The World's Technological Capacity to Store, Communicate, and Compute Information

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MAPPING OUT THE TRANSITION TOWARD INFORMATION SOCIETIES:

SOCIAL NATURE, GROWTH, AND POLICIES

by

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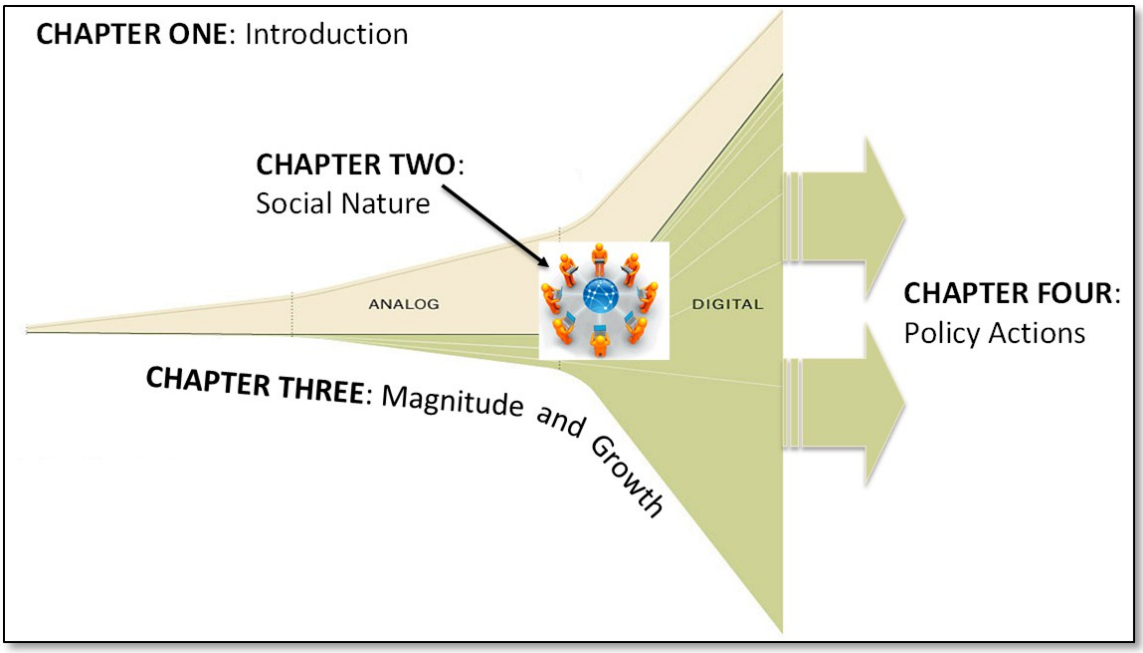
Abstract

This research thesis sheds lights on different aspects of the transition toward information societies. It consists of a collection of interrelated studies that analyze in more rigorous terms three main and complementary aspects of the transition (see Figure below). After and **introductory** **CHAPTER ONE,** the consecutive **CHAPTER TWO** of this thesis looks at the **social nature of the current transition** toward the information society, which is characterized by a diffusion process that is known as digital divide. This chapter focuses on the socio-demographic characteristics of the transition, and characterizes its bottlenecks, such as the cost-income relation of ICT and users, as well as its opportunities, such as the opportunity to fight long-standing gender inequalities. **CHAPTER THREE** focuses not only on equality, but also on growth of the world's information and communication capacity in absolute terms. The chapter consists of two sections that quantify the **magnitude and growth of information** in the information society, measured directly in bits and bytes. This provides insights into the speed and general pattern of the transition from analog to digital information processing in society. Both chapters combined provide complementary insights into what have been traditionally the two main pillars of socio-economic development: equity and growth. In this case the focus is set on the equality and growth of technologically mediated information. Various particularities of the transition become evident, such as the exponential rates of change of the transition, the all-pervasiveness of ICT in the social realm, and the unequal diffusion process. The final **CHAPTER FOUR** studies a concrete example of successful **policy making in the digital age** that takes these particularities into consideration. The case study focuses on a foresight Delphi exercise aimed at

identifying future policy priorities that offered input into the inter-governmental negotiation of an Action Plan in Latin America. It is believed to have been the most extensive online participatory policy-making foresight exercise in the history of intergovernmental processes in the developing world. The process of policy-making in this international multi-stakeholder Delphi embraces the particular characteristics of the transition toward Information Societies by design.

Figure 1 Overview: "Mapping Out the Transition toward Information Societies"



The Chapters consists of a collection of complementary studies, which use a diverse array of methodologies and data sources to map out diverse aspects of the transition toward this new form of socio-economic organization. The three main Chapters consist of 6 articles that have been produced during the time of my doctoral program at USC's

Annenberg School of Communication (since August 2008). Chapter Two consists of three articles (resulting in three complementary sections), Chapter Three consists of two articles, and the final Chapter Four of one article. These articles are by now all published in recognized peer-reviewed Journals, all of which are indexed in the Thomson Reuters Social Science Index. Some of these Journals are leading in their fields (such as Technological Forecasting and Social Change, the world's leading journal in foresight studies, with a 5-year Thomson Reuters Journal Citation Impact factor of 2.2; or World Development, the world's leading journal in international development studies, with a 5-year impact factor of 2.5), while other Journals are among the most recognized outlets for multidisciplinary science research in general (such as Science, with a 5-year impact factor of 32). Each of the articles has passed the peer-review of at least 2 specialized reviewers (most often 3 or 4), plus one editor, resulting in an estimated number of over 20 specialized and independent reviewers for this collection of articles. The articles, in their order of inclusion in this thesis, include:

Hilbert, M. (2011). The end justifies the definition: The manifold outlooks on the digital divide and their practical usefulness for policy-making. *Telecommunications Policy*, *35*(8), 715-736. doi:10.1016/j.telpol.2011.06.012

Hilbert, M. (2010). When is Cheap, Cheap Enough to Bridge the Digital Divide? Modeling Income Related Structural Challenges of Technology Diffusion in Latin America. *World Development*, *38*(5), 756-770. doi:10.1016/j.worlddev.2009.11.019

Hilbert, M. (2011). Digital gender divide or technologically empowered women in developing countries? A typical case of lies, damned lies, and statistics. *Women's Studies International Forum*, *34*(6), 479-489. doi:10.1016/j.wsif.2011.07.001

Hilbert, M., López, P., & Vásquez, C. (2010). Information Societies or "ICT Equipment Societies?" Measuring the Digital Information-Processing Capacity of a Society in Bits and Bytes. *The Information Society*, *26*(3), 157-178. doi:10.1080/01972241003712199

Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 -65. doi:10.1126/science.1200970

Hilbert, M., Miles, I., & Othmer, J. (2009). Foresight tools for participative policy-making in inter-governmental processes in developing countries: Lessons learned from the eLAC Policy Priorities Delphi. *Technological Forecasting and Social Change*, *76*(7), 880-896. doi:10.1016/j.techfore.2009.01.001

Chapter One: Introduction

More than a quarter of a century ago, the USC Annenberg scholar Beniger (1986) already enlisted dozens of works that took a outlook on the social transformations provoked by the massive introduction of modern information and communication technologies (ICT). Since these early days, the resulting form of social organization has been given many names, including the "Computerized Society" (Martin and Norman, 1970), "Information Revolution" (Lamberton, 1974), "Electronics Revolution" (Evans, 1977), the "Information Economy" (Porat, 1977), the "Microelectronics Revolution" (Forester, 1980), "Information Technology Revolution" (Forester, 1985), "Network Society" (Castells, 2009), "age of Information and Communication Technology" (Freeman and Louça, 2002), "the fifths Kondratieff" (Perez, 1983; 2004), "Information Age" (Jorgenson, 2005; Castells, 2009; Brynjolfsson and Saunders, 2010), and "Information Society" (Masuda, 1980; Martin and Butler, 1981, Miles, 1988, Webster, 2006; Mansell, 2009). This last term has stuck with many and even started to dominate the global political agenda. Between 2003 and 2005 the highest possible political level of the world gathered to discuss the social, political, economic and cultural implications of this revolution during the "World Summit on the Information Society".[1]

[1] A World Summit is a gathering of all acting Head of States or government. The World Summit on the Information Society (WSIS) was held in two phases. The first phase took place in Geneva hosted by the Government of Switzerland from 10 to 12 December 2003, and the second phase took place in Tunis hosted by the Government of Tunisia, from 16 to 18 November 2005: http://www.itu.int/wsis

Theoretical Background: Societies in Transition

All of these complementary descriptions of the ongoing social transformations find their collective theoretical foundation in the Schumpeterian notion of socio-economic evolution (Schumpeter, 1939; Perez, 2004; Freeman and Louça, 2002, Castells, 2009), which holds that human progress "goes on in units separated from each other by neighborhoods of equilibrium. Each of those units, in turn, consists of two distinct phases, during the first of which the system, under the impulse of entrepreneurial activity, draws away from an equilibrium position, and during the second of which it draws toward another equilibrium position" (Schumpeter, 1939: p. 142). Schumpeter points out that these phases seem especially related to different technological systems and their diffusion and absorption by the social and economic system, which is reflected in their usage levels, prices, employment, and economic output. Some of the fluctuations are as short as a few months, while other span decades. Schumpeter explains that "innovations, their immediate and ulterior effects and the response to them by the system, are the common 'cause' of them all, although different types of innovations and different kinds of effects may play different roles in each… If waves of innovations of shorter span play around a wave of a similar character but of longer span, the sequence of the phases of the latter will so determine the conditions under which the former rise and break as to make a higher unit out of them, even if the innovations which create them are entirely independent of the innovations which carry the longer wave".

This results in an interpretation of development in terms of so-called "long waves" that arise as a consequence of innovations on different levels of human activity, such as previously proposed by the Russian economist Nikolai Kondratieff (1925) in his work on

"The Major Economic Cycles". This incessant process of "creative destruction" modernizes the modus operandi of society as a whole, including its economic, social, cultural and political organization.

As already noted by Schumpeter, the motor of this incessant force of creative destruction is technological change (Perez, 1983). The literature distinguishes between five recent so-called "long waves" of technological change (Freeman and Louça, 2002). The key enabling technology of the first Industrial Revolution (1770-1850) was based on water-powered mechanization (based on classical mechanics), the second long wave (1950-1895) was enabled by steam-powered technology (thermodynamics), the third (1895-1940) was characterized by the electrification of social and productive organization (electromagnetism), and the fourth by motorization and the automated mobilization of society (1940-1970) (mechanical and chemical engineering). The most recent long wave that transforms the social fabric in based on the digitization of information and communication processes in social systems with the help of so-called information and communication technologies (ICT) (engineered on basis of insights gained from information theory and computer science). Each one of those long waves (or Kondratieff) has been characterized by a sustained period of social modernization, most notably by sustained periods of increasing economic productivity.[2]

While empirical evidence is much weaker for previous periods, the logic of classifying phases of human development by its dominating technological tool is not new, and has been borrowed by social scientists from historians. The archaeological

[2] The reason why most theories on social evolution focus on economics instead of focusing on the modernization of cultural or political processes might simply be due to the fact that the respective performance indicator are much more accessible in the economic realm (i.e. monetary, productive output, etc).

period of early human history is commonly subdivided into the sequence of stone-age (2,000,000 b.c. – 3,300 b.c., duration 1,996,700 years), bronze-age (3,300 b.c. – 1,200 b.c., duration 2,100 years) and iron-age (1,200 b.c. – 44 b.c., duration 1,156 years).

According to Perez's seminal 1983 article, each of the resulting "quantum jump(s) in productivity can be seen as a technological revolution, which is made possible by the appearance in the general cost structure of a particular input that we could call the 'key factor', fulfilling the following conditions: (1) clearly perceived low-and descending-relative cost; (2) unlimited supply for all practical purposes; (3) potential all-pervasiveness; (4) a capacity to reduce the costs of capital, labour and products as well as to change them qualitatively."

Digital Information and Communication Technologies (ICT) fulfill those requirements: the cost-performance relationship of computers, storage and communication devices has seen respective compound annual growth rates of 60-80 % during the period from 1980-2005 (Hilbert and Cairo, 2009); their practically unlimited supply has led to a technological diffusion process that is unprecedented in human history (ITU, 2010); their nature as a general purpose technology touches all aspects of human development (Hilbert and Peres, 2010); and ICT have proven to be the driver of sustained productivity increases during recent decades (Jorgenson, 2005; Cimoli, Hoffman and Mulder, 2010). As such, ICT are the enabling technology of the most recent and current socio-economic transformations, and therefore represent the core of profound and ongoing social transformations.

Chapter Two: The Social Nature of the Transition

The transition toward information societies is not instantaneous, but is characterized by an unequal diffusion process of technology adoption. This diffusion process is generally known as the digital divide: the divide between those that are already part of the new form of social organization, and those still marginalized. In order to get a better understanding of this transition, I carried out three studies that concentrate on the socio-economic and demographic characteristics of social adoption of ICT. In the first section of this Chapter I created a conceptual framework to classify the diverse definitions of the digital divide, and showed how complementary outlooks on this multidimensional challenge are not necessarily harmful, but can rather be useful for impact oriented policy-making. The section study focuses on the economic bottlenecks of technology diffusion, in particular on the cost-income relation. I calculated how cheap ICT would have to be in order to be affordable for everybody in developing countries. The final study of this Chapter focuses on a widely debated demographic aspect of the divide: gender differences in ICT access and usage. Using an extensive database from Latin America and Africa, I provide empirical evidence that women are more enthusiastic ICT users than men, but since women are discriminated in terms of income, education, and employment, they end up with fewer possibilities to embrace their natural affinity with digital communication technologies.

The End Justifies the Definition: the Manifold Outlooks on the Digital Divide and their Practical Usefulness for Policy-Making[3,4]

Based on the theory of the diffusion of innovations through social networks, the article discusses the main approaches researchers have taken to conceptualize the digital divide. The result is a common framework that addresses the questions of who (e.g. divide between individuals, countries, etc.), with which kinds of characteristics (e.g. income, geography, age, etc.), connects how (mere access or effective adoption), to what (e.g. phones, Internet, digital-TV, etc.). Different constellations in these four variables lead to a combinatorial array of choices to define the digital divide. This vast collection of theoretically justifiable definitions is contrasted with the question of how the digital divide is defined in practice by policy makers. The cases of the United States, South Korea, and Chile are used to show that many diverse actors with dissimilar goals are involved in confronting the digital divide. Each of them takes a different outlook on the challenge. This leads to the question if this heterogeneity is harmful and if countries that count with a coherent national strategy and common outlook on digital development do

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[3] This article is published as: Hilbert, M. (2011). The end justifies the definition: The manifold outlooks on the digital divide and their practical usefulness for policy-making. Telecommunications Policy, 35(8), 715-736. http://dx.doi.org/10.1016/j.telpol.2011.06.012

[4] Acknowledgements: A considerable part of the figures and insights of this article have been produced by the team of the Information Society Program of the United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC,http://www.eclac.org/SocInfo), which the author had the pleasure to coordinate between 2000-2008, including Doris Olaya, Valeria Jordan, Massiel Guerra, Cesar Cristancho, and Priscila Lopez. The author is also indebted with the blind peer reviewers for their demanding, insisting, and very productive comments, with the participants of the 38th Research Conference on Communication, Information, and Internet Policy (TPRC 2010), and with his students at the Annenberg School of Communication, University of Southern California (USC).

better than others. It is shown that the effect of a coherent vision is secondary to tailor-made sector specific efforts. On the contrary, a one-size-fits-all outlook on a multifaceted challenge might rather be harmful. This leads to the conclusion that it is neither theoretically feasible, nor empirically justifiable to aim for one single definition of the digital divide. The digital divide is best defined in terms of a desired impact. Since those are diverse, so are the definitions of the challenge. The best that can be done is to come up with a comprehensive theoretical framework that allows for the systematic classification of different definitions, such as the one presented in this article.

Introduction

The term "digital divide" has defied a consented definition since its conception in the early 1990s (e.g. NTIA, 1995). This has led to confusion and frustration among researchers and policy makers. In an effort to clarify and separate distinct definitions, this article returns to the most widely accepted theoretical basis for the digital divide: the study of diffusion of innovations. Based on this theory the article starts by reviewing existing literature and identify four broad classes of variables that have been used to define the digital divide. Differences in definitions arise because scholars distinguish between (1) the kinds of Information and Communication Technology (ICT) in question; (2) the choice of subject; (3) diverse attributes of the chosen subjects; and (4) levels of adoption, going from plain access to effective usage with real impact. This results in a four dimensional matrix and a vast combinatorial array of different combinations that can be used to define the digital divide. Is it possible to identify one overall definition that is particularly useful?

