountainous areas or those relatively immobile due to age or disability creating a more inclusive society. The barriers to e-health and m-health (i.e., ICT-based) developments are the lack of funding for the ICTs and medical service fees required, and the lack of competitive incentives for medical specialists and physicians to consult with and diagnose patients online.

Recommendation 8: Government policy and health regulatory bodies should seek to reduce barriers to adoption of ICTs by enhancing ICT-based consumer controlled budgets, and promoting easier entry by ICT-based small and medium sized enterprises (SMEs) to compete with the incumbent health service providers.

Sustainable Education (SDG 4)

UN SDG 4 aims to “Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all”. ICT-enabled applications provide opportunities for more sustainable education systems. ICTs demonstrably offer enormous benefits in the education sector by lowering costs and extending access to knowledge. Broadband communications can be used to improve education, both traditional classroom type (formal) education and distance learning or online classroom from the very beginning, from pre-school to higher education. For example, broadband communications empowered by interactive computer and animation technology can provide opportunities for access to cutting-edge and specialist knowledge at low cost in poor and remote regions and facilitate new ICT start-ups in urban and rural areas.

Many developed countries, however, have a 30 to 50% difference between the number of people reached by digital networks (coverage) and the number actually online (penetration).¹⁵⁶ This gap jumps to 55 to 75%, and up to 90% in some cases in emerging markets. The gap is 63% in Brazil and 73% in Argentina. Adoption lags especially among women and certain disadvantaged groups, such as people in remote areas.¹⁵⁷

A key source of this divide is the failure of national education systems to deliver basic skills. The problem begins with low literacy rates that make the Internet irrelevant to many. More than a billion people in developing countries cannot read or write. This highlights the fundamental importance of early childhood, primary and secondary education. By adulthood, the primary reasons given by people for not using the Internet are a perceived lack of need and perceived lack of skills. This creates a potential virtuous circle, where improved education will improve ICT penetration within a country, and improved ICT penetration can improve education.

¹⁵⁶ WEF (2015), p. 4.

¹⁵⁷ Economic Commission for Latin America and the Caribbean (ECLAC) (2013).

In the absence of well-designed tax-funded government education, however, many countries suffer from very poorly developed education systems. Education is often not the first priority in developing countries, where water, public health services, and transportation rank as higher-demand goods. Public expenditures for schooling are therefore low, and provision of public education does occur in these countries. But much of the education occurs in the private sector. In Macau, 94% of primary students enrol in private schools. In Zimbabwe, approximately 88% of students at primary-level enrol in private schools. In Belize, it is 87%.¹⁵⁸ Unsurprisingly given the lack of public infrastructure in developing countries, the efficiency superiority for private schools is very robust. In multiple case studies, including China, Colombia, the Dominican Republic, India, and the Philippines, students in private schools performed at higher levels than those in public ones even after controlling for socioeconomic differences across students.¹⁵⁹ Importantly, these performance advantages in private schools also require fewer dollar expenditures per pupil. In order to further reduce their costs, private schools have the incentive to adopt ICT-based education solutions that offer greater cost effectiveness. The problem then is not a lack of performance of the privately dominated education sector in developing countries, but ultimately the lack of scale, or the limited extent of participation in education as a whole.

As with health, the rationale for tax funding of education stems from the fact that financing the demand for education in private markets is difficult. Due to a lack of collateral, it is not easy for the poor and uneducated to secure funds for education, even though it may enhance their future earnings and well-being. While offering a solution to such capital market problems, government funded education policy needs to be well designed to avoid recurrent problems or risks, on both the demand- and the supply-side with state-funded education.

On the demand side, the key risk is that taxation-funded education systems become captured by particular consumer groups (by gender,

¹⁵⁸ Toma (2005), p. 4.

¹⁵⁹ *ibid*, p. 4.

age and income) and/or by the education service providers. Reforms are then required to better empower all consumers and increase competition in the supply side of education services. For example, the social returns to pre-adult education, especially early childhood education, but also primary and secondary education, far exceed those in tertiary or higher education. The political system, however, may fail to allocate as much tax funding per student to universal pre-adult education as it does to adults for higher education. The apparent reason for this is voter, and interest group/middle-class capture where adult participants in tertiary education (students and teachers) are able to extract greater rents from the political system than children, even though the social returns to education and training lie primarily in pre-adult school education. An obvious solution to this is ICT-based “smart education” fixed-budget accounts for individuals which can be drawn on at fixed rates for different forms of education over the life cycle.

As the OECD notes, creating an environment that enables individuals to choose and acquire appropriate skills, and that supports the optimal use of those skills in work, also requires incentives for institutions to improve the quality and relevance of their teaching.¹⁶⁰ Poorly designed government policy, regulation and funding of education services markets that undermine incentives for better performance will also undermine ICT-based education and ICT-based sustainable development.

On the supply side, the critical problem around the world is the lack of competition in education and training services. It tends to be subject to heavy licensing; and regulatory burdens which create barriers to entry, and state ownership and management of heavily subsidised resources, with regional monopolies that crowd out competition from the private sector. There is a long-standing perception among economists¹⁶¹ that competition can improve school markets’ performance. Research on the effects of competition between private and public schools shows improved outcomes but depends on how this competition is designed.

¹⁶⁰ OECD (2015), p. 47.

¹⁶¹ E.g. Smith, 1776; Friedman, 1955.

¹⁶² The same is true in the case of school decentralization or school autonomy.¹⁶³ Thus, in voucher experiments that have introduced more competition between private and state schools, children have experienced higher achievement gains in private schools in some subgroups and in some contexts.¹⁶⁴ For example, the single group of students who exhibit the greatest test score gains from attending private schools in the US are minority students in inner cities. This group also does better in terms of high-school graduation rates when in private schools. The evidence is also consistent on cost advantages, with private schools producing skills at lower cost particularly in low-income countries and at the primary level.¹⁶⁵ Public administration scholars have argued that a prime reason for the difference in output in the two sectors of schooling can be attributed to managerial efficiencies and the role of the principal in the private sector compared with that in the public sector.¹⁶⁶

Poorly designed government policy, regulation and funding of education services markets can thus create weak incentives for better performance including for the adoption of ICT-based solutions in education and training markets. These problems also manifest themselves in the lack of education and training in ICT skills – a further key input for sustainable development. Education and training in science, technology, engineering and maths (STEM) disciplines are crucial inputs to the ICT sector. These ICT-related skills in STEM complement those in the ICT sector, and a lack of adequate training of the population in these skills limits the development of the ICT sector itself.

Recommendation 9: The education system should be adapted and improved to better exploit the changing ICT and digital environment and better prepare people for the new digital economy with ICTs as the centre of sustainable development.

¹⁶² Urquiola (2016).

¹⁶³ Galiani and Schargrodsky, 2002; Hanushek et al., 2013.

¹⁶⁴ Urquiola (2016).

¹⁶⁵ Urquiola (2016), p. 211.

¹⁶⁶ Toma (2005), p. 4.

4.6.3 Environmental Goods and Services Markets

Arguably the only markets that suffer more from poor government policy than the health and education markets are the markets for environmental goods and services. Indeed, often there are quite simply missing markets in environmental goods and services. This is in large part because of the lack of tradable property rights in environmental goods and services. The three key UN SDGs in this area are:

- SDG 13: Take urgent action to combat climate change and its impacts;
- SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development; and
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation as well as halt biodiversity loss.

Taking an example of SDG 13 (sustainable climate), global efforts to establish limits on carbon emissions and create tradable rights in carbon emissions that could support market pricing of carbon emissions and optimally deter pollution causing climate change have progressed very slowly. The same is true in relation to SDG 14 (sustainable oceans and seas) and SDG 15 (sustainable terrestrial ecosystems). Significant parts of the marine and terrestrial ecosystems are over-exploited because large parts of these ecosystems remain in the public domain, creating a tragedy of the commons, or are inefficiently managed under state ownership.

This poor government policy on environmental goods and services markets then undermines the adoption of ICT systems that could readily enable more sustainable development of environmental goods and services globally. ICT-enabled applications provide opportunities for more sustainable environments. ICT-enabled systems, for example, can better ensure sustainable environmental goods and services with ICT-based rights trading systems and computer controlled compliance monitoring, using inspecting sensor systems connected to laboratory quality testing to ensure compliance with the environmental rights.

4.7 Conclusion

We reviewed what governments need to do for ICT-based sustainable economic development. The key challenges relate to the nature of government policy directly affecting ICT markets and the supply of ICT services as well as government policy affecting non-ICT markets that indirectly affect the demand for ICT solutions for sustainable economic development. The chapter thus identified two important points for governments in charting their ways forward.

- First, in the ICT sector itself, government should remove policies that prevent competition and limit innovation, and encourage and facilitate the introduction of innovative ICT-based products, and solutions.
- Second, in non-ICT sectors of the economy (e.g. agriculture, health, energy, transportation, commerce), government needs to actively identify barriers that prevent competition and limit innovation in non-ICT sectors and can indirectly limit and distort demand for ICT solutions, preventing the efficient use of ICTs to achieve sustainability in economic development benefits.

In many countries and across most sectors, existing government policy is frozen in time, and prevents the efficient use of ICTs to achieve sustainability in economic development. Hence, governments need to adapt their visions and the objectives of their regulatory regimes to remove all barriers to the introduction of innovative ICT-based products, and promote ICT solutions across a wide range of sectors. General reforms of non-ICT markets that promote competition and innovation will thus be complementary or synergistic with direct ICT-related reforms, and *vice versa*.

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References

- Acemoglu, D., and Robinson, J.A. (2012). [Why Nations Fail: Origins of Power, Poverty and Prosperity](#). Decker Edge.
- Adolph, M. (2009). Distributed computing: utilities, grid & clouds. ITU-T Technology Watch Report 9. www.itu.int/dms_pub/itu-t/oth/23/01/T23010000090001PDFE.pdf
- Annez, P. C. and Buckley, R. M. (2009) “Urbanization and Growth: Setting the Context” (In Spence, Michael; Annez, P. C. and Buckley, R. M. Urbanization and Growth. Commission on Growth and Development The International Bank for Reconstruction and Development / The World Bank. http://siteresources.worldbank.org/EXTPREMNET/Resources/489960-1338997241035/Growth_Commission_Vol1_Urbanization_Growth.pdf
- Angel, S., et al. (2011a). The dimensions of global urban expansion: estimates and projections for all countries, 2000–2050. *Progress in Planning* 75, 53–107.
- Angel, S., Parent, J., Civco, D.L., and Blei, A. (2011b). Making room for a planet of cities. Policy Focus Report, Lincoln Institute of Land Policy, Cambridge, MA.
- Annez, P.C., and Buckley, R.M. (2009). “Urbanization and growth: setting the context” In *Urbanization and Growth*, Spence, M., Annez, P.C. and Buckley, R.M. (eds). <https://openknowledge.worldbank.org/bitstream/handle/10986/2582/470610PUB0Urba101OFFICIAL0USE0ONLY1.pdf?sequence=1>
- Angelucci, M. et al. (January 2002). “The Effect of Ownership and Competitive Pressure on Firm Performance in Transition Countries: Micro Evidence from Bulgaria, Romania and Poland.” William Davidson Working Paper, Number 434.
- Ardila-Gomez, A., and Ortegon-Sanchez, A. (2016). *Sustainable Urban Transport Financing from the Sidewalk to the Subway: Capital, Operations, and Maintenance Financing*. World Bank, Washington, DC. <https://openknowledge.worldbank.org/bitstream/handle/10986/23521/9781464807565.pdf?sequence=1&isAllowed=y>
- Barker, G.R. (2016). Digital convergence and diminished creative industry growth: a New Zealand case study (July 28, 2016). <https://ssrn.com/abstract=2818563>
- Barker, G.R. (2017a). Diminished creative industry growth in Australia in the digital age. <https://ssrn.com/abstract=2915246>
- Barker, G.R. (2017b). Diminished creative industry growth in Canada in the digital age.
- Barker, G.R., Cave, M., and Gordon, C. (2015). How should transport be regulated in 2025? Research Reports on Specified Topics, NZ Ministry of Transport. www.transport.govt.nz/assets/Uploads/Our-Work/Documents/Regulation-2025-How-should-transport-be-regulated-in-2025-Research-Reports-on-Specified-Topics.pdf

ICT-centric economic growth, innovation and job creation

Barker, G.R., Fuss, M.A., and Waverman, L. (2008). The contribution of ICT to productivity in 18 OECD countries: focus on Australia (June 30, 2008). Working Paper 3: ICT and Productivity Paper, ANU Centre for Law and Economics.
<https://ssrn.com/abstract=2967322>

Benkler, Y. (1998), "Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment", in *Harvard Journal of Law and Technology*, vol. 11(2), pp. 287-400

Benkler, Y., 2002, "Some Economics of Wireless Communications", in *Harvard Journal of Law and Tech.*, vol. 16(1), pp. 25-84.

Börger T., Beaumont N. J. , Pendleton L, Boyle K.J., Cooper P., Fletcher S., Haab T., Hanemann M., Hooper T.L., Hussain S.S., Portela R., Stithou M., Stockill J., Taylor T., Austen M.C. "Incorporating ecosystem services in marine planning: The role of valuation" *Marine Policy* 46 (2014) 161–170

Boardman, A. & Vinning, A. (1989). "Ownership and Performance in Competitive Environments: A Comparison of the Performance of Private, Mixed and State-Owned Enterprises." *Journal of Law and Economics*. 32, 1–33.

Boubakri, N., Cosset, J. C. & Guedhami, O. (December 2001). "Liberalization, Corporate Governance, and the Performance of Newly-Privatized Firms." William Davidson Working Paper, Number 434.

Boycko, M., Shleifer, A., and Vishny, R. (1996). A theory of privatisation. *Economic Journal* 106, 309–319.

Bresnahan, T., Brynjolfsson, E., and Hitt, L. (2002). Information technology, workplace organization, and the demand for skilled labor: firm-level evidence. *The Quarterly Journal of Economics* 117(1), 339–376.

Bresnahan, T., Davis, J.P., and Yin. P. (2015). Chapter 8: economic value creation in mobile applications. In *The Changing Frontier: Rethinking Science and Innovation Policy*, Jaffe, A.B., and Jones, B.F. (eds), pp. 233–286. University of Chicago Press.

Brito J (2007) "The Spectrum Commons in Theory and Practice" *Stanford Technology Law Review*

Cardona, M., Kretschmer, T., and Strobel, T. (2013). ICT and productivity: conclusions from the empirical literature. *Information Economics and Policy* 25(3), 109–125.

Cave M., (2005) An Independent Audit of Spectrum Holdings for Her Majesty's Treasury December 2005.

<http://www.spectrumbaudit.org.uk/pdf/20051118%20Final%20Formatted%20v9.pdf>

Chone, P., Flochel, L., and Perrot, A. (2002). Allocating and funding universal service obligations in a competitive market. *International Journal of Industrial Organization* 20, 1247–1276

ICT-centric economic growth, innovation and job creation

Coase, R.H. (1959), “The Federal Communications Commission”, in *J. of Law and Economics*, vol. 2(1), p. 1

Corneo, G., and Rob, R. (2003). Working in public and private firms. *Journal of Public Economics* **87**, 1335–1352.

Cragg, M., and Dyck, A. (2003). Privatization and management incentives: evidence from the United Kingdom. *Journal of Law, Economics and Organization* **19**(1), 176–217.

Davenport, T.H., Kudyba, S.H. (2016). Designing and Developing Analytics-Based Data Products. *MIT Sloan Management Review*, 58(1), 83-88

Davis, J. *et al* (2000). Fiscal and macroeconomic aspects of privatisation. Occasional Paper 194, International Monetary Fund.

Debande, O. (2001). “Deregulating and Privatising Statutory Monopolies.” *Journal of Economics and Business*. 53, 111–137.

De Fraja, G. (1993). “Productive Efficiency in Public and Private Firms.” *Journal of Public Economics*. 50, 15–30

DeGood, K., and Madowitz, M. (2014). Switching from a gas tax to a mileage-based user fee. Center for American Progress.

Demsetz, H. (2009). Creativity and the economics of the copyright controversy. *Review of Economic Research on Copyright Issues* 6(2), 5–12.

Durant, R., Legge, J.& Moussios, A. (1998). “People, Profits, and Service Delivery: Lessons from the Privatisation of British Telecom.” *American Journal of Political Science*. 42, 117–140.

Economic Commission for Latin America and the Caribbean (ECLAC) (2013). *Broadband in Latin America: Beyond Connectivity*. ECLAC Books.
www.cepal.org/en/publications/broadband-latin-america-beyond-connectivity

EC. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Off J Eur Union 2000; L327:1–73.

EC. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off J Eur Union 2008; L164.

Estache, A. & Gonz’alez, M. (2002). “What does ‘Privatization’ do for Efficiency? Evidence from Argentina’s and Brazil’s Railways.” *World Development*. 30, 1885–1897.

Estrin, S. & Rosevear, A. (1999). “Enterprise Performance and Ownership: The Case of Ukraine.” *European Economic Review*, 43, 1125–1136.