To answer this question, the methodological discussion is complemented with an empirical analysis of policy relevance and impact. The article discusses how the diverse definitions of the digital divide affect the understanding of who is in charge of fighting the divide. The other way around, the article also stresses how the perspectives of the actors influence the definition of the challenge. An analysis of the public ICT expenditure budgets from the United States, South Korea and Chile shows that there are many diverse authorities involved in confronting the digital divide. The evidence suggests that in practice, policy makers have a much more heterogeneous outlook on the digital divide than the infrastructure and access oriented definitions that were traditionally assumed in a large part of the respective literature during the 1990s and 2000s. It is shown how those diverse definitions of the digital divide are useful and often even necessary to achieve sector specific development ends.

From a policy perspective, such diversity can easily be confused with immaturity of the response to the challenge. In an effort to streamline the heterogeneous outlooks many countries have started to create a coherent and consensus-oriented policy strategy on the national level. Specific examples and empirical evidence from Latin America is analyzed to show that a common outlook is very useful when it comes to the creation of synergies among the different agents involved in the challenge, but that the measurable impact of such common outlook is only secondary to sector-specific policies. In order to achieve real-world impact, it seems more important to count with a tailor-made solution for a particular problem, than with inter-sectorial coherence and analytical elegance in definitions. The challenge is multi-dimensional and complex, and so are is solutions.

In conclusion, from an analytical perspective, the literature has identified a large variety of justifiable definitions of the digital divide. From a practical perspective, a large variety of diverse policy makers aim to exploit ICT to achieve very different ends. There is no evidence to suggest that the introduction of a common outlook leads to significant positive impacts. Combining these analytical and practical conclusions leads to the same consequence: the desired impact of ICT is the conditioning variable of any useful working definition of the digital divide, and different ends justify different definitions. Notwithstanding this defensible heterogeneity, there are important synergies and complementarities that can be obtained by clearly keeping track of the manifold definitions of the digital divide and of the agents that execute them. The common framework presented in this article provides a tool for doing so.

Theoretical background: Diffusion of innovations

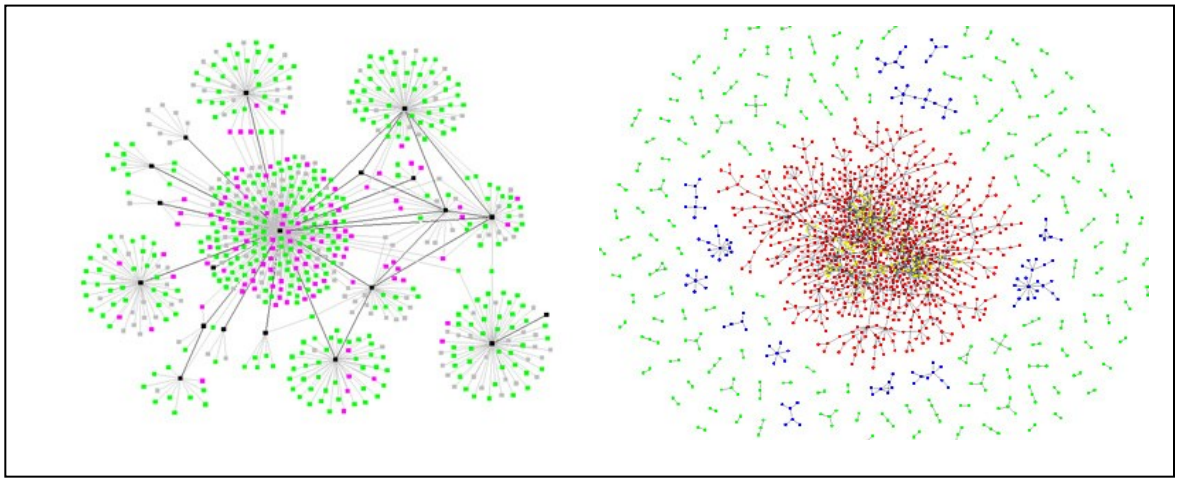
The study of the diffusion of innovation provides the general theoretical framework to categorize the different approaches researchers have taken to analyze the digital divide. The dynamic is well-understood by social scientists and related studies have their roots in the 19th century (e.g. Frobenius, 1897; Tarde, 1903).[5] In 1962, Everett Rogers formulated a coherent theory in his seminal work The Diffusion of Innovations (Rogers, 2003). Rogers (2003, p.5) defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system". The logic behind this approach is today known as social network analysis and

[5] The first innovation that was rigorously studied was the diffusion of hybrid seed corn among farmers (Ryan & Gross, 1943).

analyzes social systems in terms of nodes (or vertices) and edges (or ties) (e.g. Scott, 2000; Strogatz, 2001; Albert & Barabasi, 2002; Newman, 2003, 2010). Social networks are usually depicted with graph-based structures and studied with the analytical tools of graph theory and matrix algebra. The Figure shows two typical social networks.

Conceptually, the diffusion of ICT is not very different from any other kind of diffusion through social networks, such as the prominent example of the diffusion of contagious diseases, like the spread of the HIV epidemic or an airborne infectious disease (Valente, 2010). The diffusion of both a contagion and an innovation through human networks is influenced by the nature of the ties among agents (the network structure) and by the characteristics of each agent (the personal adoption threshold).

Figure 2 Social network of the spread of diseases and online communities



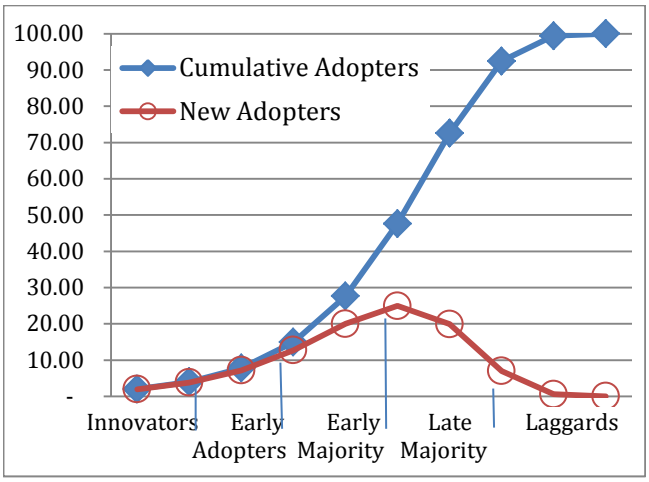
Source: Krebs, 2003, 2005.

With the framework of a social network in mind, it is straightforward to model the basic logic of the characteristic S-shaped diffusion curve that gives rise to the digital divide. Figure assumes a social group of 100 people, whereas some technological

innovation was adopted by 2 initial innovators. These 2 innovators interact randomly with the 98 who have not yet adopted and they persuade ("infect") them at a constant rate of 1% (assuming homogeneous mixing, without any particular network structure). This leads to 1.96 (say 2) new adopters during the next time period (2 x 98 x 0.01) (see Figure). The resulting 3.96 early adopters of the innovation (2 + 1.96, say 4) again interact randomly with 1% of the rest, leading to 3.80 new adopters, and so forth. The lower curve of Figure shows the resulting number of new adopters, which first increases, and then naturally decreases, because with increasing diffusion, there are less and less potential new adopters available. In the example of Figure, the maximum amount of new adopters per period is 24.94 (say 25), and happens in the sixth of the ten time intervals, which represents the inflection point of the diffusion process. The upper curve in Figure is the respective integral and yields the well-known S-shaped pattern, which Rogers subdivided into five categories: "innovators, early adopters, early majority, late majority and laggards" (Rogers, 2003, p.281). The growth in adoption occurs gradually at first and then accelerates toward the middle of the diffusion process, in order to naturally taper off as the number of non-adopter vanishes (Valente, 1995). Several mathematical models have been developed to evaluate the rate and character of these kinds of diffusion curves (Mahajan & Peterson, 1985).

Figure 3 Hypothetical example of homogeneous mixing Overview: "Mapping Out the Transition toward Information Societies"

	Cumul. Adopters	Rate of adoption	Non-adopters	New Adopters
	2.00	0.01	98.00	1.96
=>	3.96	0.01	96.04	3.80
=>	7.76	0.01	92.24	7.16
=>	14.92	0.01	85.08	12.70
=>	27.62	0.01	72.38	19.99
=>	47.61	0.01	52.39	**24.94**
=>	72.55	0.01	27.45	19.91
=>	92.47	0.01	7.53	6.97
=>				
	99.43	0.01	0.57	= 0.56
=>	100.00	0.01	0.00	0.00



Source: based on Rogers, 2003, and Valente, 2010.

This hypothetical example of homogeneous mixing is the simplest model. Besides its simplicity, it has shown to represent the process of diffusion quite accurately. However, in reality the characteristic S-shaped diffusion curves come in different shapes and sizes. This is because real-world diffusion is not following a random process of homogeneous contagion (such as assumed in Figures), but is influenced by the particular structure of the social network and by the characteristics of its nodes (such as shown in Figures). Some networks are more centralized than others, and others are characterized by clusters and cliques. Besides, innovators can often be found at the periphery of social networks, which means that they have few ties (Figure). As a result, the process tends to start off even slower. Once opinion leaders in the center of the network adopt the innovation (those with many ties), the novelty usually spreads quickly. Network thresholds (Valente, 1995) and the notorious tipping points (Gladwell, 2002) play a crucial role here. The specific attributes of the nodes act as can shape the diffusion curve.

Income- and educational levels of individuals often act as adoption thresholds. The nature of the ties also influences diffusion. Some actors might be connected by strong ties (e.g. family, friends or formal work relations), while others only relate to each other through informal weak ties or through some form of media (Granovetter, 1973). In short, the structure and nature of the network (i.e. the ties and its nodes) influence the diffusion process (Valente, 1995, 2010; Newman, 2010). This gives a particular and distinct shape to each individual diffusion curve (e.g. Bass, 1969; Andrés, Cuberes, Diouf, & Serebrisky, 2010).[6]

Independent of the kind of network, the diffusion through a social network is never immediate. While the innovation spreads through the network and the diffusion curve unfolds, some are included and others excluded from the benefits of the new innovation. The result is an unavoidable divide. This divide is inevitable. It is the inescapable result of the fact that it takes a certain amount of time for innovations to spread through social networks with particular shapes and characteristics. During the past century hundreds of innovation divides have been identified in a myriad of studies on the diffusion of innovations (Rogers, 2003). The diffusion of ICT, and its ensuing digital divide, has been given special importance, given the outstanding socio-economic significance of this powerful general purpose technology (Bell, 1976; Porat, 1977; Forester, 1985; Miles, 1988; Freeman & Louçã, 2002; Guerrieri & Padoan, 2007; Mansell, 2009; Castells, 2009).

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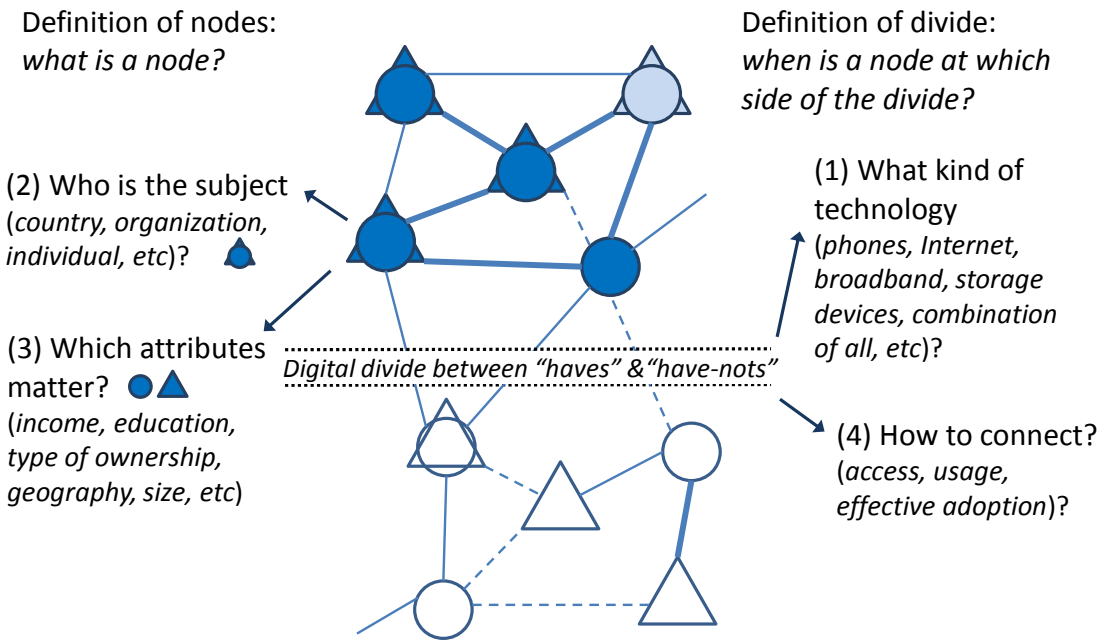
[6] According to the particularities of the diffusion process, some researchers also suggest that a modified classification of adopters' categories fits particular curves better than the five categories suggested by Rogers (e.g. Kauffman & Techatassanasoontorn, 2009).

How to define the digital divide analytically?

The theory of diffusion of innovations provides an adequate framework to classify the diverse methodological approaches that have been taken to study the digital divide. The Figure below shows a social network that tracks the diffusion of ICT. The "haves" are filled nodes, while the "have-nots" are empty. The difference between the "haves" and "have-nots" is called the "digital divide".

Figure differentiates between four perspectives on the digital divide. Two of them are concerned with the type of node: what does a node represent? Which are the attributes that are considered for each node? In short, what constitutes a node? The other two concern the diffusion of innovation: what kind of innovation diffuses through the network? Is it sufficient to have access to the technology, or is it necessary to effectively adopt the technology (e.g. requiring actual usage with measurable impact)? In short, when to color a node?

Figure 4 Social network schematization of different perspectives on the digital divide



Source: Author's own elaboration.

The following section classifies the literature on the digital divide according to the conceptual schematization of Figure. It is shown that these differences in definitions and focus not only lead to contradictory conclusions (one can show that the digital divide is closing and widening at the same time, depending on the chosen definition), but also that they have far-reaching consequences for policies aimed at confronting the digital divide.

Type of technology

The key variable of interest in studies on the digital divide refers to the technology in question. In social network graphs, nodes that have already adopted this technology would typically be marked with some specific trait, such as a distinct color (Figure). This allows to observe how the innovation spreads through the network (much like a disease follows a pattern of contagion) (see Figures). There is a large variety of Information and Communication Technologies (ICT) that might be of interest. Conceptually, ICT can be divided into three broad groups: technologies that transmit and communicate information (the movement of information through space); technologies that store information (the movement of information through time); and technologies that compute information (the transformation of information) (Hilbert & Cairo, 2009; Hilbert and Lopez, 2011a). Most current studies focus on technologies that communicate, such as telephones and Internet subscriptions. Figure shows the technologies that are most commonly studied. Depending on the choice of the analyst, diverse studies reach different conclusions. For example, the digital mobile phone divide is rapidly closing (Wareham, Levy & Shi, 2004; Barrantes & Galperin, 2008; Castells, Fernandez-Ardevol, Qiu, & Sey, 2009), while the digital broadband divide is quickly widening (e.g. Dutton, Gillett, McKnight, & Peltu, 2004; Cohen, 2008, Guerra & Jordan, 2010). In terms of the previously presented theory, this means that the mobile phone has already passed the inflection point of the diffusion curve (in the concave part of the S-curve), while the diffusion of broadband technology is still in the first (convex) period of the curve. It is inevitable that incessant technological process will continuously reintroduce new inequalities that are caused by new

technologies. Each new technology diffuses through the social network once again, creating a new divide every time.

Some studies also merge these technologies into so-called indices, such as ITU's (2009) ICT Development subindex for access and infrastructure. This index takes indicators such as fixed and mobile telephony, international Internet bandwidth, proportion of households with a computer and Internet access, assigns each of them some particular weight, and creates an average score. This approach implies that the digital divide is not considered as being closed if a user counts with one specific technology, but rather with a mix of technologies. The main problem with these indices is that it is at the discretion of the researcher which weights to assign to which technology. Some studies use experts opinions, others statistical methods (Hanafizadeha, Saghaeia & Hanafizadeh, 2009). Minges (2005) has evaluated twelve of those indices[7] and reconfirmed the predictable conclusion that the weight of each ingredient predetermines the resulting average score to a large extent. This leads to the well-known problem of subjectivity in the creation of any kind of index and therefore does not solve the problem of clearly stating which technology is relevant for closing the divide. It rather passes this responsibility on to the methodological level.

Another, maybe more justifiable way of considering a combination of different technologies into a single indicator is to measure them in terms of their performance, measured in [MB], [MIPS] or [kbps] (Hilbert, López & Vasquez, 2010; Hilbert & López,

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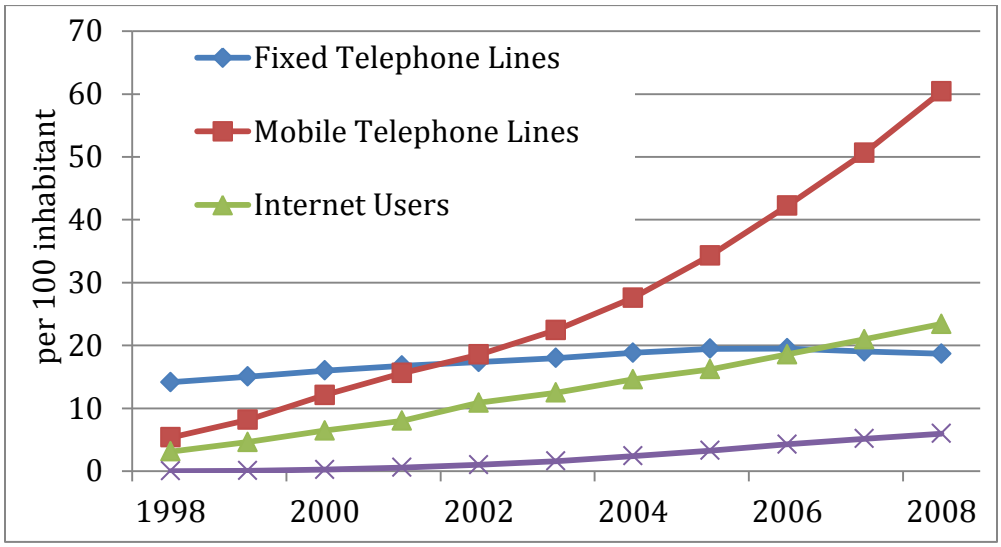
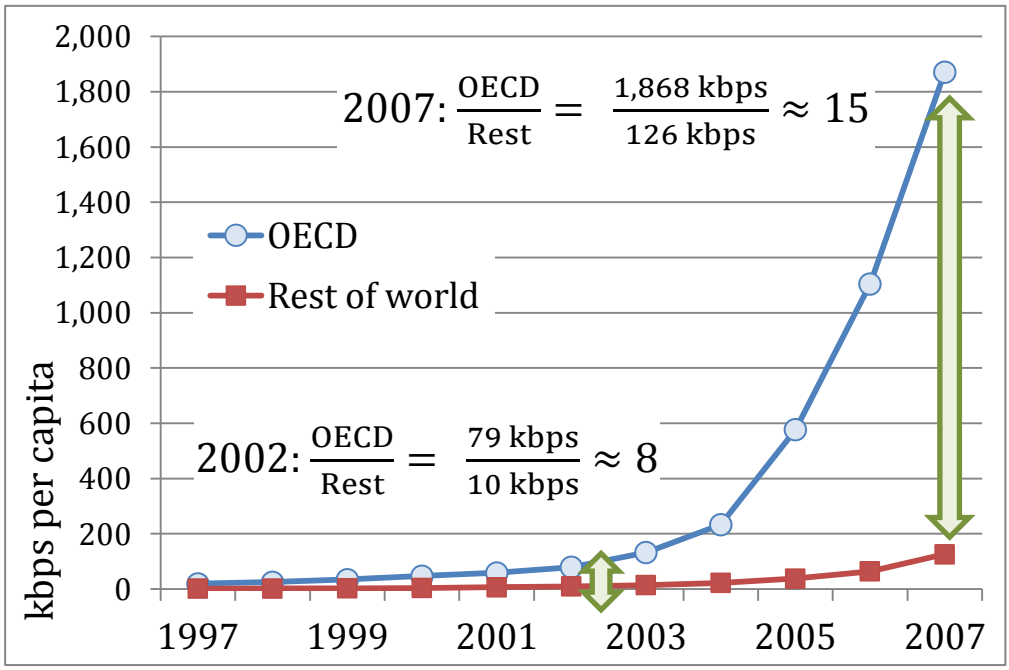
[7] These include the twelve most widespread indices on a global level: Composite index of technological capabilities across countries (ArCo); Digital Access Index (DAI); Digital Opportunity Index (DOI); Economist Intelligence Unit (EIU) e-readiness; Index of Knowledge Societies (IKS); Knowledge Economy Index (KEI); Network Readiness Index (NRI); Orbicom Digital Divide Index; Technology Achievement Index (TAI); UNCTAD Index of ICT Diffusion; UN PAN E-Readiness Index; World Bank ICT Index.

2011a). This implies not only to count the number of devices, but to multiply them with their informational performance (Hilbert & López, 2011c). The resulting sum provides insight into the technological capacity to process information. Figure combines the communication capacities of analog and digital fixed and mobile voice telephony, and mobile data and fixed Internet services, and shows the capacity to communicate of an average inhabitant of the world's most industrialized countries (member of the Organisation for Economic Co-operation and Development, OECD), and the average inhabitant of the (developing) rest of the world (based on Hilbert & López, 2011b). Figure shows an increasing digital divide: inhabitants of the industrialized world increase their informational capacity faster than their counterparts in developing countries. While in 2002, every inhabitant of the OECD had 8 times more bandwidth available than its non-OECD peer (79 kbps per capita versus 10 kbps per capita), the broadband revolution increased this divide to a factor of 15 by 2007 (1,868 kbps per capita versus 126 kbps per capita). This conclusion is different from the general conclusion that is reached when merely counting the number of technological devices. While the divide in terms of devices is closing around the world, the technological performance of those devices results in an increasing divide (Hilbert, et al., 2010).

This introduces a new aspect: not all technological innovations are equal. Some have more capacity than others. "Have" or "have-nots" is not a binary yes-no decision, but consists of a gradient with different intensities: "have how much"? One can mark these differences in performance in network graphs, for example by assigning different shades of colors to the nodes, or by adjusting their sizes (compare upper-right node in Figure).

Figure 5 Diffusion of most common ICT with individuals. Capacity to communicate through fixed line, mobile telephony and Internet in optimally compressed kilobits per second per capita





Source: ITU, 2009; Hilbert & Lopez, 2011b.

This last form of looking at the digital divide leads to an important question: when is the digital divide closed? How much bits does a person have to communicate to be a member of the information society? When is the technology actually diffused? In the analytical terms proposed in Figure, the question becomes when to color a node? These kinds of questions cannot be answered in a technocratic manner, but require normative decisions. It leads all the way back to the fundamental judgment of what is seen as necessary and sufficient for development (Sen, 2000). Adam Smith (Smith, 1776) had a very strong opinion on this issue and stated (almost 250 years ago): "By necessaries I understand not only the commodities which are indispensably necessary for the support of life, but whatever the customs of the country renders it indecent for creditable people, even the lowest order to be without. A linen shirt, for example, is strictly speaking, not a necessary of life. The Greeks and Romans lived, I suppose, very comfortably though they had no linen. But in the present times, through the greater part of Europe, a creditable day-labourer would be ashamed to appear in public without a linen shirt, the want of which would be supposed to denote that disgraceful degree of poverty which, it is presumed, nobody can well fall into without extreme bad conduct. Custom, in the same manner, has rendered leather shoes a necessary of life in England. The poorest creditable person of either sex would be ashamed to appear in public without them" (Vol.2, book5, p. V.2.148). The question is if, and if yes, then which kind of ICT connectivity represents the linen shirt or leather shoes of the 21st century? Do the customs of modern form of social organization render it "indecent for creditable people, even the lowest order to be without" a mobile phone or a broadband connection of a given bandwidth? Which level of bandwidth? Measuring the digital divide means defining and then tracking the

diffusion of the necessary and sufficient. This is a normative decision and part of the broader process of political will-formation in a society.

Policy implications of the choice of technology

As seen, different definitions of the technology in question can lead to different conclusions about the digital divide. Depending on the chosen technology, the divide can at the same time be closing and widening. The same differences in definition also affect the question of who is in charge to confront the divide. In many countries, different technologies are regulated by different authorities. If the digital divide is defined in terms of phones and Internet, telecommunications authorities should be in charge of the challenge. If the digital divide is defined in terms of a broader group of digital technologies, such as digital TV, storage devices and general computer equipment, then broadcast associations, equipment producers, and industry authorities have to be involved as well. The choice of technology influences who is in charge to bridge it.

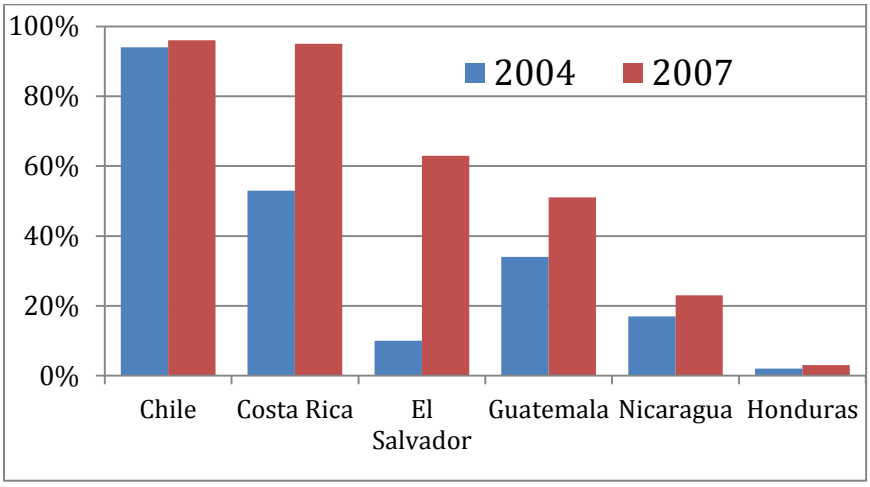
Choice of subject

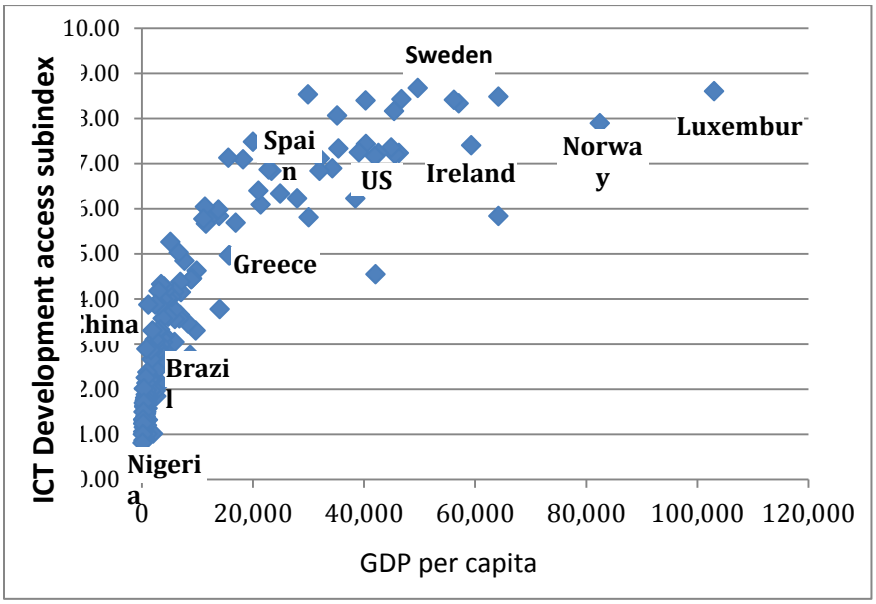
Another difference in studies about the digital divide refers to the subject of interest. This refers to the decision of what the nodes of the network represent: individuals, organizations, communities, societies, countries, or world regions. Figure focused on individuals. In this case each node of the social network represents a person. But on a higher level of abstraction, each node can also be a group of individuals, such as organizations, enterprises, schools, hospitals or municipalities, etc. For example, Figure shows the diffusion of Email among local governments of several Latin American

countries at two distinct points in time (2004 and 2007). In this case, the choice of technology is email, and the nodes of the social network represent municipalities. The figure shows that some countries, like Chile, succeeded early on connecting the large majority of their municipalities. The diffusion curve in Chile had already reached the upper end of the S-shaped diffusion curve: saturation. The figure finds the situation in other countries to be at the very steep middle part of the S-shaped curve. In only three years, the availability of Email in local governments of El Salvador jumped from mere 10 % to 63 %. Countries like Nicaragua and Honduras were lagging behind and were still struggling with reaching the critical mass of the diffusion process.

Figure looks at the digital divide from an even higher level of abstraction, whereas whole countries are the subjects of interest. The choice of technology is an aggregated index, which consists of a mix of different access technologies (ITU, 2009). The spread along the y-axis shows that some countries count with much more access to ICT than others. The divide among countries is often called the international digital divide (e.g. Corrocher & Ordanini, 2002; ITU, 2009).

Figure 6 Availability of Email in local governments. Country's access (ICT Development access subindex) and income for 2007 (n=147)





Source: OSILAC, 2007. ITU, 2009. Note: ITU's ICT Development Index (IDI) subindex for ICT infrastructure and access is a weighted average of fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international Internet bandwidth (bit/s) per Internet user, proportion of households with a computer, proportion of households with Internet access at home.

Policy implications of the choice of subject

The choice of the subject also influences policy responsibility. The digital divide can be defined to exist between countries, regional, organizations or individuals. Respectively, there are global, regional, national and local authorities that take actions at these different levels. In general, the digital realm does not recognize geographic borders. The policy response has therefore been leveraged at various levels simultaneously, which is reminiscent of the Russian matryoshka dolls, one inside another. The result is a global strategy, which was defined at the World Summit on the Information Society (WSIS)[8]; several regional action plans, such as in Europe[9] and Latin America[10]; national policy strategies (e.g. ECLAC, DIRSI, & UNDP, 2008; Guerra & Jordan, 2010), and local strategies[11]. Every organization, hospital, school or family might also grapple with its particular digital divide and a respective strategy to accelerate the internal diffusion process. All of these levels, from the global big picture to local improvisation are important to assure the success of ICT policy (Heeks, 2002). Unfortunately, the policy responsibility among those agents is often ill-defined and it is not rare that such entangled strategies end up in misunderstandings and conflicts.

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[8] The World Summit on the Information Society (WSIS) was held in two phases. The first phase took place in Geneva from 10 to 12 December 2003, and the second phase took place in Tunis, from 16 to 18 November 2005: http://www.itu.int/wsis . It produced two political declarations and two action plans that point towards the year 2015.

[9] For the history and background of the three consecutive European Action Plans, eEurope2002, eEurope2005 and i2010, see http://ec.europa.eu/information_society/eEurope/2002/index_en.htm

[10] For the history and background of the two consecutive Latin American and Caribbean Action Plans, eLAC2005 and eLAC2010 see: http://www.cepal.org/SocInfo/eLAC/default.asp?idioma=IN ; http://en.wikipedia.org/wiki/eLAC

[11] For example, Iberomunicipios (http://www.iberomunicipios.org) is a network of hundreds of municipalities and local e-government initiatives throughout Latin America and Europe.

Attributes of nodes and ties

Figure does not only show the nodes and their level of connectedness to ICT, but also another attribute of the nodes: income per capita. This leads to another distinction. The main attribute of interest is ICT connectivity, but nodes can have more than one attribute. Individuals, for example, can be distinguished by income, educational level, geographic location, age and gender, and their maternal language, among others (Parker, 2000; Katz & Rice, 2002; Rice & Katz, 2003; Roycroft & Anantho, 2003; Flamm & Chaudhuri, 2007). Traditionally, income and geographic location (i.e. urban- rural divide) are the two most frequently used attributes to describe the divide among individuals. Organizations can be characterized by their type of ownership, size, profitability, sector, geography, maturity and organizational culture (Taylor & Murphy, 2004; UNCTAD, 2009); and entire societies, countries or world regions are often classified by their level of development, wealth, size, geography and ethnicity, among others (Corrocher & Ordanini, 2002; ITU, 2009; Billon, Marco & Lera-Lopez, 2009). In social networks, the attributes of the nodes are habitually represented by a particular combination of size, shade, color and shape of the nodes. Figure uses triangles and circles to represent two distinct characteristics of each node, as well as coloring for our main attribute of ICT connectivity. Some nodes have all three of them, others only one. Figure suggests that those nodes with both triangles and circles are more likely to be on the “have-side” of the divide (filled) than those with only one of them.

Figure shows the digital divide between public and private schools in Argentina and Peru. Here the nodes are schools, the chosen technologies are computers and the Internet, and the additional attribute is related to the type of ownership of the educational

establishment. In reality, each node has an uncountable number of attributes (at the end, each node is unique in some detailed way). It is the decision of the analyst to emphasize some of them and to silence others, which inevitable moves some aspects of the divide into the spotlight at the expense of others. Figure suggests that the distinction between private and public schools is an attribute that seems to play an important role in understanding the threshold of adoption during the diffusion process of computers and the Internet through the social network of schools. In both countries, Argentina and Peru, private schools are much more connected than public schools.