ICT-centric economic growth, innovation and job creation

- Fama, E. (1980). Agency problems and the theory of the firm. *Journal of Political Economy* **88**, 288–307.
- Faulhaber, G.R. (2005), “The Question of Spectrum: Technology, Management, and Regime Change”, in *Journal on Telecommunications and High Technology Law*, vol. 4(1), p. 123.
- Fershtman, C. (1990). “The Interdependence between Ownership Status and Market Structure: The Case of Privatisation.” *Economica*. 57, 319–328.
- Friedman, M. (1955). The role of government in education. In *Economics and the Public Interest*, Solo, R. (ed). Trustees of Rutgers College, New Brunswick, NJ.
- Galal, A. (1991). Public enterprise reform: lessons from the past and issues for the future. Discussion Paper 119, World Bank.
- Galiani, S., and Schargrodsky, E. (2002). Evaluating the impact of school decentralization on education quality. *Economia* **20**(2), 275–314.
- Gasmia, F., Laffont, J.J., and Sharkey, W.W. (2000). Competition, universal service and telecommunications policy in developing countries. *Information Economics and Policy* **12**, 221–228.
- Gasmi, F., Maingard A., Noumba P., and Recuero Virto, L. (2013). The privatization of the fixed-line telecommunications operator in OECD, Latin America, Asia, and Africa: one size does not fit all. *World Development* **45**, 189–208.
- Gaynor, M., Moreno-Serra, R., and Propper, C. (2013). Death by market power: reform, competition, and patient outcomes in the National Health Service. *American Economic Journal: Economic Policy* **5**(4), 134–166.
- Gruber, H., Hatonen, J., and Koutroumpis, P. (2014). Broadband access in the EU: an assessment of future economic benefits. *Telecommunications Policy* **38**(11), 1046–1058.
- Guilloteau, S., and Mauree, V. (2012). Privacy in cloud computing. ITU-T Technology Watch Report. www.itu.int/dms_pub/itu-t/oth/23/01/T23010000160001PDFE.pd.
- Gupta, S., Schiller, C., and Ma, H. (1999). Privatization, social impact, and social safety nets. Working Paper 99/68, May, International Monetary Fund.
- Hanushek, E.A., Link, S., and Woessmann, L. (2013). Does school autonomy make sense everywhere? Panel estimates from PISA. *Journal of Development Economics* **104**, 212–232.
- Haskel, J. & Sanchis, A. (1995). “Privatization and X-Inefficiency: A Bargaining Approach.” *Journal of Industrial Economics*. 43, 301–321.
- Havelaar, A.H. (1994). “Application of HACCP to drinking water supply”. *Food Control*. 5(3) 3 November

ICT-centric economic growth, innovation and job creation

Hazlett, T.W. (2006), The Spectrum Allocation Debate: An Analysis.

www.computer.org

Henisz, W. (2000), "The Institutional Environment for Economic Growth," Economics and

Politics 12(1): 1-31. Henisz, W. (2002), "The Institutional Environment for Infrastructure Investment," Industrial and Corporate Change 11(2): 355-389.

Henisz, W. and B. Zelner (2001), "The Institutional Environment for Telecommunications Investment," Journal of Economics and Management Strategy 10(1): 123-147.

Hoernig, S. (2006). Should uniform pricing constraints be imposed on entrants? *Journal of Regulatory Economics* 30, 199–216.

Horrigan, J. (2008). Use of cloud computing applications and services. Pew Research Center. www.pewinternet.org/Reports/2008/Use-of-Cloud-Computing-Applications-and-Services.aspx

International Energy Agency (2008). World Energy Outlook. Report, OECD/IEA, Paris.

ITU (2011). ITU National Cybersecurity Strategy Guide. International Telecommunication Union.

ITU (2013a). Measuring the Information Society. International Telecommunication Union.

ITU (2013b). Universal service fund and digital inclusion for all study. International Telecommunication Union.

ITU (2014). Understanding cybercrime: phenomena, challenges and legal response. International Telecommunication Union.

ITU (2015). Global security index and cyberwellness profile. ABI Research Report, International Telecommunication Union.

ITU (2016) Measuring the Information Society Report. International Telecommunication Union ISBN: 978-92-61-21421-0 (paper version) 978-92-61-21431-9 (electronic version)

Jensen, M., and Meckling, W. (1976). Theory of the firm: managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics* 3, 305–360.

Jones, D. & Mygind, N. (2000). "The Effects of Privatization on Productive Efficiency: Evidence from the Baltic Republics." *Annals of Public and Cooperative Economics*. 71, 415–439.

Jones, D. & Mygind, N. (2001). "Ownership and Productive Efficiency: Evidence from Estonia." Department of Economics Working Paper Number 385.

ICT-centric economic growth, innovation and job creation

Jorgenson, D. (2001). Information technology and the US economy. *American Economic Rev.* **91**(1), 1–32.

Katz, R. (2012). The impact of broadband on the economy: research to date and policy issues. ITU Telecommunications Development Sector, Broadband Series.

www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf.

Kay, J. & Thompson, D. (1986). “Privatisation: A Policy in Search of a Rationale.” *Economic Journal.* 96, 18–32.

Kikeri, S., and Nellis, J. (2002). Privatization in competitive sectors: the record to date. Policy Research Working Paper 2860, World Bank.

King, S., and Pitchford, R. (1998). Privatisation in Australia: understanding the incentives in public and private firms. *Australian Economic Review* **31**, 313–328.

Le Grand, J. (2009). Choice and competition in publicly funded health care. *Health Economics, Policy and Law* **4**(4), 479–488. ISSN 1744-1331.

Lessig, L. (2001), *The Future of Ideas: The Fate of the Commons in a Connected World*, New York, Vintage

Levy, B., and Spiller, P.T. (1994). Regulation, institutions, and commitment in telecommunications: a comparative analysis of five country studies. World Bank. <http://documents.worldbank.org/curated/en/860121468779131284/Regulation-institutions-and-commitment-in-telecommunications-a-comparative-analysis-of-five-country-studies>

Liu, G. & Garino, G. (2001). “Privatisation or Competition?” *Economics of Planning.* 34, 37–51

Madrid Resolution (2009). International standards on the protection of personal data and privacy. International Conference of Data Protection and Privacy Commissioners. www.privacyconference2009.org/dpas_space/space_reserved/documentos_adoptados/common/2_009_Madrid/estandares_resolucion_madrid_en.pdf

Martin, S. & Parker, D. (1995). “Privatization and Economic Performance Throughout the UK Business Cycle.” *Managerial and Decision Economics.* 16, 225–237.

Meggison, W., Nash, R. & Van Randenborgh, M. (1994). “The Financial and Operating Performance of Newly

Milgrom, P. (1996). Procuring universal service: putting auction theory to work. Lecture, December 9, Royal Swedish Academy of Sciences.

Mirabel, F.; Poudou, J.-C. et M. Roland (2009) , "Universal Service Obligations: The Role of Subsidization Schemes", *Information Economics and Policy*, vol. 21, no 1, pp. 1-9

ICT-centric economic growth, innovation and job creation

Nestor, S., and Mahboobi, L. (1999). Privatisation of public utilities: the OECD experience.” Report Rio-9, April 23, OECD.

Nicoletti, G. & Scarpetta, S. (January 2003). “Regulation, Productivity, and Growth: OECD Evidence.” World Bank Policy Research Working Paper 2944.

Ng, C. & Seabright, P. (2001). “Competition, Privatisation and Productive Efficiency: Evidence from the Airline Industry.” *Economic Journal*. 111, 591–619.

Noam, E. M., 1998, “Spectrum Auctions: Yesterday’s Heresy, Today’s Orthodoxy, Tomorrow’s Anachronism. Taking the Next Step to Open Spectrum Access”, in *Journal of Law and Economics*, vol. XLI, p. 765.

North, D.C. (1983). *Structure and Change in Economic History*. New Edition (March 16, 1983). W. W. Norton & Company.

North, D.C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge University Press.

North, D.C. (1995). The New Institutional Economics and Third World Development. In *The New Institutional Economics and Third World Development*, Harriss, J., Hunter, J., and Lewis, C.M. (eds), pp 17–26. Routledge, London.

North, D.C., and Thomas, R. (1973). *The Rise of the Western World: A New Economic History*. Cambridge University Press.

North, D.C., and Weingast, B.R. (1989). Constitutions and commitment: the evolution of institutional governing public choice in seventeenth-century England. *The Journal of Economic History* 49(4), 803–832.

Oates, W. E. (1999) ‘An Essay on Fiscal Federalism’, *Journal of Econ. Lit.*, 37 (3): 1120-1149.

OECD (2004). The economic impact of ICT: measurement, evidence, and implications. OECD Publishing, Paris.

<http://www.ictliteracy.info/rf.pdf/The%20Economic%20Impact%20of%20ICT.pdf>

OECD (2012). Cybersecurity policy making at a turning point: analysing a new generation of national cybersecurity strategies for the internet economy. OECD Digital Economy Papers 211, OECD Publishing, Paris.

<http://dx.doi.org/10.1787/5k8zq92vdgtl-en>

OECD (2013a). New sources of growth: knowledge-based capital key analyses and policy conclusions. Synthesis Report, OECD Publishing, Paris.

<http://www.oecd.org/sti/inno/knowledge-based-capital-synthesis.pdf>

OECD (2013b). Supporting investment in knowledge capital, growth and innovation. Report, Oct 10, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264193307-en>

OECD (2015). The innovation imperative: contributing to productivity, growth and well being. OECD Publishing, Paris.

ICT-centric economic growth, innovation and job creation

OECD (2016a). Development co-operation report 2016: the sustainable development goals as business opportunities. OECD Publishing, Paris.

<http://dx.doi.org/10.1787/dcr-2016-en>

OECD (2016b). OECD science, technology and innovation outlook 2016. OECD Publishing, Paris. http://dx.doi.org/10.1787/sti_in_outlook-2016-en

Panzar, J. (2000). A methodology for measuring the costs of universal service obligations. *Information Economics and Policy* **12**, 211–220.

Parker, D. & Hartley, K. (1991). “Do changes in organizational structure affect financial performance?” *Strategic Management Journal*, 12, 631–641.

Pearce D, Markandya A, Barbier EB. (1989) Blueprint for a green economy. London: Earthscan;

RIO+20 (2012). The future we want. Final Document of the RIO+20 Conference, 20–22 June, Rio de Janeiro, Brazil. <http://rio20.net/wp-content/uploads/2012/06/N1238164.pdf>

Röller, L., and Waverman, L. (2001). Telecommunications infrastructure and economic development: a simultaneous approach. *American Economic Review* **91**(4), 909–923.

Sandvine (2016). Sandvine global Internet phenomena report.

<https://www.sandvine.com/trends/global-Internet-phenomena/>

Seto, K., Guneralp, B., and Hutyrá, L.R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *PNAS* **109**(40), 16083–16088.

Schrank, D., et al. (2015). 2015 urban mobility scorecard. Texas A&M Transportation Institute, Texas A&M University System & INRIX, Inc.

<https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015.pdf>

Shirley, M., and Walsh, P. (2000). Public versus private ownership: the current state of the debate. Policy Research Working Paper 2420, World Bank.

Shleifer, A., and Vishny, R. (1994). Politicians and firms. *Quarterly Journal of Economics* **109**, 995–1025.

Smith, A. (1776). *The Wealth of Nations*. W. Strahan and T. Cadell, London.

Smith, A. & Trebilcock, M. (2001). “State-Owned Enterprise in Less Developed Countries: Privatisation and Alternative Reform Strategies.” *European Journal of Law and Economics*. 12, 217–252.

Spiezia, V. (2013). ICT investments and productivity. *OECD Journal: Economic Studies* **2012**(1), 199–211.

ICT-centric economic growth, innovation and job creation

Staikouras P.K. (2004) Structural Reform Policy: Privatisation and Beyond—The Case of Greece *European Journal of Law and Economics* May 2004, Volume 17, Issue 3, pp 373–398

Stern, P.A., and Townsend, D.N. (2006) New models for universal access to telecommunications services in Latin America. Working Paper 40829 (Volume 2).

Treasury. HM. (2003) The green book: appraisal and evaluation in central government. London: TSO.

World Bank (PPIAF and GPOBA)/ECLAC Project on Universal Access for Telecommunications in Latin America. <http://bit.ly/2vbD8Fe>

Tiebout, C. (1956). A pure theory of local expenditures. *Journal of Political Economy* **64**, 416–424.

Toma, E. (2005). Schooling around the world: an institutional perspective: NASPAA presidential address. *Journal of Public Affairs Education* **11**(1), 1–6.

UN-Habitat (2011). Hot cities: Battle-ground for climate change. UN-Habitat, Nairobi.

United Nations (1980). Patterns of Urban and Rural Population Growth. UN.

United Nations (2001). The Components of Urban Growth in Developing Countries.

United Nations (2013a). World Population Prospects: The 2012 Revision.

United Nations (2013b). World economic and social survey 2013: sustainable development challenges.

United Nations (2014a). World urbanization prospects: The 2014 revision, methodology. Working Paper ESA/P/WP.237.

United Nations (2014b). The millennium development goals report 2014.

United Nations (2014c). World urbanization prospects.
<https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf>

United Nations (2015). Resolution adopted by the General Assembly on 25 September 2015: seventieth session, agenda items 15 and 116. A/RES/70/1 Transforming Our World: The 2030 Agenda for Sustainable Development.
http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

United Nations (2016). United Nations e-government survey 2016. Survey, UN.
<http://workspace.unpan.org/sites/Internet/Documents/UNPAN96407.pdf>

Urquiola, M. (2016). Competition among schools: traditional public and private schools. In *Handbook of the Economics of Education*, Hanushek, E.A., Machin, S.J., and Woessmann, L. (eds), Volume 5. Elsevier. ISSN 1574-0692.

ICT-centric economic growth, innovation and job creation

Van Reenen, J., et al. (2010). The economic impact of ICT. Final Report of the EU Commission's Economic Impact of ICT Project, Centre for Economic Performance, London School of Economics.

http://www.eurosfair.prd.fr/7pc/doc/1291302690_econ_impact_of_ict_2010.pdf

Waverman, L., Meschi, M., and Fuss, M. (2005). The impact of telecoms on economic growth in developing countries. *The Vodafone Policy Paper Series* 2(03), 10–24.

Weiser, P.J. and Hatfield, D.N. (2005), “Policing the Spectrum Commons”, in *Fordham Law Review*, vol. 74, pp. 101-132

Weller, D. (1999). Auctions for universal service obligations. *Telecommunications Policy* 23(9), 645–674.

Werbach, K. (2004), “Supercommons”, in *Texas Law Review*, vol. 82, pp. 863-973.

Williamson, O. (1963). Managerial discretion and business behaviour. *American Economic Review* 53, 1032–1057.

World Bank (2016). Digital dividends. World Development Report 2016, World Bank, Washington, DC. ISSN 0163-5085.

www.worldbank.org/en/publication/wdr2016

World Economic Forum (2015). Expanding participation and boosting growth: the infrastructure needs of the digital economy. World Economic Forum in Collaboration with the Boston Consulting Group, Geneva.

WIPO (2015) Guide on Surveying the Economic Contribution of the Copyright Industries 2015 revised edition World Intellectual Property Organisation.

http://www.wipo.int/edocs/pubdocs/en/copyright/893/wipo_pub_893.pdf

Biographies

George Barker is Visiting Fellow at the London School of Economics (LSE) and past Director of the Centre for Law and Economics at the Australian National University (ANU) 1998-2017. He obtained a DPhil. in Economics from Oxford University, and holds a Bachelor of Law and a Master of Economics. He has extensive expertise in economic analysis of law, regulation, public policy, governance and market design in Information and Communications Technology (ICT). Since 1990s, he has advised governments and private clients in Asia Pacific, North America and Europe on privatisation and regulation of telecommunications, spectrum use, fixed line and mobile telephony, digital television, the evolution of the 2G, 3G and 4G markets,

international Internet contractual and pricing arrangements, and the effects of ICT on economic growth. He was the Olin Fellow in Law and Economics at Cornell University in 2000; and has been a visiting fellow at Oxford University (2008), at the University College in London (2010-2015), and at the British Institute of International and Comparative Law in London (BIICL) since 2010. He is on the Editorial Board of the European Journal of Law and Economics, currently the President of the Australian Law and Economics Association, and a Founder and elected Honorary Fellow of the Law and Economics Association of New Zealand. Dr. Barker was a Member of the Governing Board of Wolfson College at Oxford University from 1990 – 1992, Chief Analyst and Economic Advisor at New Zealand Treasury (1984-1996), and Board Member of LECG Asia-Pacific Ltd. (1997-2005), Celtic Pacific Ltd., Upstart Investments Ltd. (1999-2003), KEA Global, and past Chairman of KEA Australia (2001-2010).

Prasit Prapinmongkolkarn is a Professor of Electrical Engineering at Chulalongkorn University, Bangkok, Chairman of the Industry Professional Group of the National Research Committee in Thailand, and Member of the University Council at Stamford International University, Thailand. He has published 4 books, more than 50 papers and supervised 7 Ph.D. students. He was the Chairman of National Telecommunications Commission and the National Broadcasting and Telecommunications Commission in Thailand.

Supavadee Aramvith is an Associate Professor and head of Digital Signal Processing Lab at the Department of Electrical Engineering, Chulalongkorn University, Bangkok. She has published over 120 papers in international conferences and journals as well as 3 book chapters. She is specialized in video communication technology, and serves as a technical advisor to the National Broadcasting and Telecommunications Commission in Thailand. Dr. Aramvith received her M.Sc. and Ph.D. degrees from the University of Washington, Seattle, USA, both in Electrical Engineering.

Chapter 5

Business Models for ICT-Centric Sustainable Development

*Jean-Pierre Auffret**

Innovation is a key driver of future economic developments and plays an important role in creating new jobs. This chapter highlights the importance of establishing a business environment in which ICT-based innovative products, services, and applications can flourish, new jobs can be created and maintained, and sustainability in development can be achieved. The flexibility that ICTs afford in how resources and productive activities are organized within firms, markets, and industry value chains renders the design of business models a choice variable. No longer are business models dictated by legacy production techniques. Instead, ICTs enable incumbents and entrepreneurs to develop new strategies for promoting economic activity and achieving development goals. In this chapter we discuss the history of business model theory and how it is changing and being newly energized by ICT technology, offering the potential for developing countries leapfrog strategies to accelerate development. We provide short descriptions of the current trends and concepts in forming and offering ICT-based novel products and services, and discuss some important factors that are instrumental in establishing successful ICT-based business entities.

5.1 Introduction

With industry convergence driven by wireless networks, handheld devices, and the Internet, preparing proper business models is a vital

* George Mason University, Virginia, USA

step that needs to be carefully considered and planned with a view to ensuring sustainability in businesses, shaping realistic expectations, and creating job opportunities in a fast changing environment. Governments, the private sector and civil societies each have important and specific roles and motivations in the formation and longevity of ICT-centric businesses. As a result, a major challenge for governments and other stakeholders is to foster an environment for the existing and new businesses that appropriately aligns stakeholder incentives.