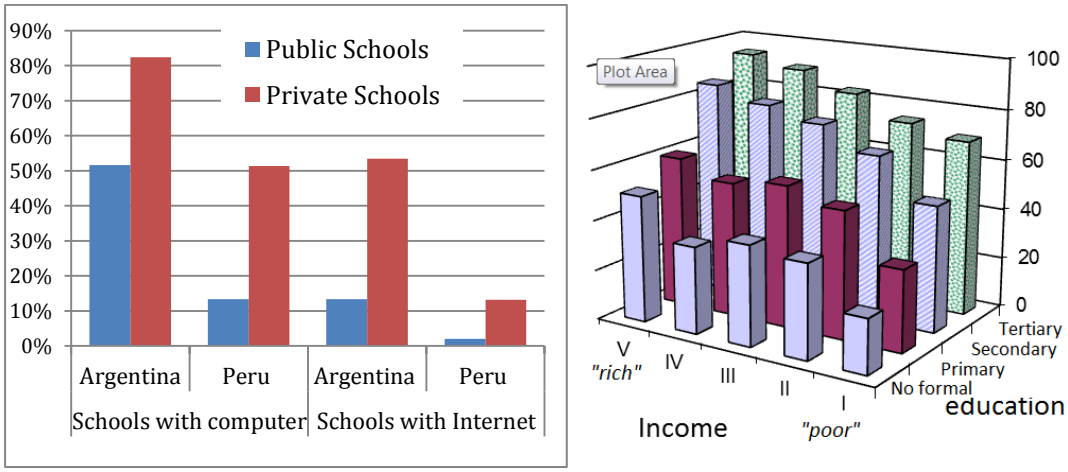
Figure shows the diffusion of mobile telephony in Brazil according to two different attributes: income and education of individuals. It can be seen that both attributes have independent effects: at the same level of income, access grows with increasing education, and independent of education, access grows with more income. Since the diffusion and adoption of ICT is a complex phenomenon that is influenced by multiple attributes, it makes often sense to track several of them and to analyze their combined effects.

Figure presents a multivariate discriminative analysis of ten attributes of individuals, testing for household Internet access.[12] It shows that education and income are the most significant indicators (see also Chaudhuri, Flamm & Horrigan, 2005). Age turns out to be the third most important determinant of Internet access. It turns out that other attributes, such as urban/rural, gender or ethnicity rather seem to be a mere consequence of these three previous ones: women and ethnic minorities have less income and less education and this is the reason why they lack Internet access. Carefully

[12] Multicollinearity can usually be expected in these kinds of exercises (for example between income and education) and has to be tested. In this case, the tests indicated a low level of multicollinearity. Also, all test turn out to be highly significant (Hilbert & Peres, 2010).

controlled studies have shown that being a woman by itself (with the same level of income and education) rather turns out to be positively correlated with the use of ICT (Hilbert, 2010a). Given that ICT diffusion is determined by so many different attributes, it is important to be careful with these confounding relations when analyzing the different attributes of the digital divide.

Figure 7 Computer and Internet access in schools (2004/5). Mobile penetration in Brazil (2005). Multivariate analysis of household Internet access for the individual



	Standardized Canonical Discriminant Function Coefficients					
	Chile 2006	Mexico 2007	Paraguay 2007	Nicaragua 2006	Uruguay 2007	Brazil 2007
Education of person	**.591**	**.690**	**.716**	**.802**	.464	.416
Income per decile (p.c. of household)	.551	.469	.634	.475	**.755**	**.753**
Household size (single/pair vs family)	.412	.209*	.245	.056*	.404	.345
Age	.329	.348	.425	.252	.094	.131
Enrollment in school/education	.180	.247	.310	.056	.122	.115
Job category	.018	.107	.107	.021	.050	.113
Color TV in household	n.a.	.034^	.095^	.233	.028	.060
Geographical region (urban/rural)	.189	.017	.122	.002	-.038	-.073
Gender	.042	.037	.220	.039	-.038	-.023
Indigenous ethnicity	n.a.	n.a.	n.a.	n.a.	n.a.	.008
	Strength of overall correlation					
Wilks lambda	.854	.792	.896	.983	.696	.682
Canonical correlation coefficient	.382	.456	.322	.132	.522	.564

Source: OSILAC, 2007; Hilbert & Peres, 2010. Note (12): Canonical correlation coefficients are normalized between 0 (no correlation) and 1 (total dependence).

The income dimension of the divide has probably been the one attribute that has received most attention as a potential bottleneck: if some “node” is below a certain level of income, it can potentially not been reached by the innovation that spreads throughout the network. Since ICT has a certain cost, the income attribute represents an absolute impediment that allows to predict to which nodes the innovation can (eventually) spread. Therefore, several studies claim that affordability is the key attribute of interest to track and bridge the digital divide (e.g. Barrantes & Galperin, 2008; Hilbert, 2010b; Beilock & Dimitrova, 2003). It has been shown that in Latin America the threshold is roughly around the “magical number” of US$ 10 per person per month, or US$ 120 per year (Hilbert, 2010b, p. 761). This is how much ICT people seem to strive for and therefore how much ICT everybody would like to have as necessary and sufficient. Notwithstanding, this desire is not in agreement with what people actually have: around 40 % of the world population lives with less than US$ 2 per day, and around 20% on less than US$ 1 per day, or less than US$ 365 per year. It can hardly be expected that the poor spend one third of their income on ICT (120/365 = 1/3). Normally people spend less than 3 % of their income on communication (Hilbert, 2010b). This implies that 40 % of human kind (who live with less than US$ 2 per day) count with less than US$ 1.80 per month to spend on these technologies (30.5 days/month * 2 US$/day * 0.03), or less than one fifths of the magical number of US$10 per month. This is the economic reality of the poor. Nodes with this income level can only be reached by those innovations that are available at this price level. While some suggest that relatively cheap mobile phones (Wareham, et al., 2004) and public Internet access (Simpson, Daws & Pini, 2004) are

adequate solutions to reach those income groups, even those solutions provide very limited access if one counts with less than US$ 1.80 per month[13] (e.g. Hilbert, 2010b).

As already mentioned, there are also different kinds of ties among the agents of the social network. The diffusion of innovations is characterized by the attributes of the nodes, as well as by the attributes of the ties. If individuals are bound by a contract with the same company, or if they are bound by the same law or regulation, the diffusion pattern might be more dependent on their peers than individuals or countries that merely have informal and sporadic ties with each other. In Figure, differences in the ties are represented with different kinds of lines (thicker and dashed, etc). The hypothetical schematization suggests that those nodes that have already bridged the divide have stronger ties among them.

Unfortunately, the effect of the nature of the linkages and the resulting structure of the network is often neglected when studying the diffusion of innovation. Statisticians are used to collect statistics about the attributes of the nodes, and not about the nature of the relations between the nodes.[14] It can be expected that the effect of the kind of ties and the resulting network structure is quite large, since the effect of the attributes of the nodes alone usually only explains about half of the diffusion process (see for example the canonical correlation coefficients in Figure: with a correlation coefficient that is normalized between 0 (no correlation) and 1 (total dependence), it reaches around 0.5). It can be expected that the other half of the story can be explained when considering the

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[13] With an average mobile phone minute price of US$ 0.05 per minute in 2009 (ITU, 2009), one can obtain around 1 minute of mobile phone traffic per day with US$ 1.80 per month(1.8/0.05 = 36).

[14] In contrary to traditional statistical software programs (like SPSS and SAS), software programs for social network analysis work (like Pajek or UCINET) use two different databases: one to register the attributes of agents (like in traditional statistics) and another one to register the type of relations between those agents.

relations between nodes (e.g. Bass, 1969). Much more research and adequate statistics are required to better understand this issue.

Policy implications of the chosen attributes

The selection of the most important attributes is subject to much policy debate, since it often directly influences the nature of any policy. For example, focusing on individuals, the traditional focus of the digital divide set on the divide between urban or rural areas. The reason is historical and has its origins in the times when access to fixed-line telephony was determined by urban-rural infrastructure deployment constraints. Nowadays, it seems that other variables, like income, are much more important (Navas-Sabater, Dymond, & Juntunen, 2002). Figure suggests that the educational level of the individual is seems to be very important as well. Therefore, many countries start to involve the education authority into the policy strategy. Others argue that language barriers are important (Roycroft & Anantho, 2003), which implies the involvement of cultural and linguistic authorities. Another much-debated question is if there is a digital gender divide, or if the lagging ICT usage by women is merely a reflection of the unfavorable conditions of women in terms of income, education and working conditions (Rice & Katz, 2003; Hilbert, 2010a). Which divide to fight: urban-rural, rich-poor, men-women? These kinds of definitions of the digital divide often directly influence the nature of policy interventions and decide which public and private authorities are involved in fighting the potential inequality.

Making things more complex, this definition can of course be combined with the previous distinctions between different kinds of subjects and various types of technology.

For example, taking schools as subjects and broadband connectivity as the technology, a program might provide connectivity subsidies when they are private or public, rural or urban, large or small. A rural hospital might be subject to natural discrimination when employing mobile devices to facilitate their interaction with patients. Different types of technology can be combined with a diverse choice of subjects with particular attributes. This creates an increasingly complex matrix that can be used to define the digital divide.

Level of digital adoption

Last but not least, the digital divide can be defined in terms far beyond sole access to ICT. Usually, words like connectivity or adoption are used to refer to the diffusion process. But what does it actually mean to be connected or have adopted?

Rogers (2003) originally distinguished among five stages of adoption: (i) initial exposure to an innovation; (ii) persuasion and the development of positive or negative attitude; (iii) decision to access or reject the innovation (this is the stage which is often measured in contemporary ICT statistics); (iv) implementation and actual usage; and (v) confirmation of its utility to continue and improve. This last step implies that the user is not only using the innovation effectively, but has started to internalize its benefits and mold it according to particular needs.[15]

Statistical practitioners have simplified these five steps of adoption and mainly distinguish between ICT access and usage (OECD, 2002). The first step, access, refers to Rogers' stages (i) to (iii) and is already ambiguous. The previous discussion about

[15] This then often results in feedback that goes back to shape the very nature of the technology (for example by users demanding a particular kind of technology from manufacturing companies; von Hippel, 2005).

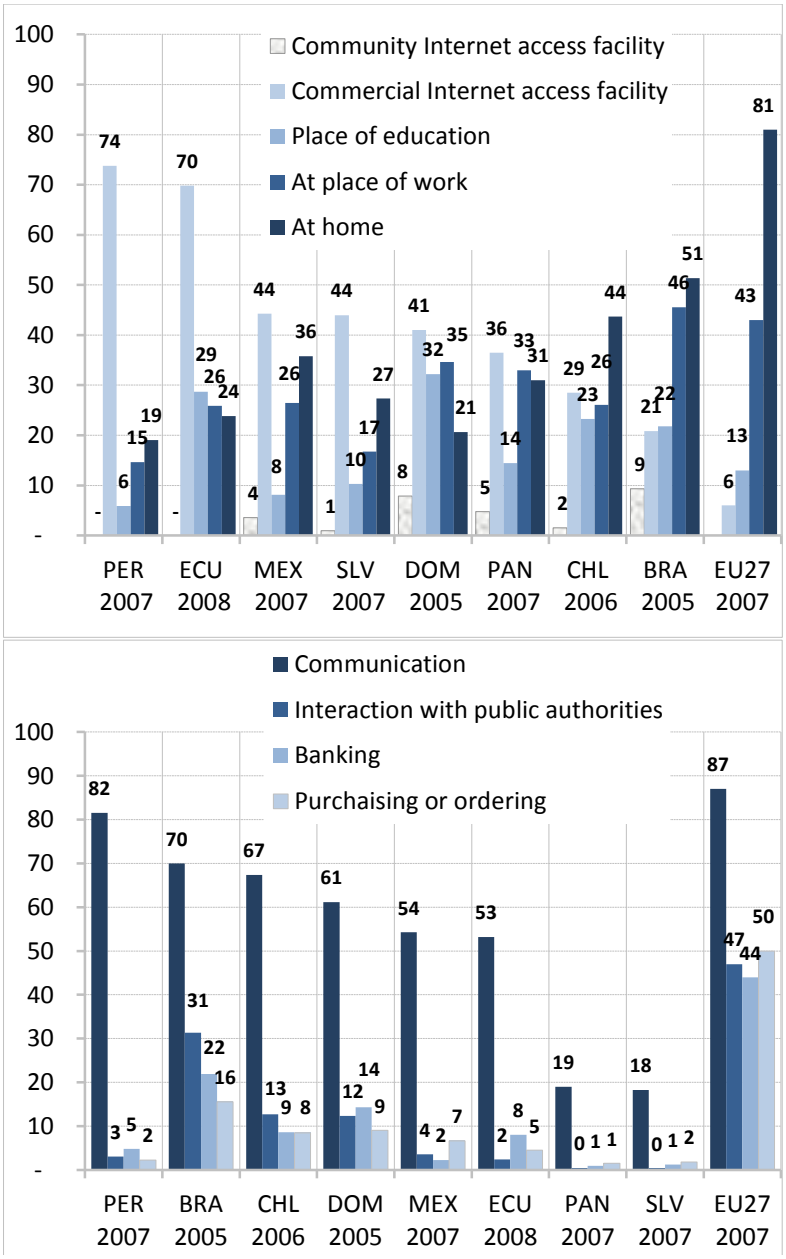
different technologies has already touched upon the question when a person can be considered to be connected: which and how much of which technology is necessary to reach the necessary and sufficient level of connectivity? (see Figure). Figure shows another perspective on this question. There are different kinds of access within the same technology, for example individual or shared access. Comparing several countries of Latin America with the average of the 27 countries of the European Union, it can be seen that patterns of access are quite different in the developing and the developed world. The vast majority of Internet users in countries like Peru, Ecuador, Mexico and El Salvador access the internet through public and shared access facilities, such as cybercafés, community centers or ICT equipped libraries. These are quasi not existent in Europe (Figure). Given that 40 % of the world population counts with less than US$ 1.80 per month to spend on ICT (see discussion above), collective access seems to be the only economically viable solution to bring them some kind of access to the digital realm (also Simpson et al., 2004). Is sporadic public access enough to be considered as being on the "have" side of digital connectivity? Dominating statistics, such as the Internet user statistics from ITU (2009), consider only household Internet access, not potential access through public access centers. Therefore, most studies that analyze the digital divide in terms of Internet access miss the hidden alternative of public access.

The step from access to usage refers to Rogers' stages (iv) and (v) and is also not free from ambiguities. Figure compares the usage pattern of some Latin American countries with those of Europe. It shows that more sophisticated services, such as e-government, e-banking and e-commerce, were much more common in developed regions, whereas the Internet was mainly used for simple communication in developing countries.

One of the main benefits of digital conduct is the reduction of transaction costs. Transaction costs can be largely reduced by online transactions such as those involved in banking, e-government or e-business. While a financial transaction over the counter at a branch of a bank costs on average over US$1, an online bank transaction costs less than US$0.01 (Lustsik, 2004). Mere online communication might also contribute to the reduction of transaction cost (by lowering search costs, etc.), but communication alone does not reap the entire potential benefits. It is therefore not merely the use of ICT, but the effective adoption of ICT.

The analysis of the digital divide at different levels of adoption can lead to contradictory results. For example, analysts who measure international access levels to ICT devices have long claimed that the access divide among countries is diminishing, since the number of devices reaches a certain level of saturation in developed countries and developing countries are quickly catching up (e.g. Compaine, 2001; Andrés et al., 2010). At the same time, however, patterns of effective adoption, which depend on skills and socio-cultural reorganization, show largely diverging trajectories and suggest a widening digital divide (van Dijk, 2005).

Figure 8 ICT access at different locations. sophistication of Internet usage



Source: OSILAC, in Hilbert & Peres, 2010.

The steps from access to usage to effective adoption turn out to be crucial and are often not automatic (Katz & Rice, 2002). It has been shown that first use and intensification of use represent independent choices (Battisti & Stoneman, 2003;

Hollenstein & Woerter, 2008; Battisti, Hollenstein, Stoneman & Woerter, 2007). The mere usage of ICT already requires skills, capabilities and involves adjustments in attitudes (Mossberger, Tolbert, & Stansbury, 2003). The step from usage to effective adoption entails the effective integration of technology into the daily lives of individuals, communities, institutions, and societies (Warschauer, 2004). This implies cultural transformations that modernize the way of doing things. It often requires a change in the most basic modus operandi of daily routines, as well as changes in the setting of priorities for long-established procedures. Brynjolfsson and Hitt (1995) talk about the necessity to invest into so-called intangible assets that complement the deployment of infrastructure, like the costs of implementing a new business process, acquiring a more highly skilled staff, or undergoing a major organizational transformation, etc.