The business model concept became popular in the late 1990's initially in the business press and then in the academic press. The term gained cachet during the Internet boom when the Internet was providing a foundation for Web based businesses to compete with the traditional "brick and mortar" companies. An early overview was provided by Magretta (2002) who gave the historical context for the business model idea and contrasted the concept with business strategy. She defined *business models* as "stories that explain how enterprises work" and highlighted the American Express Traveler's Check business. In the late 1890s, American Express developed the Traveler's Check in order to help travelers convert letters of credit into cash. The traveler paid a small fee for a check that was widely accepted and insured, and merchants accepted the checks as a means to gain customers. The system worked because both the travelers and merchants trusted American Express. American Express in turn benefited financially by taking advantage of the float generated by customers paying in advance of using the checks.

Magretta contrasted the difference between business models and strategy by noting that while business models describe the system, they do not consider competition. She explained that strategy is "doing better by being different" and provided the two examples of Walmart and the eCommerce bust in the early 2000s. The Walmart business model was the same as many discount retailers but with a different strategy of targeting customers in small towns instead of major cities. In the eCommerce bust, many online retailers failed by having the same business model but no strategy as to how to compete effectively.

The origin of the business model concept can be attributed to Peter Drucker's 1994 article "Theory of the Business". Drucker defined the theory of the business as assumptions about the environment (market, customer and technology), organizational mission, and core competencies. He utilized the two high profile cases of GM in the 1970s and IBM in the 1980s to highlight how changing assumptions can lead to a major change in a company's performance and prospects. For GM after the specialization of the car market and for IBM after the launch of the PC, their assumptions and associated theories of business were no longer valid, and they experienced strategic crises and financial downturns (Drucker 1994).

As noted earlier, business model innovation is also a key concept in practice, highlighted by the academic and research community as well as the business groups and governments. Mary Meeker highlighted the great impact of business model innovation and coined the phrase "re-imagination of nearly everything" in her *Internet Trends* (Meeker 2012). She described how mobile phones and new devices, Internet and connectivity, and user interfaces have resulted in the rapid transformation of existing industries and development of new industries.¹⁶⁷ As examples, she noted transitions from desktops to smart phones, delayed news to Twitter, phone calls to email to SMS to WhatsApp, dedicated camera and film development to smart phone camera and photo sharing services, books to Apple iPad and Amazon Kindle, albums and CDs to music streaming, movie rental to YouTube, maps to crowdsourced application such as Waze, taxis to Uber, and telephone books to Yelp.

In a review of academic literature since the 1990s, Zott, Amit and Massa (2011) concluded that while there is not an agreed definition of business model, there are some common themes. These include that a business model provides a holistic view of a business and considers both value creation and value capture. Common business model elements include: customer value proposition, profit formula, key resources and key processes (Johnson, Christensen and Kagermann

¹⁶⁷ Teece (2010) also highlights how business model innovation is needed in conjunction with technology innovation in order to develop and capture value.

2008); customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure¹⁶⁸ (Osterwalder and Pigneur 2010); and choices (policies, assets and governance) and consequences (flexible and rigid) (Casadesus-Masanell and Ricart 2011).

With the increasing adoption of the business model concept, many authors have turned to investigating the relevance of business models to international cooperation in developing new products and services. C.K. Prahalad in *Fortune at the Bottom of the Pyramid* (2006) and in an earlier article with the same title (Prahalad and Hart 2002), proposed that doing business with the world's four billion poor requires "radical innovations in technology and business models". He also highlighted how the developing countries can participate in the evaluation of environmentally sustainable technologies and products.

A differing perspective on the "bottom of the pyramid" business models was provided by Karnani (2006) who described the "fortune" as a "mirage," and argued that the actual potential is in considering the world's poor as producers and not consumers. In this manner, the orientation is towards raising per capita incomes. He mentioned examples such as Grameen Bank in microfinancing and e-Choupal in creating market efficiency for soy bean farmers to bring crops to the market. Karnani further questions the "bottom of the pyramid" focus on consumers by arguing that it de-emphasizes the role of government and policy in international development.

Many authors have pointed out that failures in emerging markets often are caused by erroneous business models. Eyring, et al (2011) pointed out that some firms "get their business models wrong" by directly importing business models from other countries with limited modifications. They went further and stated that many firms do not have a systematic process for properly adjusting their business models to their target markets. Oyedele (2016) emphasized the need for business models that are focused on emerging markets, which can be

¹⁶⁸ Osterwalder and Pigneur label the portrayal of the nine elements as the "Business Model Canvas".

achieved by utilizing the Osterwalder's and Pigneur's business model canvas.¹⁶⁹ This theme was further elaborated in a Harvard Business School Analytics Services study emphasizing that the need for proper business models is often more important than technologies in developing countries (Harvard Business School Analytics Services 2011). The study stated that differences in the utilities, distribution and transportation infrastructures, customer sensitivities to value and cost, labor costs, and types of firms in developed and developing countries require changes in business models.

Recent articles focus on the need for business model innovation in specific countries and industries. Two such examples are Goyal, et al. 2017 and Schmida, et al. 2016. Both articles emphasize the need to develop business models appropriate to local contexts. The first article highlighted the business model commonalities in India including the need for understanding target segment requirements, ensuring affordability, addressing last mile channels, effectively utilizing scarce resources, and consistently integrating business model elements. The second article outlined cases such as Airjaldi providing WiFi and broadband to villages in India using network relays and solar power (Gupta 2014). Mawingu described the provision of WiFi to rural areas in Kenya that utilizes TV spectrum whitespace and solar power (Muraga 2015).

Policy Insight 1. Fostering proper and innovative, yet realistic business models is an absolute necessity for developing new businesses, creating new jobs, and achieving the SDGs.

5.2 Business Models for ICT-Based Innovative Ventures

In business models for innovative ICT-based activities, all players and stakeholders, including governments, the private sector, and civil societies as well as NGOs are engaged. In Porter 1990 and OECD 1997,

¹⁶⁹ The *business model canvas* is a strategic management tool that provides a template for characterizing the key elements that comprise a business model, allowing firms to analyze how the different elements may interact so as to better understand tradeoffs of alternative designs (Osterwalder & Pigneur, 2010).

the respective roles of different players in developing an agile national innovation system in a fluid and fast changing business environment were highlighted. The Fraunhofer Institute for Systems Innovation Research has emphasized this point by contrasting the national innovation system in 2001 as shown in Figure 1 (Kuhlmann and Arnold) with an updated one in 2016 as depicted in Figure 2 (Warnke et al. 2016).

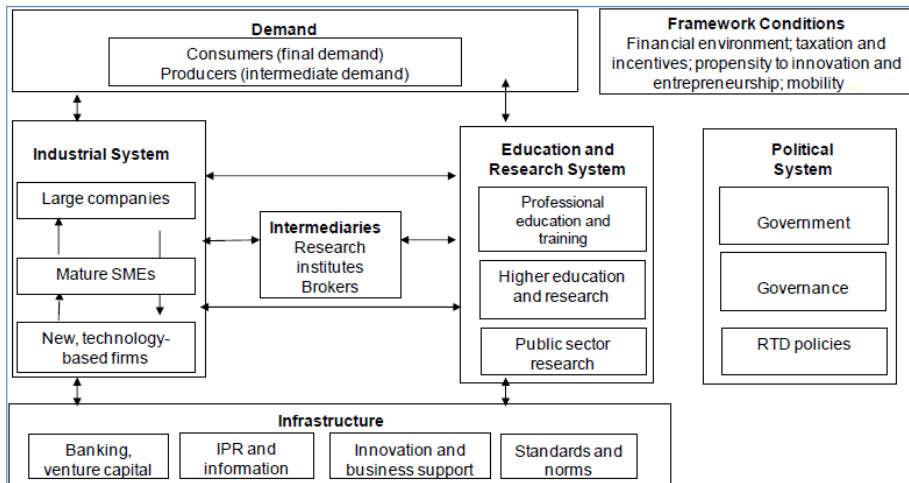


Figure 1. National Innovation System Model (Kuhlmann and Arnold 2001)

In the 2001 model, industry and academia, assisted by intermediary institutions are the key players. The objective of innovation is to meet customers' needs, and is impacted by factors that characterize the political and financial market environment and depends on the foundation of national and local infrastructure. (Kuhlmann and Arnold 2001) The expanded model (Figure 2) takes into account new requirements such as being user based and open, as well as the need to encourage collaboration, and adds new stakeholders and elements including collaborative innovators and creative consumers in co-creation and sharing platforms. (Warnke et al. 2016)

Recommendation 1. Owners of ICT-based businesses should meticulously utilize the available tools and methods, such as the business model canvas, to develop realistic business models for their ventures.

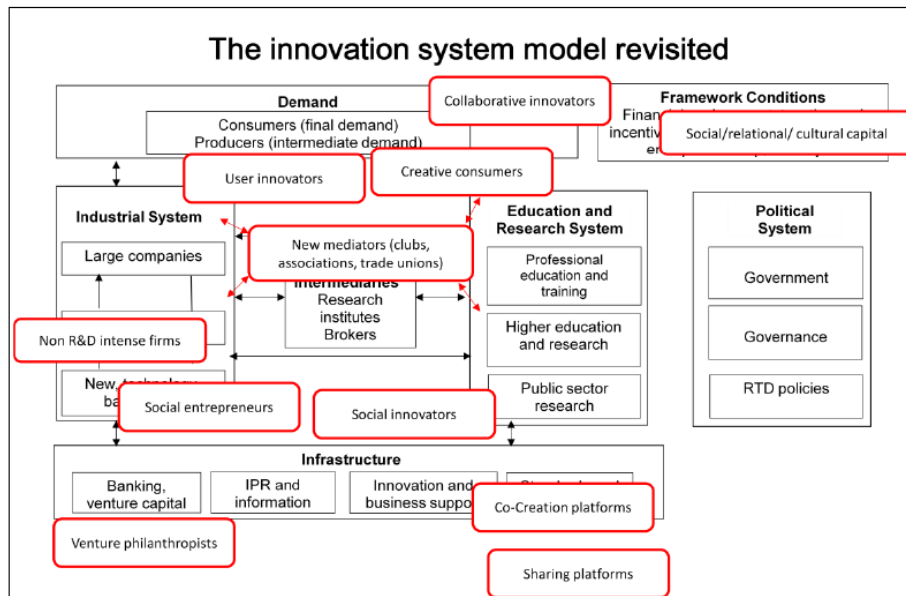


Figure 2. National Innovation System Model Revisited

(Warnke et al. 2016)

5.3 Current Concepts in ICT-Based Products and Services

Current concepts in ICT-based products, services, and applications, including platforms, crowdsourcing, personalization, data driven, and sharing are described briefly in the following subsections.

5.3.1 Platforms

Apple iPhone, Aadhaar, Uber, Alibaba, Facebook and Airbnb are well known examples of platforms. Zhu and Furr 2016 defined platforms as “intermediaries that connect two or more distinct groups of users and enable their direct interaction”. They further note that a single revenue stream for a product can become multiple revenue streams with a

successful platform business model. A platform provides the foundation for multiple services that can be scaled.

India's digital identity system known as Aadhaar (meaning "foundation" in Hindi) is a platform that is being used as the foundation for India's Digital India program. Aadhaar provides citizens with a unique 12 digit identification number and has the objective of empowering citizens especially those that are unbanked. Citizens enroll by providing an iris scan and ten finger print scans as a means for authentication and de-duplication. Aadhaar has scaled rapidly and now has 1.1 billion Indian citizens enrolled. India first utilized Aadhaar to provide payments to citizens for Liquefied Petroleum Gas (LPG), Public Distribution System (PDS) and kerosene programs. Aadhaar was then utilized for providing payments to citizens by different government programs including pensions, EPFO (Employees' Provident Fund Organization), and payments for the National Rural Employment Guarantee Act (NREGA). Aadhaar is also used to obtain bank accounts and mobile numbers, and is increasingly adopted by the private sector (Gupta 2015). Aadhaar is a key element of the Digital India program for empowering citizens and transforming India into a knowledge economy with priorities including better health, education and agriculture.

The Apple iPhone and App Store are also platforms. The Apple App Store provides app developers with means to develop and offer apps for use by iPhone owners. By connecting developers and customers through this platform, Apple has been able to increase the value of the iPhone to customers by way of value creation by app developers. As with Aadhaar, the iPhone and App Store platforms have networking effects, in which the value of the service increases with the number of participants.

Business models for platforms are not necessarily technology based and there are many historical examples such as shopping malls and city markets where individual stores or sellers provide products to customers through the intermediary of the shopping mall or the city market. Technology though provides a means to scale and scale quickly. In addition, a technology-based business model may lessen reliance on ownership of physical assets.

Key elements of platform business models are the ecosystem partners, the nature of intermediary, trust, and governance. In Apple's case, the ecosystem partners are the app developers and iPhone owners, the Internet is the intermediary and Apple provides the governance and maintains a system of trust.

The degree of openness is a key question in the design of a platform-based business. Van Alstyne, et al. (2016 a) defined the degree of openness as “the degree of access that consumers, producers and others have to the platform and what they are allowed to do there”. Esoko, an Africa based agricultural exchange, emphasizes the importance of design, motivation and degree of openness in a platform. Founded in Uganda in 2005, Esoko initially provided market price information to rural farmers and subsequently was developed into a full marketplace. Esoko supplements the marketplace by providing weather alerts and crop assistance to rural farmers that have been traditionally disadvantaged by having only limited and asymmetrical information when selling their products to middlemen.

5.3.2 Crowdsourcing

Waze, Wikipedia, TripAdvisor, Kiva and Zooniverse are a few examples of successful crowdsourcing in which a crowd of end-users participate in creating and capturing value. In Waze, the crowd provides real time traffic information; in Wikipedia, the crowd writes and edits encyclopedia entries; in TripAdvisor, the crowd reviews hotels, restaurants and travel; in Kiva, the crowd provides microloans; and in Zooniverse, the crowd participates in analyzing and interpreting data in science projects. Crowdsourcing is based on an open model and leverages technology to facilitate the creation of value and its potential transfer by and to a crowd. (Kohler 2015)

Crowdsourcing has its own challenges as well. As an example, Maji Matone, a Tanzania water quality project started in 2010 has experienced some of the difficult challenges of crowdsourcing initiatives (Taylor 2013). Prior to the start of Maji Matone, a Wateraid survey found that only 54% of rural water points in Tanzania were functioning. The main idea of Maji Matone was for citizens to use their mobile phones and SMS to report water quality issues to the local

authorities who would then quickly dispatch a technician to solve the problem. In Maji Matone, the technology worked well and in cases where citizens sent SMS messages, the local authorities were responsive. However, the project failed because very few citizens reported water issues due to a sense of powerlessness to affect accountability in the government and also because of the fear of reprisal.

The concepts of co-creation, citizens' driven innovation and open source in crowdsourcing platforms are not universal and unique on how participants engage and who "captures value". In crowdsourcing, the platform owner gains much of the value, but in the open source, the benefits are made available to the community. Co-creation has similarities to crowdsourcing, but in co-creation, participation can be confined to a few individuals and not necessarily a crowd.

5.3.3 Personalization, Localization and Contextualization of Services and Products

Personalization, localization and contextualization provide major new business opportunities. Tomasz Janowski in "Digital Government Evolution: From Transformation to Contextualization" (Janowski 2015) states that the fourth stage of digital government is contextualization, which is the process of putting the information that is specific to a country, region, locality and / or sector into context.¹⁷⁰

Related to contextualization is localization, which is the tailoring of products or services to the characteristics of a location or customers in that location. Localization can apply to one aspect or several aspects of a product or service, such as Starbucks tailoring store design to the local context. In U.S. cities, Starbucks patrons usually come alone or in pairs, and Starbucks designs the stores using long bar areas. In contrast, in Mexico City and China, patrons visit in larger groups, and the stores have bar stools that can be moved to create group seating areas. (Stinson 2014) Localization can also refer to tailoring of the supply

¹⁷⁰ Contextualization follows the stages of Digitization (Technology in Government), Transformation (Electronic Government) and Engagement (Electronic Governance) (Janowski 2015)

chain to the local context. As an example, Amazon has tailored its distribution system in India by engaging local store owners in rural villages. Amazon delivers products to the rural village store through one of its distributors, and the store owner notifies the Amazon customer who comes to the store to pick up the package. The store owner collects the payment and receives in return an administrative fee from Amazon. (Govindarajan and Warren 2016)

Personalization refers to the tailoring of a product or service to an individual. Today's music streaming industry provides a good example where a subscriber's playlist for Pandora's new premium service is based upon their preferences. Pandora tabulates the subscriber's preferences from the customer's previous radio listening and engagement by way of clicking on a "thumbs up" button when he/she likes the music. (Wolverton 2017)

Emergency support and disaster management has, by its nature, a local and personal context. Current instances range from locating emergency support for patients with cardiac arrest through mobile apps showing locations of the automated external defibrillators (AEDs), notifying citizens trained in CPR of a nearby cardiac arrest patient, providing emergency evacuations of patients with special needs in advance of hurricanes and floods by utilizing the patient and location databases, and/or developing situational awareness in the immediate aftermath of a natural disaster through the use of mobile devices and applications.

5.3.4 Data Driven Services, Products and Applications

With data generated from mobile devices, the Internet and now the Internet of Things (IoT), data driven businesses are becoming increasingly common and successful. These range from the content based businesses to newer cognitive computing based businesses. In addition, businesses are increasingly utilizing the data provided through the government's open data programs.

To enhance the understanding of data driven businesses, Hartmann, et al (2014) developed a taxonomy of data driven businesses in terms of key resources, activities, value proposition, customer segments, revenue model and cost structure. Since data is a key resource, the authors

identified several sources including internal sources from the existing IT systems or data generated through web tracking or sensors, externally acquired or purchased data, customer provided or freely available data, and data generated by web crawling or crowdsourcing. They also divided the category of freely available data into open data, social media data and web crawled data. In 2014, the World Economic Forum undertook a survey of 300 data driven businesses in developing countries with the objective of forming a framework for the open data business ecosystem as well as its enabling environment (Morrison 2014). The results point to several challenges in data quality, financing and scalability.

5.3.5 Sharing

The business of sharing is based on the concept of providing customers with access to goods or services through a trusted intermediary. Examples include Zipcar, Uber, Airbnb, Little Cabs in Kenya and Grab in Indonesia. Kenya provides a good example in the adoption of sharing goods or services (Constable 2017). Both Uber and Airbnb have successfully entered the Kenyan market and experienced significant growth. In addition, local companies such as Little Cabs are competing effectively. The challenge though is that Uber and Little Cabs are undercutting the income of existing players and stakeholders such as cab drivers and hotel owners. Constable argues that the sharing businesses have different roles and objectives in the U.S. and Kenya. In the U.S., most citizens have full time employment and are supplementing their incomes with a sharing economy “gigs”. In contrast, in Kenya’s informal economy, employment is more limited and the sharing business assists the participating service providers to find customers more frequently.