Scholars of innovation theory underline that the diffusion of ICT does not occur in a vacuum and—as with any other general purpose technology—the relationship between ICT and the complementary surrounding economy becomes essential to advance from mere access to real impact (Guerrieri & Padoan, 2007). Carlota Perez (Perez, 2004) points to three different requirements for the successful adoption of ICT: (a) the development of surrounding services (required infrastructure, specialized suppliers, distributors, maintenance services, etc.); (b) the cultural adaptation to the logic of the interconnected technologies involved (among engineers, managers, sales and service people, consumers, etc.); (c) the setting up of the institutional facilitators (rules and regulations, specialized training and education, etc.). As long as these complementarities are lacking, one might achieve universal access to some kind of technological

infrastructure without achieving the desired positive impact for socio-economic development.

In short, a broader definition of the digital divide calls for the broader approach to digital development, which goes far beyond infrastructure deployment and includes the creation of an enabling environment. In concrete this might include a focus on training and capacity building, the creation of content and online presence, modernization of legal frameworks and the creation of supporting industries.

Policy implications of the level of adoption

Is it enough to provide users with access to ICT, or is the divide still existing until effective adoption leads to tangible impacts? In most countries, the telecommunication regulator is in charge of confronting the digital divide (e.g. Guerra & Jordan, 2010). It is also telling that at the global level, the International Telecommunications Union (ITU) has led the World Summit on the Information Society on behalf of the United Nations (WSIS).[8] These infrastructure authorities have the mandate to regulate the respective infrastructure and its deployment, which is undoubtedly an indispensable first step. Notwithstanding, scholars argue that it is not enough to define the digital divide in terms of access to infrastructure (Mossberger, et.al., 2003; Warschauer, 2004; Battisti, et al., 2007; Galperin, 2010), but to evaluate the divide in terms of the effective adoption of the technologies and their impact. For example, one could call for the successful integration of ICT into the sectors of education, health and public administration. To achieve this, it is not sufficient to expand access in schools, hospitals and among government authorities. E-education entails an adjustment of the curricula in educational establishments and

therefore requires the educational authorities to be involved. E-health requires the modernization of the health care sector by the digitization of medical records and procedures, which demands that health and pharmaceutical authorities are present at the table that defines an ICT strategy. It might even require changing health care legislation. E-government implies the effective modernization of public administration, and therefore calls for the leadership of the highest governmental level to introduce digital transparency and efficiency in governmental processes of all levels. The digital revolution does not stop here and continues to the realms of culture, business, family, youth, gender, entertainment, democracy, transport, finance, sports, military defense and security, among many others. The effective integration of ICT into the social organization of a society requires the expertise and guidance of authorities that are concerned with issues that are complementary to the deployment of technological infrastructure. If the divide is defined in terms that go beyond access, it is indispensable to count with a much broader group of expertise in the design and execution of respective policies.

Who, with which characteristics, connects how, to what?

Based on the long-established theory of the diffusion of innovation, it was straightforward to distinguish among four broad classes of variables that have been used to define the digital divide (Figure). These can be abridged in the question of: who, with which characteristics, connects how, to what? All kinds of studies and approaches to the digital divide can be classified into these four categories:

• WHO (choice of subject): individuals vs. organizations/communities, vs. societies/countries/ world regions, etc.;

• with WHICH characteristics (attributes of nodes and ties): income, education, geography, age, gender, or type of ownership, size, profitability, sector, etc.;

• connects HOW (level digital sophistication): access vs. actual usage vs. effective adoption;

• to WHAT (type of technology): phone, Internet, computer, digital TV, etc.

This results in a matrix with four distinct dimensions, whereas each dimension consists of various variables. Each additional variable increases the combinatorial complexity of this matrix exponentially. For example, counting with only 3 different choices of subjects (individuals, organizations, or countries), each with 4 characteristics (age, wealth, geography, sector), distinguishing between 3 levels of digital adoption (access, actual usage and effective adoption), and 6 types of technologies (fixed phone, mobile phone, computer, digital TV, general Internet, broadband with a certain speed), already results in 3*4*3*6 = 216 different ways to define the digital divide. Each one of them seems equally reasonable and depends on the objective pursued by the analyst. Despite their heterogeneity, all of them are the result of a common generative mechanism: diffusion through social networks. The existing diversity in the definitions of the digital divide are simply the result of prioritizing some aspects of this general process, while silencing others. Considering the vast combinatorial range of possibilities arising from this matrix, it is not surprising that discrepancies among diverse methodological approaches to the digital divide have often led to more confusion than common understanding.

What determines the choice of a specific one of those possible combinations? Is there an overall definition that transcends the differences? The preceding sections have

put emphasis on the fact that the particular definition of the digital divide has far-reaching implications for the decision on who is in charge to confront the challenge. This can also be turned around: each policy authority in charge has a different outlook on the digital divide. Given that the final impact and gain from ICT depends on the successful integration into a particular environment, and given that all of these different thematic fields have their particularities and characteristics, it seems very difficult to find a one-size-fits all definition. Infrastructure authorities will naturally have different priorities than education and health authorities, and the military or cultural communities have again a different interpretation of what matters most. The nature of the digital divide is in the eye of the beholder.

For example, telecommunications authorities traditionally emphasized the diffusion of infrastructure to every home in their definitions of the digital divide, while others who are concerned with social welfare and social equality might prefer a definition that defines the divide in terms of a certain amount of kbps per capita as a socially accepted minimum (this affects the choice of type of technology in the definition, compare Figures). International authorities will naturally look at the divide between countries, while local authorities will be concerned with the exclusion of specific parts of a community (this affects the choice of subject in the definition, compare Figures). Somebody who has the goal to modernize education with ICT will identify individuals with different attributes as core subjects than somebody that focuses on improving national security (this affects the choice of attributes in the definition, compare Figures). And finally, somebody who wants to employ ICT to diffuse the work of national museums has a different understanding of the necessary level of ICT adoption than

somebody who wants to use ICT to effectively modernize the domestic health care system (this affects the choice of level of digital adoption in the definition, compare Figure). In short: the end determines the definition of choice.

Who defines the digital divide in practice?

With this in mind, the following section looks at empirical evidence on who is in charge of fighting the digital divide in some selected countries. This will provide a better understanding of the breadth of the existing perspectives in practice. The most straightforward way to identify who is in charge on a national level is to see who counts with how much resources to fight the digital divide. The identification of the funds that each government authority has available to execute digital policies provides an idea how governments perceive and define the digital divide in day to day policy making. If it should turn out that most resources are spent by infrastructure authorities, it can be concluded that –in practical terms—policy makers understand the digital divide in terms of access to telecommunications. If other authorities receive even more resources (e.g. e-government, education and health authorities), it can be concluded that the de facto definition of the digital divide goes beyond access, etc.

Who manages the resources to fight the digital divide?

In the case of the United States, the Federal Communications Commission (FCC) manages roughly US$ 8 billion annually to fight the digital divide in the country. However, the newly appointed first Federal Chief Technology Officer of the United States (CTO) estimates that the federal government spends up to US$ 70 billion (Chopra,

2010). So even in times where the American Reinvestment and Recovery Act appropriated an additional ad-hoc and onetime US$ 7.2 billion to expand digital broadband access and adoption in communities across the country (NTIA, 2010), it becomes clear that the bulk of the pie is by far still dispersed with authorities that do not mainly focus on ICT itself, but try to make ICT work for the development of the country from different perspectives. If one assumes that money talks louder than discourse, it turns out that in reality the telecommunications authorities FCC and NTIA are not really in charge of fighting the digital divide, independently of what any official mandate might say. While the divide in the United States has traditionally been defined exclusively in terms of access to infrastructure (NTIA, 1995), it turns out that the bulk of the respective budget is spent elsewhere in the meantime.[16]

The case of South Korea is also interesting in this regard. The country set up a specialized Informatization Promotion Fund which invested a total of US$ 5.33 billion between 1994 and 2003. Of that, 38 % was invested in ICT Research & Development, 20 % into informatization promotion, 18 % in ICT human resource development, 15 % in broadband infrastructure and promotion, 7 % in ICT industries, and some 3 % in

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[16] In response to this fragmented challenge, President Obama has set up a coordination-trio, consisting of three posts (Obama, 2009): the Federal Chief Information Officer was created by the e-government Act from 2002 (Congress 107th, 2002) and is the administrator of the Office of Electronic Government, which in turn is part of the Office of Management and Budget. It is "responsible for setting technology policy across the government, and using technology to improve security, ensure transparency, and lower costs" (Obama, 2009). This post has been complemented by the Chief Performance Officer, in 2009, which is also part of the Office of Management and Budget and concentrates on general government reform. Finally, the Chief Technology Officer was created in 2009 as a position within the Office of Science and Technology Policy. It is its assigned task to "promote technological innovation to help achieve our most urgent priorities – from creating jobs and reducing health care costs to keeping our nation secure" (Obama, 2009). He is also tasked with increasing American's access to broadband. Even though none of these positions is very high up in the hierarchy of the federal government, it is envisioned that their interventions gain efficiency by working closely together. At the time of writing this article, the judgment is still out if such trilogy of power is effective to coordinate the dispersed US$ 70 billion spent annually on ICT issues by the federal government.

standardization (Suh & Aubert, 2006). It can be seen that the ambitions of Korea have been quite broadly defined: only 15 % of the total was dedicated to infrastructure deployment, while the rest was dedicated to dimensions that complement the infrastructural gap, such as the development of skills and the integration of ICT into governmental processes (informatization).

Unfortunately, it was not possible to obtain more detailed information on the budgetary distribution of the United States and South Korea or many other countries. This is mainly because those inventories hardly exist. Not even the government often knows how much it spends on ICT. One exception is the detailed ICT spending inventory of the government of Chile. An analysis of this data will provide anecdotic evidence to answer the question of who is in charge of the digital agenda in practice.

The Chilean ICT budget

The Chilean Telecommunications Development Fund (FDT) is seen as a best practice in the developing world (Wellenius & Bank, 2002; Hawkins, 2005; Mena, 2006). The fund was created in 1994 with an objective to improve payphone access in rural and low-income urban areas with low teledensity. The fund offered subsidies to private companies to provide payphone service. Subsidies were allocated through competitive tenders and were taken from the national budget (Wellenius & Bank, 2002). Like all funds of this interventionist nature in a privatized market it has been subject to much debate and public and private conflicts of interest right from the days of its conception (Rosenblut, 1998). The debate continues as the fund moves into the Internet age and started to subsidize data services (Hawkins, 2005; Mena, 2006). The fund is managed by

the national telecom regulator SUBTEL, a sub-secretariat of the Ministry of Transport and Telecommunications.

In 2003 the Fund spent a total of US$ 4.86 million, allotted by two public contests (SUBTEL, 2003). At the same time, the national government set up the first generation of the Chilean Digital Agenda.[17] In the frame of this comprehensive strategy, the Ministry of Finance carried out an inventory of public ICT spending, which covered 210 public institutions from 22 budgetary rubrics (DIPRES, 2005). The initiative did not come without protest, since it additionally complicated the already intricate process of national budgeting. This might also be one of the reasons why detailed statistics on government wide ICT spending are very scarce. For the same reason, the Chilean study excluded entities that correspond directly to Congress, as well as establishments of higher education (which make up a considerable part of public funding). It also does not include the subsidies used in the Chilean Telecommunications Development Fund. The inventory identified a total spending on ICT and related services of US$ 205 million in 2003. Table 1 enlists the 22 authorities that handle this budget and shows their fiscal power in the field of digital development.

It turns out that the e-government projects of the Ministry of Finance occupied the largest share of the pie (15.2%). The Ministries of Education and Defense almost spent the same amount of resources on their ICT projects (14-15% each), while the US$ 22 million spent by the Ministry of Health account for 10.7% of the total. Together, these

[17] Chile was one of the pioneers in national agenda setting for digital development in developing countries. The first generation of the plan, between 2004-2006, was called Agenda Digital Chile, while the 2007-2012 plan is called Digital Strategy (http://www.estrategiadigital.gob.cl). It focuses on the modernization of the State, ICT investments and the effective usage of ICT by the society at large.

four authorities account for 55% of the national public spending on ICT. Note that none of these authorities sees infrastructure deployment as their main task.

The lower part of Table 1 shows the ends toward which the government spending is directed. 20.4% of the total goes toward salaries and specialized ICT staff. One could argue that this amount does not really make part of any digital divide policy, since it is spent on improving internal processes of the government, without being directly aimed at the public. Without this amount, the total spending still amounts to US$ 163 million. These resources are exclusive investments into the successful deployment of ICT and related services for the benefit of the public, spent by the most diverse public authorities.

In the light of these kinds of resources, the much-cited US$ 4.86 million of the Telecommunications Development Fund seem almost negligible: total government spending consists of 34 times the resources of the specialized fund.[18] Alone the resources the overall government spends on ICT investments and purchases (15.7% of the total, see lower part of Table 1) sum up to almost 7 times the US$ 4.86 million of the Telecommunications Development Fund ([205*0.157]/4.86). The amount of resources the government spends yearly on general Development Projects that involve ICT (11.5% of the total ICT budget, see lower part of Table 1) is almost five times as much as the resources provided by the much-cited best-practice fund ([205*0.115]/4.86).

In short, the case of Chile suggests that in practice the digital divide is seen as a challenge that goes far beyond mere infrastructure deployment. Only 3 % of the public ICT budget is assigned to the national ICT access authority, while the bulk of the available funds are dispersed among 210 institutions from 22 budgetary rubrics. The

[18] 163/4.86 = 33.6; or with a broader definition of ICT spending, including salaries: 205/4.86 = 42.

Ministries of Finance, Education, Defense, Health, Labor and Social Security, and Justice carry out the most important initiatives regarding digital development in the country, and given the nature of their thematic priorities, they certainly count with different definitions of the nature of the problem.

Table 1 Governmental spending on ICT in Chile, 2003, in percent of a total of US$ 205 million

	General governm., security & defense	Fiscal functions	Regulatory functions	Investment functions	Social functions	
Ministry of Finance	6.2	0.0	9.0	0.0	0.0	**15.2**
Ministry of Education	11.2	3.0	0.2	0.4	0.0	**14.9**
Ministry of Defense	12.9	1.1	0.0	0.0	0.0	**14.0**
Ministry of Health	0.6	9.5	0.6	0.0	0.0	**10.7**
Ministry of Labor and Social Security	0.2	6.5	1.9	0.0	0.0	**8.6**
Ministry of Justice	5.3	0.7	1.3	0.1	0.0	**7.3**
Judicial Power	5.1	0.0	0.0	0.0	0.0	**5.1**
Ministry of Public	3.3	0.0	0.0	0.0	0.0	**3.3**
Ministry of Economy & Reconstruction	0.3	0.2	0.6	2.0	0.0	**3.1**
Ministry of Public Works	0.2	0.0	0.2	0.0	2.7	**3.1**
Ministry of Agriculture	0.2	0.0	0.0	2.6	0.0	**2.8**
Ministry of Interior	1.8	0.0	0.0	0.0	0.7	**2.5**
Ministry of Housing and Urban	1.4	0.0	0.0	0.0	0.5	**2.0**
Ministry of Planning and Cooperation	0.8	0.9	0.0	0.1	0.0	**1.8**
Ministry of General Secretary of Governm.	0.4	0.6	0.0	0.1	0.0	**1.0**
Ministry of General Secretary of President	0.2	0.0	0.0	0.7	0.0	**0.9**
General Accounting Office	0.0	0.0	0.9	0.0	0.0	**0.9**
Ministry of Exterior	0.4	0.0	0.0	0.4	0.0	**0.8**
Ministry of Mining	0.1	0.0	0.0	0.6	0.0	**0.7**
Ministry of Transport and Telecom	0.1	0.0	0.0	0.4	0.0	**0.5**
Presidency	0.4	0.0	0.0	0.0	0.0	**0.4**
Ministry of National Goods	0.0	0.0	0.0	0.4	0.0	**0.4**
	51.0	**22.6**	**14.7**	**7.7**	**3.9**	**100.0**
Which are distributed toward the following ends:						
Staff and salaries	8.9	5.2	1.5	0.8	4.0	**20.4**
Computer and telecom services/leasing	23.9	7.4	3.5	2.0	15.6	**52.4**
Investment and ICT purchases	8.0	2.1	1.6	1.1	2.9	**15.7**
Development projects involv. ICT	10.2	0.1	1.0	0.0	0.2	**11.5**
	51.0	**14.7**	**7.7**	**3.9**	**22.6**	**100.0**

Source: DIPRES, 2005.