5.4 Business Model Design

Developing business models that lead to successful and sustainable businesses is dependent on aligning suitable choices for customers, stakeholders and their motivations, value proposition, customer experience, channels, awareness, governance, security, credibility, trust, and privacy, among other things. These choices depend on the national

and local context and should be tailored accordingly in developing the business model for each venture.

The difference in approaches to last mile delivery for eCommerce is an illustrative case. The business in this case is eCommerce, which includes identification, selection and purchase of a product or service via the Internet and its delivery. Of these elements, product delivery is very much locally tailored. In many countries, there is a mature logistics infrastructure with third party providers and couriers providing physical delivery services. In contrast, in some other countries where the logistics infrastructure for local delivery is not as developed, eCommerce companies have adopted novel strategies to deliver goods to customers. They are experimenting with self-pickup or other innovative delivery channels such as establishing mini depots or lockers at heavily frequented shops, school campuses or community locations and / or utilizing crowd delivery mirroring the Uber model.

Policy Insight 2. Business model innovation can provide the means for local contextualization by empowering citizens and tailoring of both private sector and government services.

5.4.1 Customers, Stakeholders and Their Motivations

Knowing and understanding customers, other stakeholders and their respective motivations, expectations and needs are key factors in establishing successful businesses. Aligning stakeholders' motivations so that all stakeholders are benefitting from the service in a manner consistent with their interests is important for successful ventures.

Recommendation 2. Governments and private sector should ensure alignment of stakeholders' interests and motivations in the development and establishment of new businesses.

5.4.2 Value Proposition

Value proposition is the perceived benefits and costs of a business for different stakeholders and is important in any business model. Eyring, et al (2011) use this term to denote the cost of doing a job for a customer and the price the customer is willing to pay. In many cases, technology plays a key role in delivering value. A very recent example

is Zipline in Rwanda which delivers blood and medical products to 21 hospitals in Rwanda by fixed wing drones. Zipline's value proposition is to deliver quickly, reliably and with product integrity to Rwanda's rural hospitals that are often difficult to reach by road. Zipline makes deliveries seven days a week and also during rainstorms and at night. Zipline's value proposition also includes good customer experience with text based ordering and notification of the physician.

5.4.3 Customer Experience

Customer experience is the perception of the full range of interactions with other players and stakeholders that are involved in delivering a product or providing a service. When customers are satisfied with a given service or product, they expect the same quality of experience in other cases involving other businesses. The value of customer experience for a large transaction based business and a large subscription based business was quantified in Kriss 2014, where it was noted that customers in the transaction based business with customer experience score of 10 spent 140% more than those with customer experience score of 1 to 3 in the following year. Similarly, for the subscription based business, customers with experience score of 1 were only 43% likely to retain their subscription for the following year while those with a customer experience score of 10 were 74% likely to continue. The Canadian Government's Institute for Citizen-Centered Services has identified some important drivers for citizen's satisfaction of public service delivery, which are timeliness, outcome (receiving what was needed), extra mile (supportive staff), and fair and knowledgeable staff (Marson 2007).

Recommendation 3. Government policy makers and private business owners should consider customer experience as a key element in providing new services or establishing new businesses.

5.4.4 Channels

Channels are the paths for governments and private companies to connect with citizens and customers. Channels can include persons as in the citizen kiosks, Internet, phone, etc.. Two major channel trends are omnichannel in retail and multichannel service delivery in

governments. With the transition from the traditional retail stores to online shopping, shop owners are increasingly adopting a channel strategy of integrating online channels and their physical stores in a manner that provides an advantage over solely online retailers. In turn, some historically online only retailers such as Amazon are now opening physical stores. In a study of 46,000 shoppers at a major U.S. retailer from June 2015 to August 2016, it is reported that 7% shopped online only, 20% in store only and 73% utilized both online and in store channels. It was reported that customers, who were engaging through multiple channels, made more purchases in stores and online and were also more loyal (Sopadjieva, Dholakia Benjamin 2017). Multichannel service delivery is conceptually similar, but it integrates the back office in multiple paths (e.g., Internet, in person and phone) for customers to connect with a government service provider.

5.4.5 Awareness

Scaling Aadhaar to 1.1 billion enrolled Indian citizens required the development and successful implementation of a communications plan to increase awareness about Aadhaar and its value proposition amongst the India population. The Indian Government developed different messages for the rural and urban citizens highlighting the government's subsidies in the rural areas and conveniences for citizens in urban areas. Similarly, in order to increase the use of online services for renewing the driver's license, the State of Texas in the U.S. has utilized television and billboard advertising to promote the availability and value proposition of online renewal.

GSMA undertook an interesting study on the differences in the implementation and adoption of M-PESA in Kenya and Tanzania including a review of advertising strategy (GSMA 2009). The initial M-PESA advertisements in Kenya used the tagline "Send Money Home" which was tailored to the remittances sent from cities to rural villages by family members who had moved to cities for employment. Early adopters then promoted M-PESA to other citizens so they would also be on the network and send or receive transfers. In contrast, early advertising was not as effective in Tanzania, as Tanzania is not urbanized as Kenya and the tagline was not as effective. In addition,

advertisement needed to highlight the benefits of M-PESA as well as the benefits of having a financial account and being able to transfer money.

Consistent with the earlier discussion on localization and national differences in business needs, the strategy for building awareness also needs to be tailored to take into account the local conditions. Zarantonello, et al (2013) reviewed 256 commercial television tests from 23 countries and concluded that in general, functional advertising about a product's features and benefits was more effective in emerging markets while advertising that appeals to sensations, feelings and imagination was more effective in the economically developed areas.

5.4.6 Governance

Governance is also a key element of ICT-driven businesses. Casadesus-Masanell and Ricart (2011) define governance as how an organization (or system) approaches policy choices and asset choices in shaping its business. Aadhaar was rolled out by an innovative organizational structure called the Unique Identity Authority of India (UADAI). Established as an office in the India Planning Commission in 2009, UADAI comprised of leadership and staff from both the government and private sector. Nandan Nilekani, the co-founder of Infosys, was the first UADAI chairman having the rank of cabinet minister. In November 2010, sixteen months after UADAI's start, it had 140 staffs from the government and 60 from the private sector. UADAI also was innovative by having a hybrid government-high tech culture. The New Delhi headquarters operated in a manner closer to traditional Indian Government in terms of organizational structure and communications, but its Bangalore technology center was closer to that of a high tech startup. As a result, the Aadhaar' governance was shaped jointly by the government and the private sector.

Recommendation 4. Governments should encourage and facilitate joint initiatives through cooperation by different stakeholders, including the government, the private sector, and civil societies.

5.4.7 Security, Credibility, Trust and Privacy

Cybersecurity, credibility, trust and privacy are related though somewhat different, and each is a key element in ensuring the success and flourishing of ICT-driven businesses. Without effective cybersecurity in terms of confidentiality, availability and integrity, the customers and citizens will not use the services due to lack of trust and confidence. Privacy is increasingly becoming more important as wireless devices are vital elements of daily life around the world.

Trust and security are also vital in all ICT-driven services such as mobile banking. Ericsson ConsumerLab interviewed citizens in Kenya, South Africa, Ghana, Mexico, Argentina, Brazil, Vietnam, India and Indonesia in regard to the potential use and adoption of mobile banking services (Ericsson ConsumerLab 2015). A major finding was that security concerns are a major barrier to adoption of mobile banking services (other considerations included convenience and ease of use). In addition, “circles of trust” with relatives, friends and colleagues play an important role in loans and savings due to the trust in the existing social structures and distrust in newer or existing institutions.

Recommendation 5. Government policy makers in cooperation with the private sector should develop effective policies to enhance and ensure trust and confidence so that the end users utilize new ICT-driven services without fearing cyber threats.

5.4.8 Path to Scalability and Sustainability

A good business model provides a path to scalability and sustainability. In countries with large populations, the challenge is to scale quickly and effectively across the population. In countries with smaller populations and markets, the challenge is to design the business model in a way that can be adopted and then scaled. In general, the existing approaches to implement scalability and growth are: organic growth with selective outsourcing to partners, and multi-stakeholder partnership working with partners for scaling, licensing, open licensing and getting acquired.

Recommendation 6. Government policy makers and the private sector should encourage and facilitate scalability and sustainability in the design and deployment of new ICT-driven services and applications.

5.5 Conclusion

In this chapter, we highlighted the importance of establishing a business environment in which ICT-based innovative products, services, and applications can flourish, new jobs can be created and maintained, and sustainability in development can be achieved. We also emphasized the vital importance of meticulously utilizing the available tools and methods, such as the business model canvas, to develop realistic business models for ICT-based ventures. In addition, we provided short descriptions of the current trends and concepts in forming and offering ICT-based novel products and services, and discussed some important factors that are instrumental in establishing successful ICT-based business entities.

Acknowledgement

I would like to congratulate ITU-D for twenty-five years of fostering, facilitating and promoting the development of telecommunication networks as well as application of ICTs to many development and societal challenges. I also thank Dr. Eun-Ju Kim for organizing and leading the ICT④SDGs academic group, Director Brahima Sanou for his support and encouragement, Professor Ahmad R. Sharafat for his leadership and guidance and Dr. William H. Lehr for his many insights. Lastly, I would like to thank all of the academic group members – it has been a tremendous pleasure meeting everyone and discussing ICT4D and related topics.

References

- Casadesus-Masanell, Ramon and Ricart, Joan Eric (2009) “*From Strategy to Business Models to Tactics*”, Working Paper 10-036, Harvard Business School.
- Casadesus-Masanell, Ramon and Ricart, Joan Eric (2011) “*How to Design a Winning Business Model*”, Harvard Business Review, 89(1-2): 100-107.

ICT-centric economic growth, innovation and job creation

Constable, Harriet (2017), “*Kenya’s Booming Digital Sharing Economy*”, Africa Business Magazine, 5 January 2017.

Drucker, Peter (1994), “*The Theory of Business*”, Harvard Business Review, 72(5): 95-107.

Eyring, Matthew, Johnson, Mark and Nair, Hari (2011), “*New Business Models in Emerging Markets*”, Harvard Business Review, 89(1-2):89-95.

Fielt, Erwin, “Conceptualizing Business Models: Definitions, Frameworks and Classifications”, Journal of Business Models, 1(1):81-105.

Govindarajan, Vijay and Warren, Anita (2016), “*How Amazon Adapted Its Business Model to India*”, Harvard Business Review, 20 July 2016.

Goyal, Sandeep, McCord, Mark and Kapoor, Amit, “*Models in Fast Emerging Markets - Lessons from India*”, Thunderbird International Business Review, 59(1):23-32.

Gupta, Ishika, “*Villages Log in With Airjaldi*”, Hindu Business Online. 5 December 2014.

Gupta, Srishti, “*Aadhaar is Here to Stay: Nandan Nilekani*”, Live Mint, 16 Dec. 2015.

Hartmann, Phillip Max, Zaki, Mohamed, Feldmann, Niels, and Neely, Andy, “*Big Data for Business? A Taxonomy of Data Driven Business Models for Startup Businesses*”, University of Cambridge Working Paper, March 2014.

Harvard Business School Analytics Services (2011), Business Model Innovation in Emerging Markets: New Opportunities and Challenges.

Janowski, Tomasz, “*Digital Government Evolution: From Transformation to Contextualization*”, Government Information Quarterly, 32(3):221-236.

Johnson, Mark W., Clayton M. Christensen, and Henning Kagermann (2008). “Reinventing Your Business Model.” *Harvard Business Review*, 86 (12): 50-59.

Karnani, Aneel, “The Mirage of Marketing to the Bottom of the Pyramid: How the Private Sector Can Help Alleviate Poverty”, *California Management Review*, 49(4):90-111.

Kohler, Thomas (2015), “*Crowd-sourcing Based Business Models: How to Create and Capture Value*”, California Management Review, 57(4):63-84.

Kriss, Peter (2014), “*The Value of Customer Experience, Quantified*”, Harvard Business Review, 1 August 2014.

Kuhlmann, Stefan and Arnold, Erik (2001), “*RCN in the Norwegian Research and Innovation System*”, Background Report No. 12 in the Evaluation of the Research Council of Norway, Technopolis.

ICT-centric economic growth, innovation and job creation

Magretta, Joan (2002), “*Why Business Models Matter*”, Harvard Business Review, 80(5): 86-92.

Marson, Brian, “*Citizen-Centered Service Measurement in Canada: From Research to Results*”, OECD Senior Budget Officials Meeting, Madrid, October 2007.

“Mobile Commerce in Emerging Markets”, Ericsson ConsumerLab, 2015.

Meeker, Mary (2012), “*Internet Trends*”, Presented at the D10 Conference, Rancho Palos Verdes, California, 30 May 2012.

Morrison, Alla, “*How the Developing World is Using Open Data*”, World Economic Forum, 2014.

Muraga, Daniel, “*Mawingu: \$3 a month Kenyan internet via TV white space & the sun*”, IDG Connect, 10 September 2015.

“National Innovation Systems”, OECD, 1997.

Osterwalder, et al., Business Model Generation: A Handbook for Visionaries, Games Changes and Challengers, Hoboken, NJ: J. Wiley & Sons, 2010.

Oyedele, Adesegun (2016), “*Emerging Market Global Business Model Innovation*”, Journal of Research in Marketing and Entrepreneurship, 18(1):53-62.

“Pathways to Scale: A Guide for Early Stage Health Innovators on Health Models and Partnership Approaches to Scale Up”, U.S. AID Center for Accelerating Innovation and Impact, 2016.

Porter, Michael (1990), “*Competitive Advantage of Nations*”, Harvard Business Review, 68(2):73-93.

Prahalad, C.K., Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits”, Upper Saddle River, NJ: Prentice Hall, 2006.

Prahalad, C.K. and Hart, Stuart, L. 2002, “*Fortune at the Bottom of the Pyramid*”, Strategy+Business, 26, First Quarter 2002.

Schmida, S., Williams, I. and Lovegrove, C. (2016), “*Business Models for the Last Billion: Market Approaches to Increasing Internet Connectivity*”, U.S. Agency for International Development.

Sopadjieva, E., Dholakia, U. and Benjamin, B., “*A Study of 46,000 Shoppers Shows That Omnichannel Retailing Works*”, Harvard Business Review, 3 January 2017.

Stinson, Liz (2014), “*With Stunning New Stores, Starbucks Has a New Design Strategy: Act Local*”, Wired, 8 January 2014.

Taylor, Ben (2013), “*Let’s Make a Success of Failures*”, SciDev.Net, 8 January 2013.

Teece, David (2010), “*Business Models, Business Strategy and Innovation*”, Long Range Planning, 43: 172-194.

ICT-centric economic growth, innovation and job creation

- Van Alstyne, Marshall, W., Parker, Geoffrey, G., and Choudary, Sangeet Paul (2016), “*6 Reasons Platforms Fail*”, Harvard Business Review, 31 March 2016.
- Van Alstyne, Marshall, W., Parker, Geoffrey, G., and Choudary, Sangeet Paul (2016), “*Pipelines, Platforms and the New Rules of Strategy*”, Harvard Business Review, 94(4):54-60.
- Warnke, Philine et al. (2016), “*Opening Up the Innovation System Framework to New Actors and Institutions*”, Innovation Systems and Policy Analysis, 49:1-46.
- “What Makes a Successful Mobile Money Implementation: Learnings from M-PESA in Kenya and Tanzania”, GSMA, 2009.
- Wolverton, Troy (2017), “*Personalization Makes Pandora a Worthy Rival to Spotify*”, The Denver Post, 27 March 2017.
- Zarantonello, Lia, Jedidi, Kamel and Schmitt, Bernd (2013), “*Functional and Experiential Routes to Persuasion: An Analysis of Advertising in Emerging Markets Versus Developed Markets*”, International Journal of Research in Marketing , 30:46-56.
- Zott, Christophe, Amit, Raphael and Masso, Lorenzo (2011), “*The Business Model: Recent Developments and Future Research*”, Journal of Management, 37(4):1019-1042.
- Zhu, Feng and Furr, Nathan, “*Products to Platforms: Making the Leap*”, Harvard Business Review 94(4):72-78.

Biography

Jean-Pierre Auffret is Co-Founder of the International Academy of CIO, an NGO in Tokyo, Japan with to foster best practices on CIO and ICT leadership. He is also Director of Research Partnerships in the School of Business and Associate Director in the Center for Assurance Research and Engineering in the Volgenau School of Engineering at George Mason University. Dr. Auffret's work and research span a range of applied technology fields including ICT leadership and governance and cybersecurity and with APEC, NSF, IBM and World Bank. He has 30 years of industry and academic experience including executive positions with MCI and its joint venture with British Telecom, Concert, and academic positions with George Mason University, Duke University and American University. Dr. Auffret earned a B.S. from Duke University where he was an A.B. Duke Scholar, M.B.A. from the University of Virginia and Ph.D. in Physics from American University.

Chapter 6

Job Creation and Sustainable Development

*Raul L. Katz**

This chapter reviews the evidence generated from academic research on the impact of ICTs on employment. It outlines three types of employment effects: the “construction effect” which yields direct, indirect and induced jobs resulting from the deployment of telecommunication networks and data centers; the “spill-over effect” on jobs in the traditional economy, which can simultaneously lead to new jobs triggered by unlocking scalability in certain sectors while reducing jobs through enhanced productivity in other labor-intensive industries; and the “innovation” effect, which involves creation of new jobs due to the development and introduction of new services and applications such as telemedicine, Internet information searches, electronic commerce, distance education and social networks, new forms of trade and financial intermediation, and the development of new products and services. Additionally, empirical evidence is reviewed on the impact of ICTs on labor conditions, emphasizing positive contributions, such as flexibility and income growth. On the basis of this evidence, public policy prescriptions are outlined to maximize job creation and help mitigate any potential disruptions in labor markets that are likely to occur as a result of the diffusion of ICTs.