It is to be expected that infrastructure and telecommunication authorities will continue to play an important part in the challenge of narrowing the digital divide, but, as suggested by the budgetary priorities from the United States, South Korea and Chile, their role is in reality already much smaller than what is generally assumed. The funds managed by the telecom authorities only represent a small fraction of the total governmental ICT funds, which are distributed among the budget lines of diverse agencies. In the case of Chile, authorities of the fields of finance, e-government, education, health and social security spend much more on ICT policies than infrastructure authorities that are exclusively concerned with the diffusion of technology. This is in line with the previous argument that policies that aim at fighting the digital divide should aim at the effective integration into a specific area of interest.

A fragmented policy response

The case of Chile shows that the realm of policy making counts with a very broad and multifaceted interpretation of the challenge and opportunities posed by the digital age. The heterogeneity in policy makers and their diverse tasks inevitably leads to heterogeneity in the outlooks on the challenge. Different authorities have different priorities in their interpretation of the digital divide. This incoherence can lead to double efforts, waste of scarce resources, and even obvious contradictions.

For example, different government authorities have different ideas about the kind of technologies that matters for the well-being of society, and reflect these priorities in relevant policies. Baqir, Palvia, & Nemati (2009) report on inconsistent and contradictory policies regarding sales tax and import duties on ICT services and equipment. As a result

of the limited coordination between the diverse outlooks of different government authorities, foreign investors and local manufactures were discouraged from committing more of their resources.

A typical example of double efforts is the coordination of diverse public access strategies (such as public access centers and libraries) with access at educational facilities (computers in schools). Public ICT access centers target the larger public, while computer labs in schools focus exclusively on school students. While it is natural that the latter use their computer labs during morning hours, the general public usually visits public access centers during the afternoon and evening. By allowing the public at large to use school computer labs during times students are not at school, valuable synergies can be created. This, however, requires a coordination of the diverse definitions of the challenge at hand.

Something similar accounts for the confrontation of the skill-gap, which is at the core of the usage and impact dimensions of the digital divide. In the United States, the national telecommunication authorities FCC (Federal Communications Commission) and NTIA (National Telecommunications and Information Administration) have recently started to support training courses focused, among other things, to support people finding employment through online services. These are not directly coordinated with longstanding similar efforts from employment and labor offices, social security and industry authorities.[19] It can be expected that the funds of the latter largely surpass the funds that the telecom sector dedicates to this end in an ad hoc effort. Double efforts do not only waste resources, but are not sustainable, since the ad-hoc funds of the ICT-

[19] This statement is based on comments made by Mignon Clyburn, Commissioner of Federal Communications Commission, after a presentation at the 38th Research Conference on Communication, Information and Internet Policy Friday, October 1, 2010 at the George Mason University School of Law, Arlington.

authority are only temporal in nature. It would be more sustainable to modernize longstanding existing programs from non-ICT authorities, making digital development part of their continuous mandate.

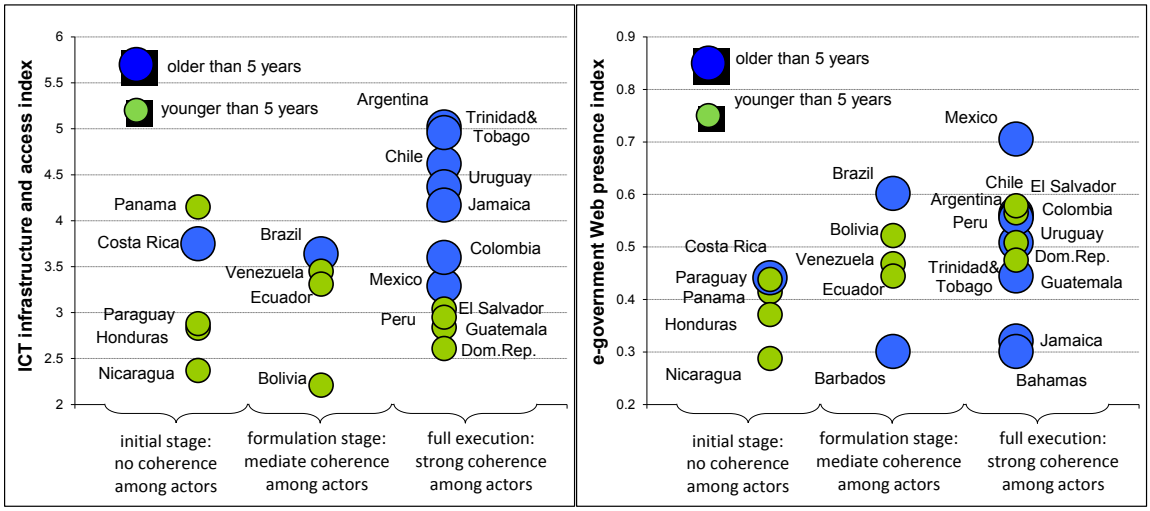
In search for evidence of impact of a common outlook

These examples point to the usefulness for one common and coherent strategy to confront the multiple challenges of digital development. With this in mind, many countries have started attempts to unify and streamline the different visions by bringing ICT policy under one common and coherent umbrella with a shared outlook on the challenge. These national ICT strategies consist of inter-ministerial and multi-sectorial policy agendas, mainly led by the public sector, and aim at coordinating the diverse and disconnected efforts carried out by different authorities (ECLAC, DIRSI, & UNDP, 2008; Guerra & Jordan, 2010). The goal of these coordination mechanisms is to create a common outlook of the nature of the challenge among the different stakeholders, which is typically written down in a public document (such as in Chile's digital strategy, Colombia's connectivity agenda, or Mexico's e-Mexico plan, among others). The natural question is if the existence of such nationwide common strategies for digital development leads to a detectable positive impact. Is a coherent outlook on the digital divide essential for the advancement toward to digital age?

To answer this question, Figures compare the stage of development of such strategies with measures of impact for several countries from Latin America and the Caribbean. Both figures show three different stages of national strategy formulation on the x-axis. Some countries, like Panama and Costa Rica, did not count with a coherent

national strategy or dialogue on digital development in 2007. There was no coherence among the different initiatives and projects, no common outlook or shared vision. A second group of countries, like Brazil and Bolivia, found themselves in the phase of formulating such national strategy; while a third group (the majority), including Mexico, Chile and Jamaica, actively executed a coherent and nationwide strategy for digital development. Figure measures these stages against a composite index that evaluates the deployment of a quality infrastructure (ITU, 2009), and Fig 16 against a composite index that measure the online presence of the national e-government (UN DESA, 2008). This provides two complementary indicators for impact: one on the level of infrastructure, and another one on the level of online content.

Figure 9 ICT policy coherence versus ICT infrastructure and access index, 2007. ICT policy coherence versus online presence of e-government index, 2007



Sources: OSILAC, 2009 and ITU, 2009. Note: ITU's ICT Development Index (IDI) subindex for ICT infrastructure and access is a weighted average of fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international Internet bandwidth (bit/s) per Internet user, proportion of households with a computer, proportion of households with Internet access at home. OSILAC, 2009 and UN DESA, 2008. Note: E-government online presence is a subindex of UN DESA's World e-Government Preparedness ranking and measures the online presence of national e-government websites, including those of the ministries of health, education, welfare, labor and finance of each State.

Both figures show a slight positive correlation between the existence of a national policy strategy and digital development.[20] Figures also show that older strategies (older than 5 years) seem to have more correlation with infrastructure deployment than with e-government development. This makes sense, since it takes much longer to employ an infrastructure than to set up transactional webpages. This suggests that the existence of a national strategy does have a positive impact. However, in both cases this correlation is not very strong. Some countries without any national vision for digital development, such as Panama and Costa Rica, do better than countries that count with an established strategy, like the Dominican Republic. Decisive differences can also be found between areas of impact. Trinidad and Tobago counts with a quality ICT infrastructure, but is struggling with their e-government initiative, while the opposite holds for Mexico. The existence of a coherent policy vision can therefore not be the main cause for the observed impact.

Digging deeper into the reasons for why some countries do well in some areas and not in others, it shows that it is not the existence or non-existence of a national strategy per se that explains success of failure in digital development, but rather sector specific projects and tailor-made policies that address specific areas of interest (ECLAC, DIRSI, & UNDP, 2008; Guerra & Jordan, 2010; Hilbert & Peres, 2010). For example, in the case of Mexico, lack of competition has notoriously limited the deployment of telecommunications infrastructure (Mariscal & Rivera, 2005), which led to a mediocre performance in this sector (see Figure 15). Infrastructure deployment is a very concrete

[20] Note that Figures represent correlations, without making any claim about causality. While the obvious goal is to foster digital development with a national ICT for development strategy, it might well be that higher impact in certain areas of digital development facilitate the existence of a national strategy.

problem and requires a tailor-made response. At the same time, the Mexican e-government authorities independently went ahead to set up one of the world's leading e-government service network (Luna-Reyes, Gil-Garcia & Cruz, 2007). The results are clearly detectable in Figure. Something similar accounts for Bolivia. The country has long struggled with the development of vibrant ICT infrastructure (ITU, 2001) (see Figure), but has successfully set up relatively well-working e-government online content (ADSIB, 2010) (see Figure). On the contrary, some small countries like Panama and Jamaica counted with well-developed infrastructures in 2007, while they had not yet set up a successful e-government strategy (see also Miranda, 2007; Lawton, 2010). The provision of high quality content is a different challenge than the deployment of infrastructure, and, to a certain extent, it is possible to advance in each area independently of the other. Each implies a different outlook on digital development.

This shows that real-world impact does not primarily seem to depend on the existence of one common outlook, but on how well a particular challenge is confronted with a specific solution. It seems intuitive that it is much more important to confront concrete challenges than to find methodological elegance and coherence. Second, the different projects are certainly complementary. For example, a thriving e-government will eventually depend on the existence of a quality infrastructure, and vice versa. These kinds of complementarities are not to be underestimated (Hilbert & Peres, 2010) and they can be harnessed by exploiting synergies as such the ones discussed in the previous section. The slightly positive correlation between the existence of a coordination mechanism and impact in Figures supports this intuitive idea. However, this effect seems

to be merely secondary to the provision of concrete and tailor-made solutions for particular challenges.

Conclusion: Impact over analytical coherence

This article started by deriving a conceptual framework that allows to differentiate among the manifold definitions of the digital divide. This conceptual framework is based on the network analysis approach to the diffusion of innovation and provides four straightforward ways to categorize the existing literature on the topic. A systematic literature review showed that there is a vast combinatorial array of different ways to define the digital divide. These diverse definitions influence the choice of who is in charge of confronting the digital divide. At the same time, the other way around, each authority has a different outlook on the challenge. Empirical evidence shows that a large and heterogeneous group of authorities with the most dissimilar thematic priorities is invested in the challenge. This is good news, since it is generally accepted that real impact and gains from ICT demand sector-specific expertise from the fields in which ICT is employed. Given the diversity of the potential benefits and impacts of such a versatile general-purpose technology as ICT, this finding argues in favor of a flexible definition of the digital divide that considers specific ends with a final impact. It is unavoidable that these different perspectives will lead to tailor-made and complementary definitions of the divide (Vehovar, Sicherl, Husing & Dolnicar, 2006).

To strengthen this point, it was also shown that the existence of a unifying institutional mechanism and common outlook on the digital divide do not necessarily lead

to detectable impact. On the contrary, it is indeed conceivable that a very stringent one-size-fits-all definition of the digital divide will be counterproductive. This is one of the main critiques of general ICT development indexes, such as ITU's ICT Development Index (ITU, 2009) or the Network Readiness Index of the World Economic Forum (INSEAD & WEF, 2009) (for an overview see Minges, 2005). If policy makers would take such indexes seriously (and finance and economic authorities often do, because of concerns related to foreign investments and national competitiveness), the content of any policy agenda would have to follow the specifications of the components of the index. For example, if computers in every household would receive a considerable weight in the definition of the digital divide, the most impact effective policy of any country would be to design projects and regulations that would assure to increase home computer penetration. Other initiatives, which might be more valuable but not included in the weighting (like mobile phone bandwidth, the establishment of software industries, or e-government initiatives, etc.) would then inevitably suffer from such policy priorities. This would of course put the cart before the horse. The ends should determine the means, not the other way around. Since there are no common ends in the deployment of ICT, it is counterproductive to pursue common means. There are only complementary definitions of the digital that fall into common categories and pursue one multifaceted final goal: achieving positive impacts from the deployment of ICT.

These insights lead to an emerging consensus among scholars. "The new consensus recognizes that they key question is not how to connect people to a specific network through a specific device, but how to extend the expected gains from new ICTs" (Galperin, 2010; p. 55; see also Bar & Best, 2008; Khalil & Kenny, 2008; Heeks, 2009).

The analytical focus shifts from the search of a definition by means of understanding the diffusion process (inductive: from real-world observations to concepts), to the identification of a desired impact, which then determines the adequate definition to solve a particular problem (normatively deductive: from concept to desired real-world change). Since the impacts of ICT are diverse, the definitions of the digital divide are as well. Therefore, questions like "what is the best definition of the digital divide?" or "when is the digital divide closed?" do not make sense by themselves, but have to be formulated on basis of a conditioning variable:

Given the desired impact, who, with which characteristics, connects how to what?

Or, normatively speaking:

Given the desired impact, who, with which characteristics, should best be connected how to what?

This leads to a relativistic and maybe unsatisfactory conclusion, which is nonetheless very certain: there is no truth about what the digital divide is. It is subjective and depends on what the aspired achievement. More formally speaking: the definition is conditioned on the desired impact. The best that can be done is to come up with a single and coherent framework based on a solid theory, which allows for the classification and comparison of the different definitions, such as done in the first part of this article. The challenge does not consist in reducing the heterogeneity in outlooks, but in better understanding and keeping track of the communalities and differences among the priorities of diverse actors and their definitions. In practical terms, a major part of this task consists in institutionalizing a mechanism that takes inventory of the budget each (public or private) authority allocates to ICT related policies and projects. This is a

practical first step in the search for synergies among diverse outlooks. Unfortunately, most countries do not count with any mechanism to track the complete amount of resources that are dedicated to ICT policies and projects.[21] The combination of conceptual clarity and relevant information among the diverse priorities eliminates confusion and allows for the effective search for synergies among complementary outlooks on a multifaceted challenge.

[21] The effort of Chile in 2003 was a onetime effort, which was not continued.

When is Cheap, Cheap Enough to Bridge the Digital Divide? Modeling Income Related Structural Challenges of Technology Diffusion in Latin America[22]

The article presents a model that shows how income structures create diffusion patterns of Information and Communication Technologies (ICT). The model allows the creation of scenarios for potential cuts in access prices and/or required subsidies for household spending in Mexico, Uruguay, Brazil and Costa Rica. One analyzed scenario would require the reduction of ICT prices to as low as 4% of the current price levels (to US$0.75 per month), or alternatively, a subsidy as high as 6.2% of GDP (a figure equivalent to public spending on education plus health). Neither existing technological solutions nor existing financial mechanisms are sufficient to cope with this challenge. Alternatives are discussed.

Introduction

The heated discussion about the digital revolution has already spanned two decades and is far from cooling down. It has been widely reported that the increased pervasiveness of digital Information and Communication Technologies (ICT) leads to significant contributions to development, including economic growth (e.g. Cole, 1986; Mody and Dahlman, 1992; Waverman, et.al., 2005; Indjikan and Siegel, 2005),

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democracy and transparency (e.g. Coleman, 2005; Banisar, 2006; Hilbert, 2009), education (e.g. Marshal and Taylor, 2006) and cultural development (Castells, 2004), among others. After a thorough and well-cited analysis, Castells (1998, p. 367) reaches the conclusion that "the generation of wealth, the exercise of power, and the creation of cultural codes came to depend on the technological capacity of societies and individuals, with information technologies as the core of this capacity."

The nature of the diffusion process of the related innovations resembles a well-known S-curve from centre-periphery, whereby the centre can be characterized as being more developed and the periphery as underdeveloped (e.g. Mahajan and Peterson, 1985; Rogers, 2003). The unfolding of the curve inevitably creates a divide between those that can first benefit from the innovation and those excluded. In the case of ICT diffusion patterns the term "digital divide" has been coined to describe the fact that some already use digital tools, while others are still deprived of access and the potential opportunities that follow from it (e.g. NTIA, 1995, 1999; OECD, 2001; ITU, 2009).