* Columbia Institute for Tele-Information, Columbia University, New York, USA

6.1 Introduction

The Sustainable Development Goal (SDG) 8 establishes “Promotion of inclusive and sustainable economic growth, employment and decent work for all” as a key objective. More specifically, SDG 8 states that “Putting job creation at the heart of economic policy-making and development plans, will not only generate decent work opportunities but also more robust, inclusive and poverty-reducing growth.”

In this context, it is absolutely pertinent to research how Information and Communication Technologies (ICTs) ¹⁷¹ can contribute to achieving this objective. The purpose of this chapter is to present the evidence that has been generated from academic research over the past years on the impact of ICTs on employment. On this basis, specific recommendations will be put forward to both create new jobs and replace those that would be lost due to the impact of automation with other ones. The chapter begins by presenting research on the impact of ICTs on job creation, putting it in the context of overall economic contributions. Following this, empirical evidence will be presented on the impact of ICTs on labor conditions, emphasizing aspects such as flexibility and incomes. The evidence will show, as is the case in many areas of social science, that the contribution of ICTs to job creation can only be detected under certain conditions. This is why the third section of this chapter will provide public policy prescriptions that can help mitigate any potential disruptions in labor markets that are likely to occur as a result of the diffusion of ICTs.

6.2 ICT Contribution to Job Creation

ICTs contribute to economic growth initially through a series of effects similar to those generated by the deployment of any type of

¹⁷¹ Here, ICT means the integration of information technology (computing, cloud processing, etc.) and telecommunications networks (fixed and mobile broadband access). It also includes all the functionality associated with the Internet use. Most empirical research on the economic impact of ICTs focus on a specific technology, such as broadband, in order to generate a measurable independent variable. Throughout this chapter, when research has been conducted on broadband impact on job creation, it is considered to be a key component of the ICT value chain.

infrastructure. Beyond deployment effects, ICTs, as general-purpose technologies, generate externalities, ranging from GDP growth to job creation and enhancement of consumer surplus.

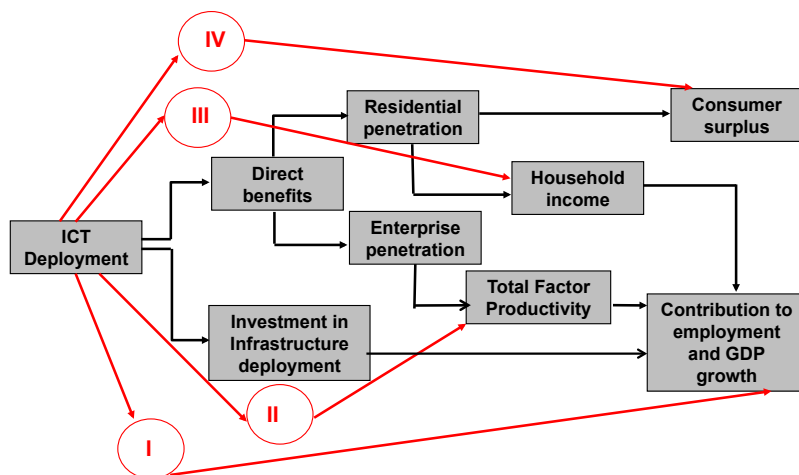


Figure 1. Social and Economic Contribution of ICTs

Source: Katz (2012)

Figure 1 depicts four distinct social and economic contributions of ICTs. Effect I refers to the impact on GDP and job creation resulting from investing in the deployment of fixed and mobile broadband networks, as well as data centers (also called the “construction effect”). Effect II depicts the impact of ICTs on business productivity by reducing transaction costs and enhancing the efficiency of enterprises (sometimes referred to as the “spillover effect”). Effect III posits the increase in the average household income as a result of enhancing the capacity of the population to market its skills. Effects II and III contribute in turn to GDP growth. Effect IV, which is not captured in the GDP statistics, has to do with an increase in consumer surplus, which is measured as the value created to consumers when they access the Internet (for example, to use e-Government and e-Health applications, or download information and entertainment). This section will present the results of research conducted over the past twenty years in support of the argument that ICTs have a significant impact on job creation.

The “Construction” Effect

The construction of fixed and mobile broadband networks, combined with the deployment of data centers, has three effects on job creation. First, ICT infrastructure deployment creates direct jobs (for example, technicians, construction workers and equipment manufacturing operators) to install these networks. Second, direct job creation has an impact on indirect jobs (for example, metallurgical and electrical product industries that supply inputs to the industries directly involved). Finally, household spending generated by direct and indirect jobs leads to induced employment.

Input-output tables help calculating the direct, indirect, and induced effects of ICT infrastructure construction on employment and production. The interrelationship of these three effects can be measured through multipliers, which estimate how one unit change on the input side affects total employment change throughout the economy (Figure 2).

As such, input-output analysis helps determine the impact on GDP and jobs created by broadband deployment. For example, this author (Katz et al., 2009) estimated that the investment by the US government in broadband deployment in 2009 as part of the American Recovery and Reinvestment Act (US\$ 6.4 billion) would result in the creation of 128,000 direct, indirect and induced jobs/year¹⁷².

There are, at least, six studies that estimate the impact of ICT infrastructure construction on employment based on input-output matrices: Crandall et al. (2003), Katz et al. (2008), Atkinson et al. (2009), Katz et al. (2009), Liebenau et al. (2009), and Katz et al. (2010a). All of these studies estimate the number of jobs created as a result of capital investment for the deployment of broadband networks: US\$ 63 billion required to deploy broadband services throughout the U.S. (Crandall et al., 2003); CHF 13 billion to build a national fiber optic network in Switzerland (Katz et al., 2008); US\$ 10 billion (Atkinson et al., 2009) and US\$ 6.3 billion as part of counter-cycle stimulus packages in the

¹⁷² These did not include any secondary job creation resulting from broadband spillovers.

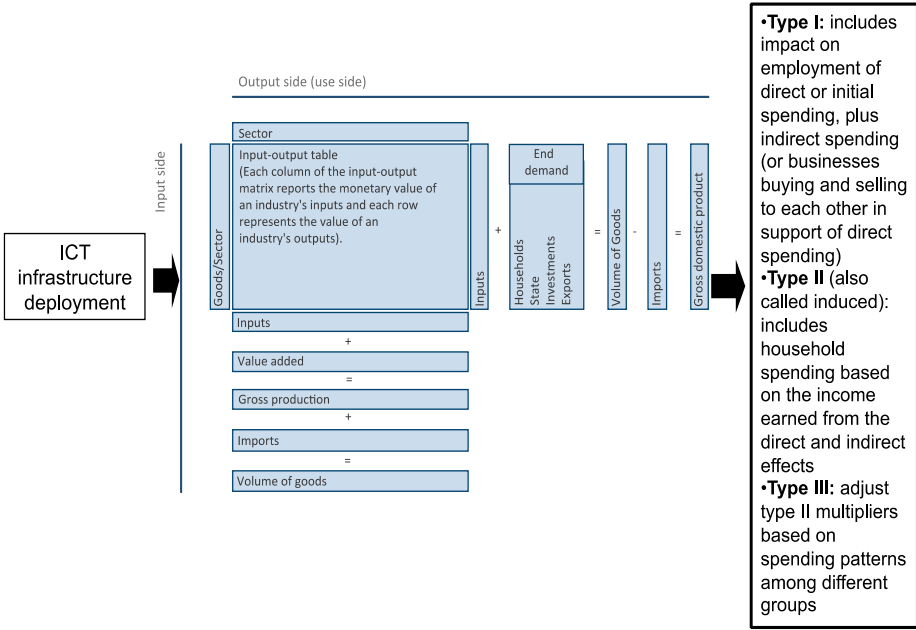


Figure 2. Structure of Input-output Table

Source: Adapted from Katz et al. (2008)

United States (Katz et al., 2009); US\$ 7.5 billion to complete the deployment of broadband in the United Kingdom (Liebenau et al, 2009); and US\$ 47 billion to implement the National Broadband Plan in Germany (Katz et al., 2010a). All of these studies have calculated multipliers¹⁷³, which measure the total employment change throughout the economy resulting from the deployment of a national broadband network (Table 1).

¹⁷³ All studies that have relied on input-output analysis have calculated multipliers, which measure the total employment change throughout the economy resulting from the deployment of a broadband network. Beyond network construction (direct employment effects), broadband construction has an employment effect at two additional levels. Following the sector interrelationships of input-output matrices, network deployment will result in indirect job creation (incremental employment generated by businesses selling to those that are directly involved in network construction) and induced job creation (additional employment induced by household spending based on the income earned from the direct and indirect effects).

In the input-output studies, two types of multipliers are considered: Type I multipliers measure the direct and indirect effects (direct plus indirect divided by the direct effect), while Type II multipliers measure Type I effects plus induced effects (direct plus indirect plus induced divided by the direct effect). Cognizant that multipliers from one geographic region cannot be applied to another, it is useful to observe the summary results for the multipliers of the six input-output studies.

According to the sector interrelationships in Table 2, European economies appear to have lower indirect effects than the United States. Furthermore, the differentiation of multipliers also indicates that a relatively important job creation effect occurs as a result of household spending based on the income earned from the direct and indirect effects. These induced effects are also significant.

While the input-output table is a reliable tool for predicting investment impact, two words of caution need to be given. First, input-output tables represent static models reflecting the interrelationship between economic sectors at a certain point in time. Since those interactions may change, the matrices may lead us to overestimate or underestimate the impact of network construction. For example, if the electronic equipment industry is outsourcing jobs overseas at a fast pace, the employment impact of broadband deployment will diminish over time and part of the potentially counter-cyclical investment will “leak” overseas. Second, it is critical to break down employment effects at the three levels estimated by the input-output table in order to gauge the true direct impact of broadband deployment. Having said this, all these effects have been codified and hence, with the caveat of the static nature of input-output tables, we believe that the results are quite reliable.

The “Spill-Over” Effect

Beyond job creation as a result of the construction of broadband networks, ICTs can help relax scalability constraints, thereby allowing traditional sectors of the economy to grow more rapidly. It is common to observe that many traditional sectors of the economy are growth-constrained by limited access to resources such as raw materials or distribution channels. In this context, ICTs can provide a way to allow

businesses to scale further, addressing additional final demand and thereby creating increased need for factor inputs, such as labor.

Table 1. Broadband Construction Impact on Job Creation

Country	Study	Objective	Results
United States	Crandall et al. (2003)	Estimate the employment impact of broadband deployment aimed at increasing household adoption from 60% to 95%, requiring an investment of US \$ 63.6 billion	<ul style="list-style-type: none"> • Creation of 140,000 jobs per year over ten years • Total jobs: 1.2 million (including 546,000 for construction and 665,000 indirect and induced)
	Atkinson et al. (2009)	Estimate the impact of a US \$10 billion investment in broadband deployment	<ul style="list-style-type: none"> • Total jobs: 180,000 (including 64,000 direct and 116,000 indirect and induced)
	Katz et al. (2009)	Estimate the impact of 2009 broadband stimulus bill included in the American Recovery Act	<ul style="list-style-type: none"> • Total jobs: 127,000 (including 37,000 direct, 31,000 indirect, and 59,500 induced)
Switzerland	Katz et al. (2008)	Estimate the impact of deploying a national broadband network requiring an investment of CHF 13 billion	<ul style="list-style-type: none"> • Total jobs: 114,000 over four years (including 83,000 direct and 31,000 indirect)
United Kingdom	Liebena u et al. (2009)	Estimate the impact of investing US \$ 7.5 billion to achieve the target of the " <i>Digital Britain</i> " Plan	<ul style="list-style-type: none"> • Total jobs: 211,000 (including 76,500 direct and 134,500 indirect and induced)
Germany	Katz et al, (2010a)	Estimate the impact of Germany's 2014 National Broadband Strategy	<ul style="list-style-type: none"> • Total jobs: 304,000 (including 158,000 direct, 71,000 indirect, and 75,000 induced)

Table 2. Employment Multiplier Effects of Studies Relying on Input-Output Analysis

Country	Study	Type I	Type II
United States	Crandall et al. (2003)	N.A.	2.22
	Atkinson et al. (2009)	N.A.	1.81
	Katz et al. (2009)	1.84	3:45
Switzerland	Katz et al. (2008)	1.37	N.A.
United Kingdom	Liebenau et al. (2009)	N.A.	2.76
Germany	Katz et al. (2010a)	1.45	1.92

Note: Crandall et al. (2003) and Atkinson et al. (2009) do not differentiate between indirect and induced effects, therefore Type I multipliers cannot be calculated; Katz et al. (2008) did not calculate Type II multiplier because induced effects were not estimated.

Source: Adapted from Katz (2012)

The initial push for alleviating the scalability constraint has been identified in several pieces of research:

- Improved productivity as a result of the introduction of more efficient business process support by ICTs, and marketing of excess inventories and supply chain optimization ¹⁷⁴ (Atkinson et al., 2009)
- Revenue growth resulting from extended market coverage (Varian et al., 2002 and Gillett et al., 2006)
- Impact on the composition and deployment of industrial value chains. ICTs can attract jobs from other regions as a result of the ability to process information and provide services remotely. The services most greatly impacted are outsourcing and the deployment of virtual customer care centers.

For example, with regards to business expansion, Clarke (2008) studied the impact of broadband access on exports of manufacturing and service

¹⁷⁴ Efficient telecommunications make it possible to reach a broader market, facilitating business processes. They also result in reduced input costs as the capacity to search for lower prices increases.

firms. The analysis was performed for countries of medium and low levels of development in Eastern Europe and Central Asia. The study controlled for variables such as firm size, industrial sector, foreign ownership, firm performance, level of domestic competition, international trade organization affiliation, progress in privatization, and telecommunication infrastructure. The author found that in the manufacturing sector, firms with broadband Internet access generated 6% more foreign sales than the rest. This particular effect has been well researched in the microeconomics literature. The opportunity provided by broadband to increase market reach and seek out the highest possible selling price in open economies is essential in the development of a vibrant manufacturing sector. In the service sector, firms with broadband Internet access generate between 7.5 % and 10 % more sales. In this case, the impact is primarily driven by enhanced access to foreign markets. In both cases of manufacturing and service industries, broadband improves export performance by facilitating communication with foreign buyers, improving information on overseas markets, consumers and standards, by ultimately linking the enterprise to consumers, and by allowing to bid for contracts or participate in business-to-business platforms.

Research has also allowed extending the causality from alleviation of the resource constraint to increased demand for labor. According to Crandall et al. (2007), the job creation impact of broadband tends to be concentrated in service industries, (e.g., financial services, education, health care, etc.) although the authors also identified a positive effect in manufacturing as well. In another study, Shideler et al. (2007) found that for the state of Kentucky in the United States, county employment was positively related to broadband adoption in multiple sectors, including manufacturing and certain services. This specific effect has also been analyzed by Katz et al. (2010b) for rural economies of the United States. In this research, it was found that within rural counties, broadband penetration contributed to job creation in financial services, wholesale trade and health sectors. This is the result of enterprise relocation enabled by broadband, which benefits primarily urban communities in the periphery of metropolitan areas (Katz et al. 2010b). The only sector where a negative relationship was found with the

deployment of broadband (0.34% – 39.68%) was the lodging and food services industry. This was the result of a particularly strong capital/labor substitution process taking place, whereby productivity gains from broadband adoption reduced employment. Similarly, Thompson and Garbacz (2008) concluded that for certain industries, “there may be a substitution effect between broadband and employment”¹⁷⁵. Therefore, one may conclude that while alleviating scalability constraints in certain sectors, the productivity impact of broadband can cause capital-labor substitution and may result in a net reduction in employment.

In summary, research on job creation in the traditional economy is starting to pinpoint different ICT employment effects by industry sector. ICTs may simultaneously cause labor creation triggered by unlocking scalability in certain sectors while enhancing productivity in other labor-intensive industries. Nevertheless, while a robust explanation of the precise effects by sector and the specific drivers in each case is still missing, it is reasonable to expect that the deployment of ICTs should not have a uniform impact across the “old” economy.

The “Innovation” Effect

Beyond job creation in the traditional economy, the impact of ICT externalities on employment, referred to as “innovation effects” or “network effects” (Atkinson et al. 2009) have also been quantified. By studying the externalities resulting from the adoption of ICTs, at least four effects have been identified:

- Introduction of new services and applications such as telemedicine, Internet information searches, electronic commerce, distance education and social networks (Atkinson et al., 2009). For example, in countries with high broadband penetration, by 2015 the percentage of total retail trade conducted through electronic commerce had already exceeded 10% (South Korea: 15.09%, Denmark: 12.63%, United Kingdom: 13.41%)¹⁷⁶.

¹⁷⁵ This effect was also mentioned by Gillett *et al.* (2006).

¹⁷⁶ Source: Euromonitor.

- New forms of trade and financial intermediation (Atkinson et al., 2009). A correlation analysis of Internet penetration versus electronic commerce as a percentage of total retailing per country indicates that after Internet adoption reaches a threshold of approximately 60%, electronic commerce flows as percentage of retailing tend to grow exponentially. In other words, the Internet creates a new more efficient retail distribution channel, which is massively adopted by consumers (Katz, 2017).
- Development of new products and services (Atkinson et al., 2009), such as the whole range of collaborative platforms that characterize the digital economy (Uber, Airbnb).
- Growth of some industries within the services sector (Crandall et al., 2007): For example, growth in software development and business process outsourcing. Abramovsky et al. (2006) analyzed an extensive dataset of UK firms and found that broadband Internet use increases the probability of a firm offshoring business processes and services between 6% and 12%, from which an emerging economy can greatly benefit.

Additionally, ICTs have been found to have a positive impact on the development of new businesses. This results from the network effects of connectivity. When a large enough number of households are connected to broadband, the incentive to develop new businesses around information search, advertising and electronic commerce increases. For example, Crandall et al. (2007) estimated that the network effects of universal broadband access could have a multiplier of 1.17 on the investment in infrastructure. Similarly, as a result of 40% lower broadband penetration in the United Kingdom, Liebenau et al. (2009) estimated the multiplier to be somewhat lower (0.33) for the British economy. This would imply that innovation effects increase with broadband penetration, a concept akin to “return to scale”.

- Empirical evidence has also been generated to support the existence of an “innovation effect” triggered by ICTs. For example, the entertainment sector is an important component in the supply and demand for digital content. The development of the Internet has resulted in the emergence of a huge potential market for creating local content and applications in native languages. In addition to

creating jobs in the production, distribution and management of a local content digital industry, its development has multiple benefits, including helping to strengthen national cultural identities, reducing foreign trade imbalances, and promoting demand for local ICT infrastructure services (e.g., domestic ISPs and cloud services to support domestic content). Our analysis of the 100 most popular Internet sites by country around the world indicates that in many emerging countries, locally developed sites represent only between 15 and 20. The development of local digital content entails enormous opportunities not only to develop a vibrant domestic content and applications industry but also to meet the needs of population that would only adopt broadband if they were to find a product that is culturally relevant to its needs.

- Similarly, on-line B2B and B2C platforms allow domestic businesses to address international markets, which in turn, yield an increase in employment. As an example, as of 2015, the videogame industry in Latin America comprised 418 companies employing approximately 7,000 developers, while developers of applications relying on Facebook platform amounted to approximately 20,000 (Katz, 2015). In the case of Latin America, *Mercado Libre*, the most important e-Commerce platform has triggered the creation of approximately 120,000 registered users offering their goods through the network¹⁷⁷. This number vastly exceeds the direct jobs created by the platform (2,635). Additional new jobs created by the “new” economy could include support services for these businesses include advertising, platform maintenance and management, and the like.

Aggregate Estimation of Externalities

Job creation as a result of ICT externalities in the “old” and “new” economies has been studied by using econometric analysis of historical data series, and has provided important conclusions. These studies have been carried out initially in the United States. However, once time series became available internationally, several studies were completed in other countries as well. Table 3 presents the econometric studies that

¹⁷⁷ Mercado Libre (2015). *Business Overview*.

were used to estimate the impact of ICTs on creating jobs as a result of positive externalities.

According to these studies, once broadband is deployed, its contribution to employment growth ranges from 0.14% to 5.32%, depending on the territory and the industrial sector composition. More precisely, a 1% increase in broadband penetration contributes between 0.002% and 0.5% to employment growth.

Like the relationship between ICTs and GDP growth, its contribution to employment is also conditioned by a number of special effects that need to be considered when formulating public policy initiatives. As an example:

- Is there a decreasing return in employment generation linked to ICT infrastructure penetration?
- Does the impact of ICTs on employment differ according to geographies?

On the first question, some researchers have found a decreasing impact of ICTs on employment. While Gillett et al. (2006) observed that the magnitude of impact of broadband on employment increases over time, they also found that the positive contribution of broadband to employment tends to diminish as penetration increases. This finding may support the existence of a saturation effect. Coincidentally, Shideler et al. (2007) also found a negative but statistically significant relationship between broadband saturation and employment generation. This would indicate that at a certain point of broadband deployment, the capability of the technology to have a positive contribution to job creation starts to diminish. The evidence regarding declining returns on job creation is not that clear, however. On the one hand, as it has been demonstrated in diffusion theory, early technology adopters are generally those who can elicit the higher returns of a given innovation.

Conversely, network externalities would tend to diminish over time because those effects would not be as strong for late adopters. On the other hand, while job creation in traditional industries tends to diminish, the emergence of “new economy” jobs compensates for the former effect. Clearly, the job mix will change over time but the positive net impact will remain.

Table 3. Impact of Positive ICT Externalities on Employment

Country	Authors	Data	Effect
Germany	Katz, et al. (2010a)	2000-2006 for Germany counties	A 1% increase in broadband penetration contributes to employment growth by 0.002%
United States	Gillett, et al. (2006)	1998-2002 United States zip codes	Availability of broadband access increases employment growth between 1% and 0.5%
	Crandall, et al. (2007)	For 48 states in the United States	For every 1% increase in broadband penetration in each state, employment would increase by an estimated 0.2%, and 0.3% per year if the economy were not at full employment.
	Thompson, et al. (2009)	2000-2006 for 48 states in the United States	Job creation varied by industry
State of Kentucky (United States)	Shideler, et al. (2007)	Data broken down by county in the state of Kentucky for 2003-4	A 1% increase in broadband penetration contributed between 0.14% and 5.32% to employment growth, depending on the industry.
State of California (United States)	Kolko (2010)	1999-2006 for California zip codes	The study does not find a significant relation in part because broadband service availability is measured based on the number of operators per zip code.
Ecuador	Katz & Callorda (2013)	Econometric model of Ecuador data between 2008 and 2012	0.56% increase in employment rate for every 10 % increase of fixed broadband penetration
Worldwide	Katz (2015)	Econometric model of 144 countries measuring the job impact of digitization, controlling for fixed capital formation and human capital	10% increase in the digitization index yields a 0.72% reduction in unemployment rate

On a related issue, the impact of ICTs on job creation also varies between developed and emerging regions. The research on broadband impact in Germany (Katz et al., 2010a) highlighted differential job creation impact between advanced and emerging regions. In regions with high broadband penetration, once penetration increased, the effect of job creation is significant in the short term, fading over time due to a potential saturation effect. On the other hand, in places with low broadband penetration, the increase in broadband deployment results in a negative impact on job creation (in other words, a reduction in the number of jobs) in the short term, reaching a positive effect in the long term. A comparison of these effects is shown conceptually in Figure 3.

Each graph conceptually depicts the impact that an increase in broadband penetration at time T would have over time (horizontal axis labeled T+1, T+2, etc.) in a given region. In the graph to the left in Figure 3, the deployment of broadband in geographies exhibiting high penetration at the inception point is extremely high both in terms of GDP and job creation. Increased broadband deployment in more advanced regions creates a “supply shock” within the context of companies who can immediately leverage technology to generate new businesses, as described above, while yielding production efficiencies. The fact that employment and GDP grow in parallel indicates that broadband is having a significant impact both on innovation and business growth, thereby overcoming any potential employment reduction resulting from productivity effects.

In contrast, in regions with lower broadband adoption (graph to the right in Figure 3), the increase in broadband penetration leads to an initial substitution between capital and labor, in which the productivity generated by the technology produces a decline in employment. This effect was alluded to by Gillett et al. (2006) in indicating, “broadband can facilitate the capital-labor substitution, resulting in lower rate of employment growth.” Thompson et al. (2008) also mentions “it is possible that a substitution effect between broadband and employment exists.” In the medium term, the increase in adoption has a positive job impact, which can be explained in terms of learning in the assimilation of the technological input and the generation of innovations that create jobs. In other words, in those regions lagging behind in ICT penetration,

ICT-centric economic growth, innovation and job creation

the effect of broadband is increased productivity in the short term and, as a result, the loss of jobs; in the medium and long term, innovation leads to job creation.

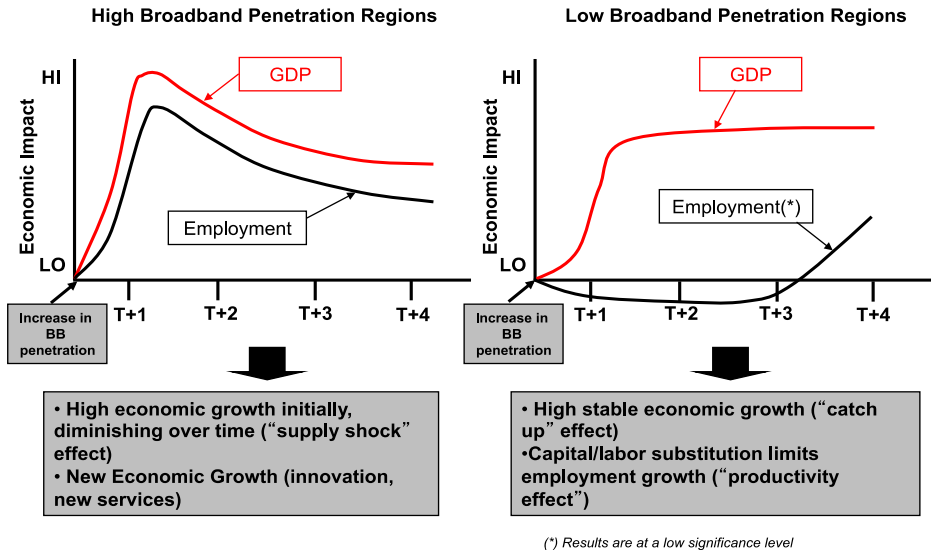


Figure 3. Impact of ICT Infrastructure on Job Creation

Source: Katz et al. (2010a)

In sum, while there is a strong consensus in the positive and statistically significant effect of ICTs on economic growth and job creation, when comparing findings across research, a number of caveats need to be raised. First, ICTs have a stronger productivity impact in sectors with high transaction costs, such as financial services. In some industries, this effect unlocks a resource constraint leading to an increase in labor. Second, in less developed regions, as postulated in economic theory, ICTs enable the adoption of more efficient business processes, leading to capital-labor substitution and, therefore loss of jobs (this could be labeled the "productivity shock theory"). Third, the impact of ICTs on small and medium enterprises takes longer to materialize due to the need to restructure the firm's processes and labor organization in order to gain from adopting the technology (called "accumulation of intangible capital").

6.3 ICT Contribution to Labor Conditions

In recent years, conducting the national household surveys that now include ICT modules has allowed to research the impact of ICTs based on microeconomic data. For example, using information from the Peruvian households between 2007 and 2009, De Los Rios (2010) found that, during this time period, the Internet adopters experienced significant income growth relative to those households that did not have the service.

The author of this chapter conducted a study evaluating the impact of ICTs on household income in Ecuador (Katz and Callorda, 2013). To estimate the contribution of ICTs on poverty reduction using microdata, the authors calculated the impact of broadband deployment on the average income at the provincial level. Ecuador is an appropriate case for this analysis because, while at the end of 2009 the country had a limited offering of residential broadband services, between that year and 2011, CNT (Ecuador's telecommunications incumbent fixed broadband provider) greatly expanded its coverage. As a result, the population in newly served townships could access fixed broadband service for the first time. This expansion led to a significant increase in broadband penetration at the provincial level in the country. Based on disaggregated data, a variable was built indicating the regions that lacked broadband access in 2009 (due to a lack of coverage) but gained service by late 2010 / early 2011 (thanks to the aforementioned extension of the state-owned telecommunications operator's network). Through this process, two groups were created: 1) a treatment group, comprised of those individuals living in regions where broadband was introduced during the 2010-11 period, and 2) a control group, comprised of those individuals living in regions that already had access to residential broadband services by the fourth quarter of 2009. Using this approach, and given that the treatment group and the control group are statistically equal at the baseline of the observed variables, a regression model that estimates the impact of treatment on individual income levels was built. Controls were included for the variables that at the individual level can affect income (age, gender, employment status and healthcare coverage, level of formal education, and role within the family).

The results indicated that broadband adoption increased the average individual income by US\$ 25.76, which represents a 7.48% increase in relation to the initial average income of the entire sample. Given that the introduction of broadband occurred over the course of two years - between December 2009 and December 2011 - the *annual* increase in the income level was 3.67%. This figure captured the increase in income generated directly by broadband use, the impact on the job market as a result of the labor required for network deployment and the new staff hired by companies to provide the service, as well as the spillover effect on society. The impact on income was shown to be greater among households owning a computer. As evidence, computer users witnessed an average income increase of US\$ 38.36, which equates to a total 8.00% increase, or 3.92% per year. Finally, the largest impact occurred among the Internet users, who benefited from increased speed and, in the case of those users who previously used dial-up Internet, elimination of the incremental cost of usage. Users who could access the service directly in their homes as a result of network deployment also benefited. For this group, the increase in the income level was substantially greater than in the previous cases: Their income increased by US\$ 51.86, a 10.27% rise relative to their initial income, or a 5.01% increase per year. A somewhat similar effect has been identified by Bohlin et al. (2012). A study covering a cross-section of 8 OECD countries and 5 emerging countries detected that in OECD countries, access to 4 Mbps service increased household income by US\$ 2,100 per year. In the three emerging nations, introducing a 0.5 Mbps broadband connection increases household income by US\$ 800 per year. This last estimate, covering Brazil, Mexico, South Africa, India and urban China is fairly close to the microdata-based model developed by Katz and Callorda (2013). Similarly, Dutz et al. (2009) showed with US data that gaining access to broadband-enabled applications enables more effective and productive ways of working, thereby boosting personal productivity.

This research demonstrated that the introduction of broadband services has a positive impact on household income, as well as working conditions. While the causes for this increase can vary, broadband does have an impact through four effects. First, broadband deployment

requires infrastructure construction in order to provide the service (the “construction” effect referred to above), additional workers for the operator’s new commercial offices, and technical personnel for the installation and maintenance of the new infrastructure. The new demand for labor in a market with an unemployment rate that is already below 5% generates a shift in the demand curve for workers, which leads to an increase in equilibrium wages. In other words, at full employment, additional demand for workers tends to result in an increase in compensation. Furthermore, the rise in wages through this channel may reflect a need for better compensation for those workers who, given the low unemployment rates, should receive better wages to meet or exceed their expectations.

A second explanation for the income increase is that, as seen in Katz (2012), broadband has a positive effect on worker productivity. Classic labor economics literature shows that wages in competitive markets equal marginal productivity. As a result, higher labor productivity should yield higher wages. This is labeled as the “productivity effect”.

Third, research also shows that the effect of broadband deployment is greater for computer and Internet users. In this sense, the introduction of broadband allowed workers with digital literacy skills to signal their computer knowledge to potential employers and then use those skills in the workplace in return for a higher wage. We call this impact the “skill signaling effect”.

Finally, the introduction of ICT can also help to reduce the time otherwise required for an effective job search, allowing underemployed workers to look for full-time work using broadband services. This increase in efficiency leads to a reduction in unemployment periods and generates an increase in the migration of underemployed workers to full-time positions, which, in turn, results in higher labor income. In other words, reduced transaction costs related to finding employment can ultimately result in higher income.

6.4 Public Policy Implications

Research has generated compelling evidence that concludes under certain conditions, ICTs have a positive contribution to job creation.

Firstly and foremost, the evidence is fairly conclusive about the contribution of ICTs to job creation in the “new” economy. As a result, ICT employment impact is higher when promotion of the technology is combined with stimulus of innovative businesses that are tied to new applications. While the size of this contribution varies, discrepancies can be related to different datasets as well as model specifications. Secondly, ICTs contribute to employment growth with spillover impacts on the rest of the “traditional” economy. While deployment programs are, as expected, concentrated in the construction and telecommunication sectors, the impact of externalities are greater in sectors with high transaction costs (financial services, education, and health care). Thirdly, ICTs can also contribute to “job destruction” particularly in certain labor-intensive sectors as a result of the productivity effect or in certain geographies with low ICT penetration.

In other words, the impact of ICTs on job creation is neither automatic nor uniform across the economic system. This emphasizes the importance of implementing public policies not only for ICTs, but also in education, economic development and planning, science and technology, finance, and others especially in the converged ecosystem. Among the initial recommendations, the followings are highlighted.

1) Coordinate ICT Infrastructure Deployment with Job Creation and Retention Programs

Externalities resulting from ICT deployment programs can be sizable. However, their fulfillment is driven by success in implementing job creation and retention programs in parallel with infrastructure deployment. As an example, governments need to work with private sector companies in using this new infrastructure for employment generation. In many cases, job creation is not an automatic effect resulting from broadband deployment. Broadband construction has to be followed by additional stimuli such as establishing innovation labs geared to launching applications, adopting new business models, and developing new digital content.

On the other hand, it is critical to deploy initiatives aimed at creating ICT-enabled jobs. As an example, governments should stimulate the development of rural virtual call centers as a way to bring jobs that were

outsourced overseas. Virtual call centers rely on rural population linked to a centrally located supervisor. They have become increasingly popular in the US due to the quality of the labor pool and economics close to matching call centers overseas. Virtual call centers rely on home-based agents to complement/replace traditional call centers from emerging markets. This concept, enabled by home-based information technology and broadband infrastructure, has a number of distinctive advantages. It avoids overhead related to traditional call centers, including real estate and utilities, as well as up-front investment/capital expenditures – particularly for the rapid-growth companies. It lowers staff turnover due to work from home and flexible schedules, and improves service level and/or labor utilization due to flexible staffing – management of time of day and seasonal peaks. Finally, it provides greater responsiveness to unforeseen changes in demand and lowers labor costs by being able to attract talent at lower wages and benefits. From an economic standpoint, a virtual call center located in an industrialized country offers 15%-30% cost advantage over the traditional centralized model

2) Carefully Select Areas to Accelerate ICT Deployment

Consider deployment not only in unserved and underserved areas, but also in regions where the possibility of developing regional growth, in coordination with ICT deployment, could act as a magnet to stimulate relocation, business creation, and, consequently, jobs. While it is possible that private operators have already targeted such areas, it is reasonable to assume that opportunities for regional core development could also be found. The experience of Germany, Sweden and the Netherlands could be very instructive in this regard. Along those lines, policy makers, particularly in emerging countries, facing decisions of where to focus ICT deployment, need to consider important trade-offs. A natural inclination might be to address any inclusion gaps, by focusing the universal service funds on the unserved areas (e.g., rural and isolated areas with concentration of disadvantaged population). However, it is important to emphasize that other options could be available. For example, how about focusing on areas where ICTs could have a maximum economic impact, with subsequent social spill-overs (for example, bring the ICT infrastructure up to world class

performance)? This raises the need to equip government planning units with the necessary social and economic impact skills to conduct such comparative analysis. Additionally, even before tackling the analysis of impact trade-offs, policy makers need to clearly outline what are the prioritized objectives to be maximized through ICT deployment.

3) Centralize Program Evaluation

As a corollary to the first recommendation, given that the ability to generate jobs as a result of externalities is dependent on the regions being targeted, it would be advisable to centralize the process of allocating funds for ICT deployment and rely on a common framework for evaluating requests focused on economic growth and job creation. In this context, it is critical to enhance the government's ability to monitor spending and outcomes, especially if the stimulus program is largely mandated like an earmark as opposed to some other methods that have more controls. This compels policy makers to have access to social, economic, and technology data and have the necessary impact-modeling skills to conduct trade-off analysis, such as the ones referred to above, that support the decisions on how to maximize the impact of technology development.