Both arguments together describe a double-edged sword. Technology is not only a parent of wealth and development (creates it), but also its child (stems from it). It has therefore the potential to spawn either a virtuous or vicious circle between existing or missing development and technology. The urgency to work on this challenge arises from the rapidly closing window of opportunity related to the dynamic between development and technological progress (e.g. Perez and Soete, 1988; Freeman and Louca, 2001). The excluded could either be armed with new empowering tools despite their unfavorable starting position or their relative situation could worsen while the benefits once more enable the already well-off to make headway.

This article focuses on the access dimension of the digital divide and analyzes the economic feasibility of providing universal ICT services. It presents a model that simulates the dynamic between access prices, eventual subsidies and ICT penetration rates, and as such allows the exploration of feasible options. A quick thought experiment sets the stage for the subsequent exercise: it has been claimed that a US$100 laptop would enable us to provide "one laptop per child" throughout the developing world (Negroponte, 2005). The World Bank reports that around 40% of the world population lives with less than US$2 per day. Optimistically estimating that they spend 2.7% of their income on communication (more on that in Figure), the poor would have US$20 per year available to spend on ICT (2*365*0.027). That would be enough to buy one US$100 laptop each fifth year. While this result does not sound too shocking, it has to be remembered that this person is not expected to spend another cent on any other form of communication during these five years (no letter post, not one phone call, etc) and still has not connected the laptop to any kind of network. Correspondingly, the scenario looks worse for the 15% of the world population living with less than US$1 per day. One alternative would be to call for public subsidies, providing free or at least cheap connectivity for the poor. How much would this cost? The other alternative would be to reduce prices even further. How cheap, is cheap enough to bridge the digital access divide?

This article tackles both questions by following the outlined logic. It presents a model to simulate various scenarios. The exercise is carried out for four representative countries: Mexico, Uruguay, Brazil and Costa Rica. We start by finding a valid working definition of the digital divide for our purposes. As a second step we empirically justify

our income-based model by looking at the importance of income distribution as a predictive variable for the digital divide. We then verify ICT spending per income level in the third section. The available resources for ICT in each income quintile can be understood as the potential market, which is then compared to the current cost of ICT access for each income segment. As a next step, we can quantify the gap between access prices, spending levels and actual ICT penetration rates per quintile, as done in the fourth section. Subsequently, we apply the model to analyze three exemplary future scenarios. The results show how much it would cost to bridge the digital divide or, alternatively, when cheap is cheap enough for the market to close the divide. For example, one scenario consists in bringing ICT access levels from below 20% for Internet and around 50% for telephony up to electricity penetration rates, which are currently above 95% in Latin America. In Mexico, for example, providing the economic possibility of ICT access to the poorest 20% of society would require to reduce current access prices of estimated US$244 per year down to US$35 per year (US$3 per month, or a price reduction down to 13%of current prices). In Brazil, the poorest 20% of the population counts with merely US$9 per year to spend on ICT (US$0.75 per month), implying the necessity to reduce current ICT prices down to 4% of its current level of US$220 per year. This is the economic reality of these income segments and the magnitude of the challenge to provide "one ICT access per child". Alternatively, a (direct or indirect) subsidy could be given to balance the purchasing power of these segments. In the case of Uruguay, this subsidy would need to be as high as 6.2% of GDP, which is equivalent to Uruguay's public spending on education plus health. This shows that the governments of developing countries (and their economies) currently do simply not posses the means to provide

personalized access to all, even if they opted for the cheapest equipments. The article ends by discussing the odds in the light of this reality and explores complementary ways to bridge the digital divide. This includes the economic feasibility of sustainable public access to ICT, which has proven to be a viable way to reduce access prices by sharing the fixed costs of the technology. The income reality of the world's poor argues for the need of policy strategies that prepare for a long period in which public access will be the only viable access solution for significant parts of the developing world. However, the required financial mechanisms for such a period are currently not in place. The article ends by discussing innovative proposals in this regard.

How to define the digital divide?

The term "digital divide" is that rare breed of a new concept that has the ability to camouflage into the author's intended meaning, often leaving confusion or tedious semantic quarrels behind. It is usually defined as the divide between those included and excluded from the digital age, leaving lots of room for interpretation.

In general, distinctions can be made with regards to the group of users (countries or population segments), the kind of technology under consideration (mobile or fixed; voice or data; communication or computing, etc) and the stage of adoption. The most straightforward notions of the digital divide select a specific technological solution as a representation of the bulk of digital technologies (such as telephones or Internet subscription) and compare the amount of equipment or services between societies (international digital divide) or within different social segments of one society (domestic digital divide). Beyond this, different stages can be distinguished in the process of

technology adaptation. In his traditional work on the "diffusion of innovations", Rogers (2003) has famously distinguished among five different stages of adoption. Statistical practitioners interested in measuring the nature of the digital divide have merged these five stages into three consecutive steps: ICT access, use and impact (OECD, 2002). Even though there might be a positive relation between the amount of ICT equipment, its usage and its impact, one of them does not automatically imply the next. The complexities in the steps from access to productive usage and from usage to impact have been widely discussed, such as in the productivity paradox of the 1980s or the new-economy hype of the late 1990s.

As a result of these distinctions many different proposals have been made on how to conceptualize the embracement of technology in each one the these stages and how they are related and intertwined with existing socio-economic and geo-spatial inequalities (e.g. Warschauer, 2003; Mossberger, et.al., 2003; van Dijk, 2006; Buys, et.al, 2009). The determinants of the divide can be assessed in each stage of the adoption process and with regards to all of the diverse existing technologies, or their combination. For example, access might depend on financial limitations, which also manifest themselves in geo-spatial requirements of infrastructure deployment, while productive usage will eventually depend on how the installed equipment is embraced, drawing the focus of attention to skills and motivations, among others. The final impact of the technology will ultimately be influenced by the purposeful application of the installed equipment, often requiring the readjustment of the general *modus-operandi* of the cultural and institutional setting, which leads to a complex dynamic of social change. Depending on the definition and the scope of the exercise, the results can be contradictory and either argue in favor of a

rapidly closing digital divide (Compaine, 2001) or one that is still deepening (van Dijk, 2005).

The common feature of all studies is the inclusion of the access dimension of the divide, which might not be sufficient, but is a necessary first step. Without neglecting that the discussion of the digital divide can become much more complex, it will be enough for the scope of this paper to focus only on this indispensable dimension.

Regarding the access dimension it is important to distinguish "universal access" versus "universal service". United Nations International Telecommunications Union (ITU) defines that universal access implies that everyone in a population has access to publicly available communication network facilities and services, typically provided through such means as pay telephones, community telecentres and community Internet access terminals; while universal service focuses on promoting or maintaining universal connectivity of all households to public network facilities and services, and at affordable prices (ITU, 2007). Over the late 1990s, it seemed that the focus should turn to universal access, instead of pursuing the ambitious goal of universal service. However, the focus on universal service was revived by a couple of occurrences, including the mobile phone revolution, which had shown that it was possible to provide personalized services to most of the world's population (mobile phone penetration has reached 60 percent of the world's population in 2008), and by the discussion that has been unleashed by the "One Laptop per Child" initiative (Negroponte, 2005).

In 2005, the MIT driven "One Laptop per Child" initiative announced the ambitious goal to produce a "$100 laptop" that would revolutionize education by being within reach of each child in the developing world. Due to various reasons, the plan did not

accomplish its goal during the years to come (The Economist, 2008a). During 2008 the initiative announced a temporary "Give One, Get One" scheme in the developed world, encouraging people to pay US$ 399 for two of the laptops, one of which would be given to child in the developing world. The initiative set in motion a snowball effect that went far beyond the potential benefits of a single quick-fix solution. The chipmaker Intel swiftly announced an alliance with software giant Microsoft to commercialize their own education-oriented laptop, called Classmate. The Classmate was first to push the price under the US$ 300 mark and the "laptop war" has been raging ever since (The Economist, 2008b). The Indian government surprised everyone with the announcement of a "$10 laptop" in 2008, but quickly readjusted its target to the well-known US$100 mark (Ribeiro 2008). At the same time private market analysts saw this goal at least three years away, with an uncertain future (Gartner, 2008). Independent from the intricate details of the ongoing projects, it had become clear that price reduction of digital access equipment became a concern of mayor interest for policy makers and industry. The race is on and universal service had once again become the benchmark for bridging the digital divide.

In this paper we will contribute to this and related discussions by evaluating basic questions like if US$100 is actually low enough to provide "one laptop per child"? Is universal service a feasible goal in the mid-term, maybe in combination with public subsidies? Answering these specific questions does not provide coherent policy advice on how to bridge the access divide, but it grounds the current discussion on the reality of existing income structures in the developing world. The results provide normative guidelines to direct policy options, much in line with Seneca's logic that if one does not

know to which port one is sailing, no wind is favorable[23]. It is beyond the scope of this article to identify the right winds to guide us from normative objectives to concrete ICT access solutions, as it is much further beyond our focus to explore how to get from access to optimal usage and real impact.

How important is income distribution for the digital divide?

Models are idealizations of reality. Because reality is too complex, models work on an elevated level of abstraction, selectively choosing to ignore parts of reality, while focusing on what is seen as the variables with the largest explanatory power. Modeling the access dimension of the digital divide is no exception and there are countless variables that define the domestic dynamic. In this section we will explore if it is justifiable to elaborate a model of the digital access divide that only focuses on income as an explanatory variable.

It has been shown that the same long established determinants of socio-economic inequality also define the digital divide, including income, education, skills, employment, geography, age, gender and ethnicity, among others (e.g. Cullen, 2001; Hilbert and Katz, 2003). In Latin America, the region that persistently shows the world's most skewed income distribution (ECLAC, 2008), it is not surprising that income structures is seen as the most influential attribute to explain access inequalities (Katz and Hilbert, 2003; Peres and Hilbert, 2009). Brazil for example, the region's largest country (with over 37% of the region's GDP and 34% of Latin America's population), has one of the most unequal income distributions. The richest 10% of society receive around half of the national

[23] "Ignoranti, quem portum petat, nullus suus ventus est".

income, while the second richest count with a 15% share, and the poorest decile has to manage with less than 1% of the available resources. Uruguay, one of the smallest countries of the region (.8% of the region's GDP and .6% of its population), has the most equal income distribution, with the richest 10% of the population receiving 37% of income, the second decile 15% and the poorest decile 2%.

Let us take a closer look at the importance of income as a determinant of access in Brazil and Uruguay. During recent years an effort has been made by national statistics institutes to incorporate ICT indicators into household questionnaires throughout Latin America (Olaya, 2008; Partnership, 2008). This now allows us to perform multivariate analysis on the determinants of variables like Internet access. For our purposes, discriminant analysis seems to be good choice among the various alternatives of multivariate analysis. It tests for a linear combination of variables, which –when appropriately weighted—will maximally discriminate between those who have access and those who do not have access[24].

Taking the 2007 household survey of Brazil (OSILAC, 2009) the following 10 potential variables have been chosen to explain household Internet access: per capita household income per decile; personal level of education (without, primary, secondary, postsecondary and tertiary); household size (single and double vs. larger families[25]); age (in groups from 5-14, 15-24, etc); current school or education enrollment; job category

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[24] Discriminant analysis goes back to Fisher (1936) and can basically be understood as a multiple regression where the criterion variable is nominal rather interval or ratio (in our case: access or not) and the aim is to search for a combination of variables that maximally discriminates between those groups (e.g. Williams and Monge, 2001).

[25] This variable is supposed to test if people in single or double households tend to connect more to the Internet to avoid social isolation.

(in four broad groups[26]); geographical region (urban vs. rural); installation of color TV in household[27]; gender (male-female); and last but not least, ethnicity (as auto-identification of belonging to an indigenous group or not[28]). The results can be seen in Table, second column.

Tests for multicollinearity indicated a low level of multicollinearity[29]. The overall test was significant (Wilks λ = .682, Chi-square = 3.44E7, df = 10, Canonical correlation[30] = .564, p <. 001), but not very strong. The identified discriminant function accounted for 32% of the variance in Internet access. This is an acceptable degree of correlation, but shows that there must be other variables to explain who has and who does not have access to the Internet at home. Reclassification of people based on the newly identified function was quite successful: based on the identified function 78.5% of Brazilians were correctly reclassified into the original categories of having or not having home access. The most interesting result for our purposes is the importance of the income variable. The weights of the standardized canonical discriminant function (see Table) tell us how the ten original variables combine to make a new one that maximally discriminates between Brazilians who have and those who do not have household Internet

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[26] 1st group (primary): agriculture/ hunting/ forestry/ fishing/ mining/ quarrying/ construction; 2nd group (secondary): manufacturing/ electricity/ gas/ water; 3rd group (services1): wholesale/ retail/ repair/ household/ community/ hotel/ restaurants; 4th group (services2): Financial/ real estate/ business/ public administration/ defense/ education/ health/ social work/ extraterritorial organizations.

[27] This variable is supposed to test for the degree of previous technological adoption and a general interest in ICT.

[28] This variable is supposed to test for eventual language or cultural barriers.

[29] Tolerance in the order of variables enlistment in text: .634; .617; .904; .759; .871; .662; .878; .722; .951; .999. Similar values result in the subsequent tests of Brazil 2005 and 2002 and Uruguay 2005 and 2007.

[30] The canonical correlation is the correlation between the new canonical variables formed by applying the weights from the discriminant function to the 10 predictors, and the grouping variable of either having or not having household Internet access.

access. We can interpret the standardized discriminant function coefficients as a measure of the relative importance of each of the original predictors. Income level (.753) is by far the strongest predictor for Internet access, followed by the level of education, household size and age.

Table 2 Results of discriminant analysis of household Internet access for the individual

	Standardized Canonical Discriminant Function Coefficients				
	Brazil 2007	Brazil 2005	Brazil 2002	Uruguay 2005	Uruguay 2007
Income per decile (p.c. of household)	.753	.743	.704	.799	.755
Education of person	.416	.487	.556	.423	.464
Household size (single/pair vs family)	.345	.305	.249	.431	.404
Age	.131	.167	.207	.084	.094
Enrollment in school/education	.115	.118	.117	.114	.122
Job category	.113	.077	.061	.026	.050
Color TV in household	.060	.117	.164	.038	.028
Geographical region (urban/rural)	-.073	-.007	.048	n.a	-.038
Gender	-.023	-.023	-.021	-.027	-.038
Indigenous ethnicity	.008	-.007	-.004	n.a	n.a.
	Strength of overall correlation				
Wilks lamba	.682	.712	.751	.708	.696
Canonical correlation	.564	.536	.499	.540	.522
Reclassification success	78.5%	81.2%	80.6%	79.4%	79.2%

Source: own elaboration; based on OSILAC, 2009

One might wonder if this result depends on a specific stage of the diffusion process and if these results change over time? The same exercise for Brazil 2005 and Brazil 2002 (see Table) shows that these results are pretty stable over time. In addition, discriminant analysis has been carried out for Uruguay 2005 and 2007 to verify that the identified tendency also holds for smaller countries with a more balanced income distribution (see Table).

Of course these results cannot automatically be generalized to other countries. They have been chosen on basis of available statistics and the exemplary nature of two dissimilar countries. Table reveals that the level of education also turns out to be an important variable and it remains to be seen what role it –and other variables—play in different countries and with regard to other grouping variables (such as Internet usage instead of plain access). Notwithstanding, these indicative results provide evidence that ICT access is significantly influenced by income distribution. These results give us enough justification to opt for a simplified model that simulates the complex dynamic of the closing digital divide exclusively in terms of income distribution. Such reduction of reality will surely not be perfect, because, as we have seen, there are other important explanatory variables. However, models are always an abstraction of reality and the presented results show that income is the single variable with the greatest predictive potential.

How much resources are available for ICT?