4) Reduce Disruption Costs

Governments need to stand ready to help reduce the costs of disruptions and adjustments resulting from ICT deployment and automation. If ICT deployment leads to job destruction in certain areas or sectors, governments should be ready to implement retraining programs and temporary safety net mitigation initiatives. Broadband technology is just one of the many components of a development strategy. The experience of deployment of the technology in emerging regions such as Chile and Saudi Arabia has highlighted the fact that once broadband is available, job creation is directly a function of human capital availability. Studies in digital economy development tend to underscore the fact that once the infrastructure gap has been addressed, human capital becomes the stumbling block. To rapidly tackle this barrier, governments are implementing short training programs focused on creating the necessary skills to utilize the technology in the development of new businesses.

6.5 Concluding Remarks

Research evidence generated over the past fifteen years confirms the positive effects of ICTs on employment, particularly in terms of creating new jobs through deployment, unlocking of resources in traditional industries, and creating new businesses. Furthermore, ICTs have a positive contribution to increasing incomes and improving work conditions. On the other hand, under certain conditions, ICTs may have a negative employment effect: By enhancing productivity in certain labor-intensive sectors, ICTs can result in the elimination of jobs. Furthermore, ICT adoption will require the implementation of skills development programs.

In light of the benefits and potential disruptions, policy makers need to play an active role in order to maximize ICTs' job creation potential. In many cases, job creation is not automatic by ICT deployment. Network construction has to be followed by additional stimuli such as establishing innovation labs geared to develop new applications, adopting new business models, and creating new digital content. It is also critical to deploy initiatives aimed at creating ICT-enabled jobs.

- Policy makers should consider deployment not only in unserved and underserved areas but also in regions where the possibility of developing regional growth, in coordination with ICT deployment, could act as a magnet to stimulate relocation, business creation, and, consequently, jobs. In light of this, given that the ability to generate jobs as a result of externalities is dependent on the targeted regions, it is advisable to centralize the process of allocating funds for ICT deployment and rely on a common framework for evaluating requests focusing on economic growth and job creation. This compels policy makers to have access to social, economic, and technology data and have the necessary impact-modeling skills to conduct trade-off analysis that support the decisions on how to maximize the impact of technology development.
- Finally, governments need to stand ready to help reduce the costs of disruptions and adjustments. If ICT deployment leads to job elimination in certain sectors, governments should implement retraining programs and temporary safety net mitigation initiatives.

References

- Abramovsky, L., & Griffith, R. (2006). "Outsourcing and offshoring of business services: How important is ICT?" *Journal of the European Economic Association*, vol. 4, no. 2/3, pp. 594-601.
- Atasoy, H. (2012). "The Effects of broadband Internet expansion on labor market outcomes." *Industrial and Labor Relations Review*, April 2013, vol. 66, no. 2.
- Atkinson, R., Castro, D. & Ezell, S.J. (2009). *The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America*. The Information Technology and Innovation Foundation, Washington, DC.
- Bohlin, E., Glaumann, M. (2011). *Socioeconomic Effects of Broadband Speed: A Microeconomic Investigation*. Goteborg: Chalmers Institute of technology.
- Clarke, G. (2008), "Has the Internet increased exports for firms from low and middle-income countries?" *Information Economics and Policy*, vol. 20, no. 1, pp. 16-37.
- Crandall, R., et al. (2003), *The Effect of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy*. Criterion Economics, Washington DC.
- Crandall, R., Lehr, W., and Litan, R. (2007), "The effects of broadband deployment on output and employment: a cross-sectional analysis of U.S. data," *Issues in Economic Policy*, no.6, Brookings Institute.
- De Los Ríos (2010). "Impacto del USO de Internet en el Bienestar de los Hogares Peruanos: Evidencia de un panel de hogares 2007-2009," *Diálogo Regional sobre Sociedad de la Información*, Lima.
- Dutz, M, Orzag, J., and Willig, R. (2009). *The Substantial Consumer Benefits of Broadband Connectivity for U.S. Households*. Internet Innovation Alliance, NY.
- Gillett, S., Lehr, W., Osorio, C., and Sirbu, M. A. (2006). *Measuring Broadband's Economic Impact*. Tech. Report 99-07-13829, National Technical Assistance, Training, Research, and Evaluation Project.
- Katz, R. (2012). *Impact of Broadband on the Economy: Research to Date and Policy Issues*. Geneva: Int. Telecommunication Union.
- Katz, R. (2015). *El Ecosistema y la Economía Digital en América Latina*. Madrid.
- Katz, R. (2017). *Increasing Broadband Internet Penetration in the OIC Member Countries*. Report to the Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation. Ankara.
- Katz, R. L., et al. (2008). *An Evaluation of Socio-Economic Impact of a Fiber Network in Switzerland*. Polynomics and Telecom Advisory Services, LLC.
- Katz, R., L. and Suter, S. (2009). *Estimating the Economic Impact of the Broadband Stimulus Plan*, Columbia Institute for Tele-Information.

ICT-centric economic growth, innovation and job creation

Katz, R. L., Vaterlaus, S., Zenhäusern, P., and Suter, S. (2010a). "The impact of broadband on jobs and the German economy," *Intereconomics*, 45 (1), 26-34.

Katz, R.L., Avila, J. and Meille, G. (2010b). *Economic Impact of Wireless Broadband in Rural America*. Rural Cellular Association, Washington, DC.

Katz, R. and Callorda, F. (2013). *Economic Impact of Broadband Deployment in Ecuador*. Dialogo Regional Sobre Sociedad de La Informacion, Lima.

Kolko, J. (2010), "Does broadband boost local economic development?" Public Policy Institute of California. www.ppic.org/content/pubs/report/R_110JKR.pdf

Liebenau, J., et al. (2009), "The UK's digital road to recovery." <http://ssrn.com/abstract=1396687>

Shideler, D., Badasyan, N., and Taylor, L. (2007), "The economic impact of broadband deployment in Kentucky," *Telecom Policy Research Conf.*, Washington.

Thompson, H., and Garbacz, C. (2008). "Broadband impacts on state GDP: direct and indirect impacts," International Telecom. Society 17th Biennial Conference, Canada.

Varian, H., et. al (2002). *The Net Impact Study: the Projected Economic Benefits of the Internet in the United States, United Kingdom, France and Germany*.

Biography

Raul Katz is a Director of Business Strategy Research at the Columbia Institute for Teleinformation at Columbia University and a Visiting Professor at the Universidad de San Andres in Argentina. His research focuses on the economic and social contribution of digital technologies, and digitization of production processes. He advises governments, multilateral organizations and private companies in the development of their digital agendas. In 2004 he retired after twenty years of service as a Partner with Booz Allen & Hamilton, where he led the North American and Latin American Telecommunications Practices, and was a Member of its Leadership Team. He has published five books in the fields of broadband demand stimulation, economic impact of ICT on development, and the digital economy. Dr. Katz holds a PhD in Management Science and Political Science, and a MS in Communications Technology and Policy from MIT, a Maitrise and Licence in Communications Sciences from the University of Paris, and a Maitrise in Political Science from Sorbonne.

Chapter 7

The Future of ICT-driven Education for Sustainable Development

*James F. Larson**

This chapter examines the role of education as the basic process in the hyper connected information era, one that is a central requirement and key tool for achieving the SDGs. It examines both the role of ICTs in the broad and global transformation of education, on the one hand, and on the crucial role of education in building a strong and healthy ICT ecosystem, on the other. Lifelong learning, massive open online courses (MOOCs) and international education hubs are all indicators of how the digital platform revolution is disrupting education. The chapter makes a series of policy recommendations on teaching ICT technologies and skills in 21st century, the need for lifelong learning, and the value of public-private partnerships in developing education platforms. Furthermore, it suggests that ICT education is needed to familiarize all stakeholders with the Internet and digital networks, big data, the mobile revolution, the Internet of Things and digital tools such as robotics, AI, and virtual and augmented reality.

7.1 Introduction

Education is the *sine qua non* for both the development of information and communication technologies (ICTs), and also for their effective utilization to achieve sustainable development. Without education, both

* SUNY Korea – Stony Brook University, Incheon, Republic of Korea

the development of the ICT sector and its role in achieving sustainable development would be almost inconceivable. As noted by Yochai Benkler, the world's advanced economies have made two parallel shifts. The first move, in the making for more than a century, was from an industrial economy to one centered on transmission of information, creation of content, and manipulation of symbols. Examples of the new economic focus include financial services, accounting, software, science, films and music. The second shift is the move to a communication environment built on inexpensive processors with high computation capabilities, interconnected in a pervasive network called the Internet. (Benkler, 2006, p. 7). The transformation was accompanied by a shift in the focus of research and scholarly attention related to the advances in ICTs to the role ICTs for sustainable development, which is the focus of this book (Schramm, 1964) (ITU, 1984).

Although the arrival of digital networks has had broad economic, social, and political impact, one of its greatest effects has been on education, which is *the* basic process of the information age (Oh M. a., 2011, p. 188). Education plays a dual role in relation to the challenges posed by sustainable development. First, advances in ICTs are at the heart of a broad transformation of education itself. ICTs have insinuated themselves into all fields, forms and levels of education around the world. Consequently they will inevitably play a role in all education that bears on achieving the Sustainable Development Goals (SDGs). Second, education plays a vital role in building a strong and healthy ICT ecosystem, a necessary requirement for optimizing the impact of ICTs on the SDGs. In addition to ensuring basic digital literacy, this includes inculcating an understanding of a growing range of key ICT trends and concepts, including networks, platforms, big data and mobility. Such education is a prerequisite for widespread adoption of the rapidly evolving digital technologies. All stakeholders, particularly those with policymaking or executive responsibilities, need to understand both of these roles in order to maximize the positive impact of ICTs for achieving the SDGs.

One byproduct of the adoption and use of the Internet and other ICTs around the globe and across all sectors is the increased need for governments and political leaders to consistently plan for and invest in

broadband networks and other ICT infrastructures. In this hyper connected era, it is impossible to imagine effective education without optimal use of ever-changing digital technologies. In considering the possible impact on achievement of the SDGs, one thing seems clear: ensuring positive impact will require successfully reaching and engaging most of the world's citizens, not just the elites. Such engagement will require a broad paradigm shift in education to harness the positive power of ICTs to develop the new skill sets required by emerging digital economies and to facilitate re-training and manage transitions to accommodate disruptions and to ensure inclusive enjoyment of the benefits that ICTs can deliver. Education, augmented by ICTs, is the key tool that can enable achievement of the SDGs. Furthermore, education for the 21st century must address the skills that are necessary to leverage the power of ICTs and focus their practical use on solving the real world problems that are the barriers to realization of the SDGs. This means problem based learning or education that makes the connection between theory and practice.

Recommendation 1: All major stakeholders in sustainable development should be taught some core skills that will drive education and employment in the 21st century. These include, among others, skills in the use of Internet search, cloud-based and mobile applications, web site creation and management, effective use of blogs and social media and the collection, analysis and visualization of unstructured big data.

As this chapter will argue, education broadly conceived is essential for innovation, economic growth, employment and achievement of the SDGs. The digital revolution creates a need to develop new approaches in such aspects of education as the followings:

- Teachers – the role of human teachers, professors, mentors and peers, as well as AI-driven robots and virtual teachers and environments.
- Curricula – the content and skills that are taught.
- Location – brick and mortar classrooms, local, global and virtual realities in cyberspace.
- Educational media – books, journals, videos and other forms of

digital and non-digital media.

- Teaching and learning methods – including the flipped classroom and the shift toward team-based, collaborative, problem-based learning focused on relevant questions.
- Timing and duration – lifelong learning is increasingly accepted as the norm in order to update skills and knowledge required to work with new and changing technologies in the workplace.
- Bridging the digital divide – success in educating people makes the assumption that the digital divide among and within countries can be removed or dramatically reduced.

The goal of this chapter is to indicate in broad outline of what needs to be done by academic and other organizations to educate people in the 21st century, in a manner that optimizes chances to achieve the SDGs. It treats the role of education in relation to the following ongoing processes: the digital disruption in education, education to build the ICT sector and the role of digitally supported education in achieving sustainability in each of its important dimensions, including environmental, social and economic aspects.

7.2 Education at Global Scale: Lifelong Learning, MOOCs and Education Hubs

The pace of digital transformation has varied across nations, cultures, and educational organizations. The large differences across and within countries in the rate of diffusion of access to the Internet and actual use of information resources constitute digital divides (NorrisPippa, 2001). The clear challenge is how to bridge the digital divide in education, between and among countries as well as within nations. In order for policymakers, corporate executives, teachers and citizens to know what must be done in any particular local context, it is important to know what best practices are in use around the world. In what follows, we describe how ICTs are changing education and the important role of education in building the ICT sector.

A key feature of the rise of digital economies is the growing importance of digital platforms in a growing range of markets and sectors.¹⁷⁸ The platform revolution places information and knowledge at the center of the new economic and social order. A platform, simply defined, is a business that enables value-creating interactions between external producers and consumers (Parker, 2016, p. 5). Through the 20th century industrial era, businesses employed a linear pipeline model in which a firm initially designed a product or service, then put it up for sale or devised a system to deliver the service, after which customers showed up and made purchases. Today, platform structures in which producers, consumers and the platform itself interact have replaced the pipeline in many industries. Prominent examples of platform-based businesses include Google, Apple, Amazon and Airbnb (Parker, 2016, p. 6).

A global survey of platform enterprises showed a significant disparity among regions, with North America and increasingly Asia home to a large and diverse group of companies, and Europe along with Africa and Latin America lagging. The survey showed that Asia leads the world in the number of transaction platforms, while North America leads in the categories of innovation and integrated platforms (Evans, 2016, p.16). It defined platform types as:

- Transaction platforms – act as a conduit to facilitate exchanges or transactions between different sets of users, buyers, or suppliers. Most of the platforms in the survey fall into this category, which includes Uber, Tencent, Baidu, Netflix, Snapchat and Paypal.
- Innovation platforms – serve as a foundation on which other firms develop complementary technologies and services. This category includes companies with large third party developer networks, such as Microsoft, Oracle, Intel, SAP and Salesforce.
- Integrated platforms – are both a transaction and an innovation platform. This category includes Google, Facebook, Apple, Alibaba, Amazon and XiaoMi.
- Investment platforms – offered by companies that have developed a platform portfolio strategy and act as a holding company, active

¹⁷⁸ Chapter 3 includes further discussion of the importance of digital platforms.

platform investor or both. This category includes Priceline Group and IAC Interactive in the U.S., Softbank of Japan, Naspers of South Africa and Rocket Internet in Germany (Evans, 2016).

Education is the prime example of a large industry ripe for platform disruption. The drive to build education platforms such as Skillshare, Udemy, Coursera, EdX and Khan Academy is well under way, with varying results. Furthermore, the platform-based unbundling of educational activities is separating the learning of specific skills from reliance on traditional universities, enabling a larger number of citizens to access learning opportunities more flexibly in a wider range of contexts (Parker, 2016, pp. 265-267). These can contribute to expanding inclusion, addressing gender disparities, and enabling life-long learning. At the same time, the rise of new digital platforms for education can disrupt traditional educational institutions and processes. To ensure that the benefits of new opportunities are realized and the adjustment costs inherent in adapting to the disruptions arising from digital transformations are minimized, will require active policy coordination.

Future economic growth, employment and other attributes are likely to flow from three fundamental characteristics of information that distinguish it from other economic goods and services. First, it is non-rival. Unlike other goods, the consumption of information by one person does not prevent its consumption by others, which is not the case for physical goods, e.g., once a bushel of apples is sold and consumed, it is no longer available for consumption by others.

Second, once a single unit of information is produced, the marginal cost of producing additional units can be negligible. The physical paper for a book may cost something, but the information it contains only needs to be created once (Benkler, 2006, p. 36). Owing to this economic characteristic of information, the digital network revolution is forcing a rethinking of the educational process itself, including a radical overhaul of pedagogy, how access to education is provisioned, and the manner in which education is financed. Already for millions of students, Massive Open Online Courses (MOOCs) have significantly reduced the marginal cost of securing college credits (Rifkin, 2014, p. 109).

Third, all knowledge builds on existing knowledge (Stiglitz, 2014). Everyone uses existing information as well as new insights, novel concepts, and innovative ideas to create a new product, invent a new service, or introduce a new application. In the digital network era, the economic characteristic of information is accentuated because of the ability to generate, store and communicate large amounts of data. Furthermore, the availability of massive amounts of information and a far wider collection of prior research, together with current and future trends and technologies in ICTs such as big data analytics¹⁷⁹, artificial intelligence (AI), deep learning, machine learning, robotics, augmented reality, virtual reality, etc. fundamentally change the role of human decision-maker and the skills that are necessary to understand the increasingly abundant information, and to advance research, developments and innovations. Accordingly, the trend in research and education is toward synthesis, analysis and problem solving, and away from rote learning. The rapid pace of changes in ICTs and continuous emergence of advance, new and powerful tools, technologies, services, and applications together with markets that embrace new offerings shape the future of education, which is to enable people to adjust to these changes in both what needs to be learned and how people learn.

A caveat is in order with regard to the economic characteristics of information. Proprietary information still exists, as do transaction costs for accessing and transmitting information. For students and educators massive amounts of information illustrates the “double edged sword” characteristic of digital technologies. On the one hand, more information is available more quickly to share and from which to learn. On the other hand the same technology contributes to the phenomenon of information overload in which machine-generated “content farms” play a role. Content farms are websites that typically contain large quantities of content pulled from other sites with the sole purpose to increase the website’s ranking by Google or other search engines. The explosion of digitally accessible information underscores the

¹⁷⁹ Big data analytics involves tools, methods and technologies to process massive amounts of empirical data to make decisions, in many cases, without understanding the underlying causes.

importance of the ability to search and find relevant information, and then to discern good and useful from worthless information.

Existing education systems have not kept pace with such changes. Neither possession of a college degree nor vocational training are able to meet the growing demand for lifelong learning to gain the skills and knowledge needed to work with continually changing technologies. To remain competitive and provide workers the best chance for success at all skill levels, nations need to offer training and career-focused education throughout the peoples' working lives.

This failure to keep pace extends even to elementary school education. While most K-12 institutions have adapted their curriculum by adding courses in entrepreneurship and computer skills, and have incorporated technology in the classroom, this is not be adequate. (Menon, 2014)

The achievement of the sustainable development goals will require citizen engagement on a global level never seen before. What is the nature and purpose of that engagement? To answer this question, one must clearly address the related question of what should be taught. On the level of skills, we might venture that the following, among others will be necessary for today's younger generations to confront the challenges posed by the SDGs.

- Ability to search for, find and assess the credibility and strength of evidence based scientific information.
- Understanding of big data and the ability to analyze with algorithms and technical skills from statistics and mathematics.
- Computer programming and scripting skills, including those relating to mobile applications.

However, before extending such a list, the caveat must be noted that technology is constantly changing and with it the skills that should be taught. Consequently, as laid out so far in this chapter, there is a need for lifelong learning.

One of the greatest changes brought to education by the digital network revolution involves the global scope and scale of the Internet. While study-abroad programs have long existed, the global Internet makes it possible to bring education to students wherever they are. This greatly

expands the potential for making educational opportunities accessible to more people in more flexible contexts, with the benefit of expanding inclusion.

Recommendation 2: Government, industry and education sector stakeholders should incorporate lifelong learning into their long term planning. The assumption should be that continued growth and development of digital networks and related technologies will change both the media and content of education.

For many people around the world, education and especially higher education is synonymous with the media used to teach and learn. Through most of the 20th century these included printed books and journals, slide presentations, audio recordings and film or movie presentations. All these media have changed dramatically thanks to digitization. Considering all forms of education both in and out of colleges and universities and at all levels from kindergarten through pre-college, the impact of digital media has been profound.

The increasing availability of video, including mobile games, along with advances in augmented and virtual reality are changing the way education is delivered in many contexts. For example, the ability of students to access videos and other multimedia before classes changes how class time is used. In the “flipped classroom”, students review material before the class, instead of confronting it for the first time through traditional lectures. Then, classroom time can be devoted to interpreting the content, problem-solving, discussions, and interactive in-class exercises. This “leaning-back” experience of traditional lecture-based rote learning is replaced with more active, “leaning-forward” learning with the teacher. The flipped classroom is also more generally referred to as “flipped learning.” Related educational initiatives in recent decades include project-based learning and problem-based learning. All of these innovations in pedagogy have one thing in common. They are a reaction to revolutionary developments in digital technologies and the accompanying growth of open courseware and related forms of sharing on the Internet. (Bishop, 2013) The media environment for teaching at all levels and in all contexts is today being shaped by the rise of MOOCs, videos, blogs and a growing array of

online educational resources. However, to use these educational innovations effectively requires access to appropriate digital infrastructure (a necessary precondition for the option to even be effectively available), as well, as teacher re-training and course/curricula redesign. This requires planning and investment in adopting the new digital teaching methods.

The Internet, by allowing increasingly realistic and immersive video conferencing, effectively changes our perception of distance. Given this inherently global scope of the Internet, the arrival of MOOCs was probably inevitable. Open online courseware makes it possible for anyone with a sufficiently fast connection to the Internet to take a broad range of courses. For skills-oriented courses such as computer programming, the completion of an online course may frequently carry just as much weight on a student's resume and have just as much impact on their employability as a course taken in a recognized and accredited college or university.

Global access to university-level course material has existed for some time. For example, MIT OpenCourseWare published its first 50 courses in 2002 (MIT). The origins of the MOOC revolution are frequently dated from 2011 when Stanford University Professor Sebastian Thrun offered a free course on artificial intelligence (AI) online. It was similar to the course he taught at Stanford where about 200 students enrolled. When the AI's MOOC started, there were 160,000 students from virtually every country in the world enrolled. Based on this experience and the irony that Stanford students were paying \$50,000 or more annually to attend world-class courses like his, Thrun and two colleagues founded an online university called Udacity (Rifkin, 2014, pp. 114-115). Udacity was soon followed by Coursera, EdX and many others. Access to knowledge, which for centuries was largely confined within the walls of academic institutions and available only to those who could afford tuition, was now available globally. Digital networks, led by the Internet, are one major reason that the walls of the so-called "ivory tower" have fallen. This is not to suggest that there will be no future role for physically located universities and face-to face interaction among students and scholars. To the contrary, digital networks and tools extend, but do not replace, human senses and

intelligence, especially considering the variety of linguistic, cultural and national contexts in which education takes place.

The importance of physical campuses and direct personal interaction in education is underscored by a related transformation, the rise of international branch campuses and education hubs in many parts of the world. Although some international branch campuses were opened as early as the mid-1950s, their growth in numbers began in the late 1990s and accelerated rapidly after the turn of the millennium, increasing from 84 at the end of 2000 to 249 at the end of 2015 (ICEF Monitor, 2016) (Crist, 2015). Some of these international branch campuses are located in so-called education “hubs” such as Education City in the UAE, Dubai International Academic City or the Incheon Global Campus in The Republic of Korea.

Closely related to the expanded geographical scope of education is the transforming influence of ICTs on pedagogy, the methods and practices of teaching or learning an academic subject. The model of instruction in which a teacher or professor who is an authority on a subject lectures to students has given way to collaborative, team based approaches, also referred to as the “flipped classroom” mentioned earlier. The flipped classroom is a pedagogical approach in which the typical lecture and homework elements of a course are reversed. Typically, such classes are divided into teams, allowing students to collaborate with each other to explore topics and solve real world problems. The rapid spread of smart mobile devices around the world is expected to place a wider range of educational resources in the hands of students for their use at convenient times and in various locations. (Educause, 2012) This aspect of the digital revolution is most relevant to the role of ICTs in achieving the sustainable development goals. It supports the notion that learning should be applied to real world problems, and opens up possibilities for experiencing those problems and attempting to solve them in real communities where people live and work. (Rifkin, 2014, p. 111)

Another indication of the profound effect of digital technologies on teaching and learning is the increased use of the term “blended learning”. Blended learning, by most definitions, refers to education

that combines the use of Internet and digital media with traditional classroom methods.

Recommendation 3: Governments should work with private sector partners, schools and universities to strengthen understanding, use, and impact of education platforms that address the SDGs. These include, but are not limited to MOOCs, flipped classroom or flipped learning teaching methods, problem-based and experiential learning.

7.3 The Future of ICT Curriculum and Content: The Innovation Imperative

While ICTs play an important and growing role in education, the converse relationship in which education influences the ICT sector is also vital. This section explores the essential role of education in building ICTs and shaping the infrastructure of the ICT sector itself. Such education is necessary to ensure the continuity of demand for new digital services such as mobile broadband, smart phones or other devices. It is also necessary to ensure the existence of vital support for the long term in expensive projects of building the next generation digital networks.

As emphasized in a 2015 report by the World Economic Forum (WEF), the building of digital infrastructure alone, while necessary to boost economic growth, is not sufficient. The presence of infrastructure itself, or access to the broadband Internet, does not itself ensure that it will be used or will have any impact on particular SDGs. The WEF report notes that in many developed countries there is a 30-50% difference between the number of people reached by digital networks and the number actually online. In emerging markets, on the other hand, this gap jumps to 55-75% and in some cases up to 90%. The same report cited research showing that there are three main reasons for not adopting the Internet: 1) a perceived lack of need, mainly because of lack of local-language content, 2) a lack of skills and 3) affordability (World Economic Forum, 2015, p. 4).

The WEF report later elaborates on “lack of skills,” referring to them as “low literacy rates,” including own language, English and digital

literacy. It notes that although billions of consumers have discovered the Internet on their own, governments and private companies alike might reap benefits from following the best practices in four key areas. These are furthering local content development, building digital literacy, simplifying access and use, and reducing the cost of devices and access (World Economic Forum, 2015, p. 10).

The rapid evolution of the ICT ecosystem makes the important question of what to teach very challenging. What seems “obvious” given the state of technology today may change within a matter of months or a few years. Consequently, we now focus on providing some criteria for making decisions about new courses, curriculum and content. The existing evidence, as partially elaborated earlier in this chapter point out that there is a serious need to replace / augment the existing courses in ICT-related fields of study to include coding (programming) skills; storage, retrieval, and processing of video information; big data analytics; application development; artificial intelligence; machine learning; deep learning paradigms; cloud computing and storage; and future networking paradigms.

The importance of developing skills and capabilities rather than focusing on content knowledge is rather widely accepted by scholars looking toward the future of ICT education. The following capabilities will be needed as today’s students of all ages grapple with the SDGs and ICTs.

- Reflective and critical thinking skills
- The ability to work in a team environment, where members not only do their own respective tasks, but help others to achieve their objectives in a timely and cost effective manner
- A capacity to weigh and choose from conflicting scientific evidence
- Ability to search, find and evaluate scientific evidence for and against a proposition.
- Communication skills including the capability to express oneself orally, in writing and with video or graphic information in a clear, unambiguous, logical and concise manner.

ICT-centric economic growth, innovation and job creation

The rise of the Internet and the rapid advancement of digital technology make it ever more important that there be stronger and more continuous connections between education and employment. Although this is not the only role of ICT education, it is an emerging reality. Increasingly, people need to learn new theories and knowledge and acquire new skills and technological competencies both on-the-job and during transitions between employment positions. Burning Glass Technologies, a Boston startup that analyzes labor markets by scraping data from online job advertisements finds that the greatest demand is for **new combinations of skills**. Coding skills, for example, now extend well beyond the technology sector, and still are the most important job skill of the future. In the United States, 49% of the postings in the highest paid quartile of occupations are for jobs that frequently require coding skills, as shown in Figure 1. As another example of rapid changes in the composition of new jobs, demand for data analysts increased by 372% over the past five years and within that segment, demand for data visualization specialists shot up by more than 2,500%. (The Economist, 2017, p. 5)

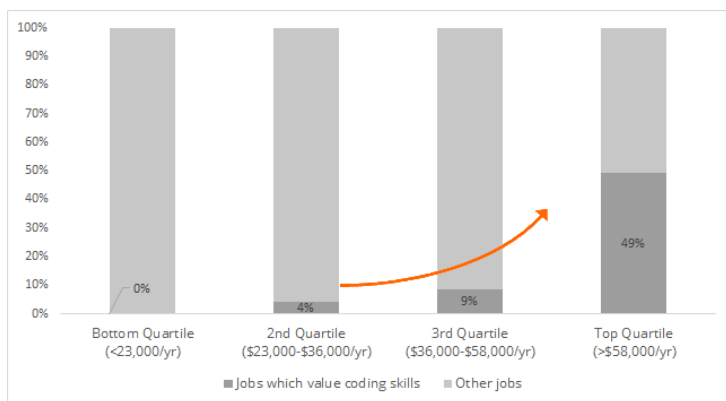


Figure 1. Percent of job openings in US in 2015 that value coding skills, by earnings quartile

Source: Burning Glass Technologies

Innovation, which involves the creation and diffusion of new products, services, processes and methods, will be necessary for the nations to move toward more inclusive and sustainable economic growth. Innovation provides an important foundation not only for economic growth but also for addressing social and global challenges, and requires the following priorities:

- Strengthening investment in innovation to foster business dynamism.
- Investing in and shaping an efficient system of knowledge creation and diffusion.
- Seizing the benefits of the digital economy.
- Fostering talents and skills that optimize their use.
- Improving the governance and implementation of innovation policies. (OECD, 2015)

Several of the priorities identified by the OECD touch on the important role of research and development. As shown in Figure 2, the intensity of R&D investment by some of the world's leading nations increased between 1991 and 2014. The figure also shows that Korea's R&D intensity, the ratio of research and development expenditure to gross domestic product, increased at a much faster rate than other leading OECD countries over the decade from 2004-2014. As of 1999, the nation's investment in R&D amounted to only 2.07% of its gross domestic product (GDP), a percentage that increased to 4.29% by 2014, putting it ahead of the runner up Israel. Although the majority of the investment went toward applied research and development in industry, the government made a big investment in basic science as well. (ZastrowMark, 2016)

It is imperative for the educational system in general, and for ICT education in particular to enable students to participate and contribute to the enormously challenging innovation-based economic development in the years to come. The 17th and last of the SDGs, Partnership for the Goals, makes it clear that their accomplishment will require active collaboration among public, private and civil society stakeholders. All of the other SDGs are cross cutting involving multiple economic sectors and segments of society. Consideration of the future impact of

ICT-centric economic growth, innovation and job creation

education on achieving the SDGs would hardly be complete without recognizing the growing role of networked digital technologies including robotics, big data, artificial intelligence and machines in education.

Imbued with the burgeoning capabilities of artificial intelligence and machine learning, there can be little doubt that service robots with increasingly human characteristics will play an ever-increasing role in education. As of 2008, the number of service robots in use around the world already outnumbered industrial robots. (Mubin, 2013, p. 1)

The engagement imperative for 21st century education also requires that individual students and teachers, wherever in the world they are located to achieve a global perspective in which each person realizes his or her personal connection to the global issues represented by the SDGs. This is what UNESCO calls “...building a sense of belonging to a common humanity and helping learners become responsible and active global citizens.” (UNESCO)

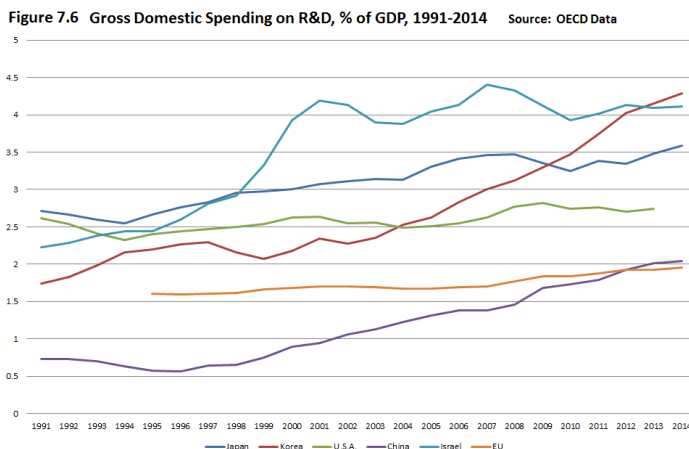


Figure 2. Gross Domestic Spending on R&D, % of GDP, 1991-2014

Source: OECD Data

Recommendation 4: To the extent possible, educational efforts should familiarize students with the technological structure and future directions of digital technologies, with emphasis on four areas. 1) digital networks starting with the Internet and including cloud storage and computing; 2) big data including data science, data mining and data visualization; 3) the mobile revolution, its impact and applications; and 4) the Internet of Things (IoT) and digital tools, such as robotics, Artificial Intelligence (AI), virtual or augmented reality. ICT education should also provide students with new combination of skills including the coding and computer programming.

7.4 Conclusion

As the foregoing discussions made it clear, consideration of the future role of ICTs in education and in achieving the SDGs cuts across different academic fields and disciplines. Hence, in order to properly address the role of education for achieving SDGs, a holistic approach is needed. This need applies equally to government policymakers at all levels, teachers, professors, researchers, technical staffs and corporate executives. We examined both the central role of ICTs in transforming education and also education focused on building the ICT sector and ecosystem. The tendency of digital networks is to encourage convergence of disciplines, fields, and departments. This highlights the need to integrate business, science, math, engineering and other fields in education aimed at achieving sustainability.

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References

- Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*. New Haven: Yale University Press.
- Crist, J. T. (2015). Innovation in a small state: Qatar and the IBC cluster model of higher education. *The Muslim World*, 105, 93-115.
- Educause. (2012). Things you should know about flipped classrooms.
- Evans, P. C. (2016). *The rise of the platform enterprise: A global survey*. New York: The center for global enterprise.
- ICEF Monitor. (2016, November 22). *China now the leading host for international branch campuses*. Retrieved November 23, 2016, ICEF Monitor.
<http://monitor.icef.com/2016/11/china-now-leading-host-international-branch-campuses/>
- ITU. (1984). *The missing link: Report of the independent commission for worldwide telecommunications development*. Geneva.
- Menon, N. F. (2014). *Rethinking K-12 education: Defining a new model*. A.T. Kearny, Inc.
- MIT. (n.d.). *Our History*. Retrieved November 21, 2016, MIT OpenCourseWare.
<https://ocw.mit.edu/about/our-history/>
- Mubin, O. C.-J. (2013). A review of the applicability of robots in education. *Technology for education and learning*, 1-7.
- Norris, P. (2001). *Digital divide: Civic engagement, information poverty and the Internet worldwide*. Cambridge University Press.
- OECD. (2015). *The innovation imperative: Contributing to productivity, growth and well being*. OECD Publishing.
- Oh, M. a. (2011). *Digital development in Korea: Building an information society*. London: Routledge.
- Parker, G. G. (2016). *Platform revolution*. New York: W.W. Norton & Company.
- Rifkin, J. (2014). *The zero marginal cost society*. New York: Palgrave Macmillan.
- Schramm, W. (1964). *Mass media and national development: The role of information in the developing countries*. Stanford, Paris: Stanford University Press, UNESCO.
- Stiglitz, J. E. (2014). *Creating a learning society: A new approach to growth, development and social progress*. New York: Columbia University Press.
- The Economist. (2017, January 14). Lifelong learning is becoming an economic imperative. *The Economist*, p. 6.

UNESCO. (n.d.). *Global citizenship education*. Retrieved January 27, 2017, UNESCO. <http://en.unesco.org/gced>

World Economic Forum. (2015). *Expanding participation and boosting growth: The infrastructure needs of the digital economy*. Geneva: World Economic Forum in collaboration with Boston Consulting Group.

Zastrow, M. (2016). South Korea's Nobel Dream. *Nature*, 534, 20-23.

Biography

James F. Larson is Vice President for Academic Affairs and Chair of the Department of Technology and Society at SUNY Korea, part of the Incheon Global Campus and an extended campus of Stony Brook University. He taught at major research universities in the U.S., Singapore and The Republic of Korea, and directed a large executive training program for Korea Mobile Telecom (now SK Telecom) at the University of Colorado in Boulder, 1994-95. He served as Associate and Deputy Director of the Korea Fulbright Commission from 1996-2010. He is a Member of the Expert Committee of SafeNet Forum, a multi-stakeholder organization involved with Korea's new Public Safety-LTE networks. His books include *The Telecommunications Revolution in Korea* (1995 Oxford University Press) and (with Myung Oh) *Digital Development in Korea: Building an Information Society* (2011, Routledge). He received the M.A. and Ph.D. degrees in Communication from Stanford University in 1976 and 1978, respectively.

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

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