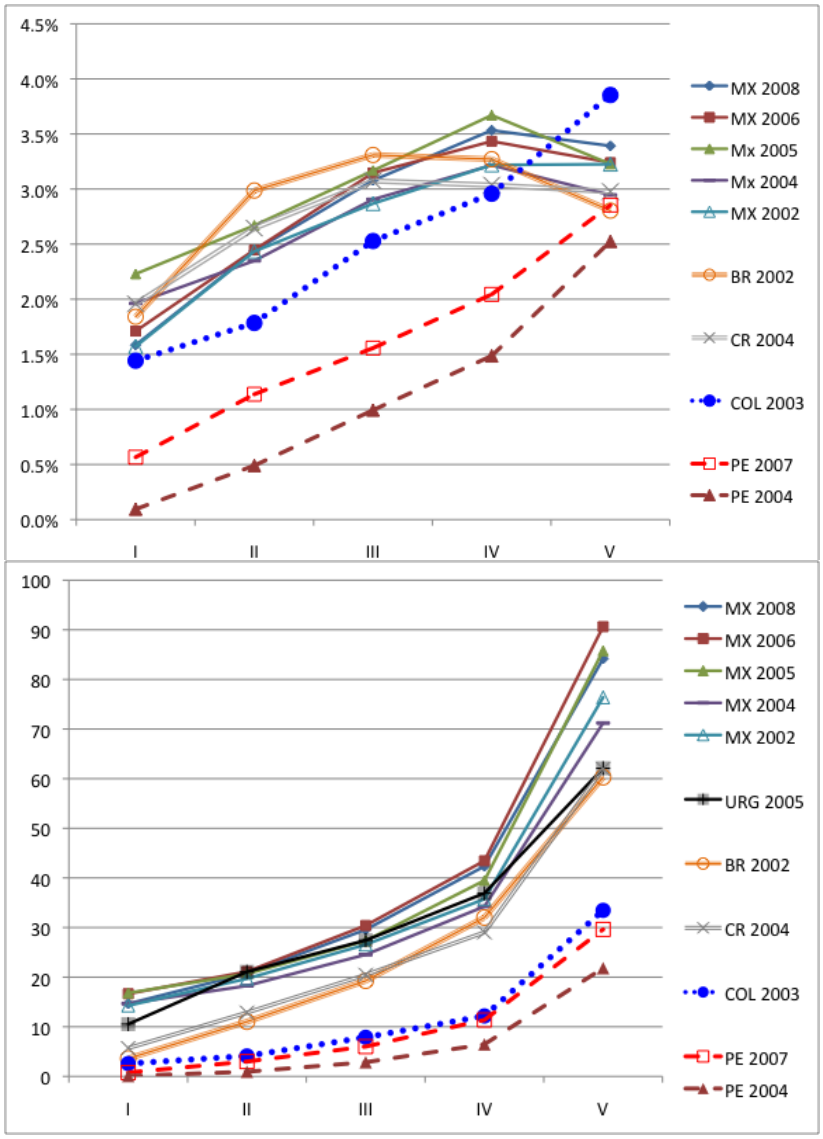
Official consumer and household spending questionnaires are scarce and valuable treasures for research in the developing world. Mexico, as a member of the statistics-savvy OECD, stands out as an exception. It has been possible to collect and harmonize some specific years for other countries as well (see Figure). The first thing that meats the eye when looking at Figure is that spending unequivocally differs among income segments (here presented in quintiles; I: lowest income 20% of population; V: highest income 20%).

The top of Figure shows a contradictory story with regard to the elasticity of household spending on communications. Traditionally consumption goods are either defined as 'necessity goods' or 'luxury goods', going back to Engel's (1857) pioneering work. Food is the prototype of a necessity good. Everybody needs to spend a comparable amount on it, implicating that the poor will end up spending a larger part of their total income on it. A luxury good, on the contrary, is characterized by elastic spending patterns, implying that the rich will spend significantly more on it than the poor, who do not depend on this good to satisfy their most basic needs. The top of Figure shows that communication seems to be a luxury good for Peru and Colombia, which is in agreement with more specific research about this question in these countries (Gamboa, 2007; Aguero, 2008), while it seems to have some characteristics of a necessity good for the other countries (especially in the richest segments), which is also in agreement of previous research on those countries (Ureta, 2005). Is communication a luxury or a necessity?

The solution of this riddle can be found at the bottom graph of Figure. It shows that Peru and Colombia (with respective Gross-National-Income per capita of US$3,990 and US$4,660 in 2008) spend noticeably less in absolute value on communications than Costa Rica (GNI p.c.: US$6,060), Brazil (GNI p.c.: US$7,350), Uruguay (GNI p.c.: US$8,260) and Mexico (GNI p.c.: US$9,980). ICT are tradable goods and therefore are not much subject to price variations among different countries. This is different from non-tradable services, such as teaching for example. A teacher in Peru might cost considerably less than a teacher in Mexico. Not so for ICT. On the contrary, it can often be seen that ICT is cheaper in rich countries (which often produce them and have larger

and frequently more competitive markets), than in poor countries (which have small markets and import the equipment). As a result, ICT spending is tied to absolute, not relative levels of spending. It seems that a certain saturation threshold has only been reached when household expenditure rises up to US$30-40 per month, making that roughly US$10 per person (see income segment IV of Costa Rica, Brazil and Mexico in both graphs). Before reaching this level, consumer continue to keep spending whatever they have available. In other words, the Figures suggest that communication spending below US$10 per person per month seems to be a necessity (for these years and these countries), while everything above appears to be an additional luxury.

Figure 10 Monthly household spending on communication, as % of total spending (top) and as absolute values in current US$ (bottom)



Source: own elaboration; based on INEGI (2000-2009), Encuesta Nacional de Ingresos y Gastos de los Hogares.2000-2005 en Mexico; INE (2006), Encuesta National de Gastos e Ingresos de los Hogares 2005-2006 en Uruguay; IBGE (2003), Pesquisa de Orçamentos Familiares 2002-2003 Brasil; INEC (2006), Encuesta Nacional de Ingresos y Gastos de los Hogares 2004 en Costa Rica; DANE (2004), Encuesta de Calidad de Vida del 2003 en Colombia; INEI (2004-2007), Encuesta Nacional de Hogares en el Peru.

How much does ICT access currently cost?

The spending figures give us a rough idea about the size of the potential market. Having quantified the demand side of ICT, we now need some figures from the supply side, in other words the price of ICT. This has to start with a definition of what ICT actually are.

The technological system that is generally referred to as ICT merges several previously separated evolutionary paths into one technological system. Traditional broadcasting technologies, such as radio and television, communication systems, such as the telephone, as well as storage devices, such as music players, and of course computing equipment make part of the dynamic that is often referred to as ICT-convergence. The current introduction of digital television is an epitome for how a traditional unidirectional information-disseminating technology is merging with bi-directional communication systems, while increasing its data processing capacities by adding different hardware and software solutions. Another example is third and forth generation mobile phones (3G and 4G), in which the telephony communication system is upgraded to include broadband Internet services and software applications. Eventually, digital TV and mobile Internet will also merge into a single technological system, becoming part of the network of networks (the 'Inter-net'), leading to all sorts of fixed or mobile solutions, for individual or collective use, with a specific resolution, bandwidth and storage capacity, blurring the traditional borderlines between broadcast, telecommunication and computation. The downside of this high-speed technological progress is that every new technological innovation reopens the digital abyss, constantly resulting in new inequalities between those who possess more and better information and communication processing capacities

and those with lower ones. The digital divide becomes a moving target, and on top of that, one that moves at the rhythm of a technology that moves faster than anything we have seen in history so far (e.g. Hilbert and Cairo, 2009).

In this sense, much more pronounced than with other challenges of technology penetration, the digital divide is not only wide or narrow, but is also deep or shallow. Actually, as the extraordinarily fast innovation cycle persistently emphasizes qualitative differences, the digital divide will never be "closed" in a uniform sense. Some people will always have more information processing capacity than others. However, we are able to build a bridge over even the deepest abyss. "Bridging" the digital divide means therefore that every member of the so-called Information Society has continuous access to sufficient resources to be able to maintain minimum connectivity with its peers. The result is the challenge of constantly defining the terms "sufficient" and "minimum". Such reasoning has led to the concept of "digital poverty," with segments of society being below the dynamically evolving digital poverty line, and others above (Galperin and Mariscal, Eds, 2007).

Considering the dynamics of multiple access solutions and their short innovation cycles, it seems advisable not limit our analysis of the digital divide to a specific technology. Rather, we should consider connectivity as access to a combination of technologies, an 'ICT access packet', that allows people to communicate and to process information through digital means, leaving the technological implementation to individual choices and later policy considerations. Consequently, bridging the digital divide would mean that a minimum ICT access packet would be in reach for everybody, still conceding that some will always continue to have more connectivity than others.

Keeping in mind that our goal is to estimate the amount of resources dedicated to ICT, independently of future technological implementation, we nevertheless have to start with what is currently seen as the standard 'ICT access packet' to get a feeling for what is right now being spent on it. This can be done by reviewing current penetration rates of different ICT and include the most popular solutions into our packet. The most popular ICT access solutions in Latin America are fixed-line telephony (70% of all households in 2007), mobile phones (70% of all individuals), personal computers[31] (45% of all households) and Internet (17% of all households) (OSILAC, 2007). We will stick to those four main technologies. We suppose that all members of the household share the fixed-line, as well as the computer and the Internet access. This inevitably favors the low-income segments, as low-income families tend to be larger in general (on average the household size of the poorest quintile in Latin America is around 4.5 members, while a household in the richest quintile counts with 2.5 members) (CEPALSTAT, 2009).

Table shows annual ICT access prices for Mexico 2002, Mexico 2007, Uruguay 2005, Brazil 2003, and Costa Rica 2004, as national average and per income quintile. These numbers could easily have been obtained for more countries, but only these cases also count with the necessary household spending surveys and the related penetration rates (which we will need in the subsequent steps). Having said this, the final selection of these cases was determined by the availability of all necessary variables in the respective household questionnaires (OSILAC, ICT statistical information system, 2009), together with the availability of household spending statistics. Luckily these countries are relatively representative for the diversity of the region, being one large and one small

[31] The term personal computer is used to refer to all kind of household computers, including laptops, notebooks and Mac.

country from South- and Meso-America in each case. Income levels of these countries vary from Costa Rica (GNI: US$6,060), Brazil (US$7,350), Uruguay (US$8,260) to Mexico (US$9,980) and are therefore almost exactly span the upper half of the region's income diversity. Unfortunately it is typical that poorer countries do not count with detailed statistical information to include them in these kinds of exercises.

The underlying methodology of Table follows generally accepted assumptions. For the calculation of the price of fixed line telephony we stick to the methodology proposed by the United Nations International Telecommunications Union (ITU, 2009) and the World Bank's "price basket for residential fixed line", which capture the average monthly cost of a basic local fixed residential telephone service (in our case divided by the average household size per income quintile), plus 30 three-minute local calls per month to the same (fixed) network (15 peak ad 15 off-peak calls). For mobile telephony we include 30 one-minute outgoing calls per month (15 on-net and 15 off-net, that is to a network of the same and a different operator). ITU reports mobile tariffs for prepaid cell-phones. This is justified not only because the overwhelming majority of mobile phone users in the developing world uses prepaid phones instead of fixed contracts (in Mexico 95% of all mobile phone users; in Uruguay 85%), but because they are often the only payment method available to low-income users who might not have a regular income and will thus not qualify for a postpaid subscription based service. For Internet services it was decided to opt for the price of a 256 kbit/s connection for the household. This is the lowest non-dial-up connectivity usually available. It was decided not to opt for dial-up because this would have required an estimation of usage minutes and because dial-up option have become much more expensive per person than low-cost dedicated services,

such as through a telephone line with DSL[32]. The price of this connection is divided by household size per income quintile. Last but not least, a USD 500 computer is chosen which would be in use for three years (which is seen as the average industry standard for computer obsolescence). This refers to some of the cheapest industry offers in the region[33] (Laplane, et.al. 2007). It is assumed that the entire household also shares the computer.

[32] For example, in Mexico 2002, only two minutes and 45 seconds daily dial-up Internet for one person cost as much as unlimited 256kbps broadband shared with the average size of household members.

[33] Industry and government collaboration, such as "mi primer PC" in Chile, offer financing plans for PCs for around USD 500. Normal industry prices are slightly above this number.

Table 3 Annual ICT prices per inhabitant in US$, national average and per income quintile

MEXICO 2002	National	I	II	III	IV	V
Fixed-line telephony	103.8	93.3	99.4	102.6	109.2	120.0
Mobile phone	99.1	99.1	99.1	99.1	99.1	99.1
Internet	155.0	121.6	140.9	151.2	172.2	206.6
Personal Computer	41.7	32.7	37.9	40.7	46.3	55.6
TOTAL PACKET yearly	399.5	346.6	377.2	393.5	426.7	481.2
MEXICO 2007	National	I	II	III	IV	V
Fixed-line telephony	94.0	83.1	89.7	94.0	100.8	112.4
Mobile phone	57.3	57.3	57.3	57.3	57.3	57.3
Internet	111.5	84.8	100.9	111.5	128.4	157.0
Personal Computer	43.9	33.3	39.7	43.9	50.5	61.7
TOTAL PACKET yearly	306.7	258.5	287.6	306.7	337.1	388.4
URUGUAY 2005	National	I	II	III	IV	V
Fixed-line telephony	69.4	57.9	67.2	73.4	80.4	84.9
Mobile phone	133.7	133.7	133.7	133.7	133.7	133.7
Internet	208.8	142.4	195.8	232.0	272.4	298.3
Personal Computer	55.6	37.9	52.1	61.7	72.5	79.4
TOTAL PACKET yearly	467.5	371.8	448.7	500.9	559.0	596.3
BRAZIL 2003	National	I	II	III	IV	V
Fixed-line telephony	58.6	50.2	54.7	62.1	63.4	69.7
Mobile phone	85.7	85.7	85.7	85.7	85.7	85.7
Internet	102.2	79.5	91.7	111.8	115.4	132.5
Personal Computer	47.6	37.0	42.7	52.1	53.8	61.7
TOTAL PACKET yearly	294.1	252.5	274.9	311.7	318.3	349.6
COSTA RICA 2004	National	I	II	III	IV	V
Fixed-line telephony	20.4	19.3	19.3	19.3	20.7	23.6
Mobile phone	21.8	21.8	21.8	21.8	21.8	21.8
Internet	150.2	139.0	139.0	139.0	154.4	185.3
Personal Computer	45.0	41.7	41.7	41.7	46.3	55.6
TOTAL PACKET yearly	237.4	221.7	221.7	221.7	243.2	286.2

Source: own elaboration; based on ITU, World Telecom. Database, 2009

These numbers therefore represent our 'ICT access packet', adjusted to family size per income segment. Realistically looking at the chosen services, this packet is rather at the very low end, meaning that it represents a minimum packet for somebody who would

like to claim to be a full-fledged member on an "Information Society". Of course, an individual could make much more than one 3 minutes fixed-line call per day, or could easily spend more than one daily minute on the cell-phone. We will look at these possible variations in the following section.

How does income distribution create ICT diffusion patterns?

One way to check the validity of the estimations for our 'ICT access packet' is to multiply the prices with the penetration rates of those technologies, which should give us the amount of the respective ICT spending. If it turns out that this multiplication results 1:1 with the identified spending figures, it has been proven that our price estimations are accurate. If the result of the multiplication turns out to be below actual spending, the conclusion would be that individuals actually spend more on ICT than defined by our minimum 'ICT price packet'. For example, broadband connectivity could be increased far beyond 256 kbps (1000-4000 kbps connections are commercially available in these countries), while standard personal computers can easily cost up to US$1500-3000. If the multiplication of price levels with penetration rates would turn out to be above actual spending levels, it could be concluded that our packet is overestimated. In other words, in these cases users spend less than 3 minutes per day on the fixed-line or less than one minute per day on their mobile phone (for example by having a non-charged prepaid phone). The existence of prepaid mobile phones that are only used sporadically has been reported frequently in the developing world (e.g. Galperin and Mariscal, 2007). Another explanation for the overestimation of our packet might be that computers are not

modernized every three years. It is not unusual to find 10-15 year old PCs and recycled computers throughout the developing world (e.g. REALC, 2009).

ICT penetration rates per income quintile can be seen in Table. Once again, the chosen countries include Mexico 2002, Mexico 2007[34], Uruguay 2005, Brazil 2003 and Costa Rica 2004.

[34] Given that no spending figures exist for Mexico 2007 (but given that this is the last year for which we count with the harmonized household penetration levels), the Mexico 2008 spending levels have been applied to model Mexico 2007. This is justifiable because Graph 1 confirms that spending levels in Mexico stay pretty constant.

Table 4 ICT penetration rates per inhabitant; Affordable portion of 'ICT access packet'; national average and per income quintile

MEXICO 2002	National	I	II	III	IV	V
Fixed-line telephony	0.45	0.24	0.33	0.47	0.58	0.76
Mobile phone	0.25	0.18	0.24	0.29	0.31	0.27
Internet	0.07	0.01	0.02	0.04	0.12	0.22
Personal Computer	0.16	0.04	0.07	0.12	0.24	0.43
How much of the 'ICT access packet' can be bought: [indiv.spending] / ∑[penetration rate * price]	1.03	0.80	0.87	0.88	0.95	1.64
MEXICO 2007	National	I	II	III	IV	V
Fixed-line telephony	0.55	0.41	0.46	0.55	0.66	0.81
Mobile phone	0.60	0.34	0.54	0.67	0.72	0.91
Internet	0.12	0.03	0.05	0.09	0.13	0.44
Personal Computer	0.25	0.10	0.16	0.21	0.28	0.63
How much of the 'ICT access packet' can be bought: [indiv.spending] / ∑[penetration rate * price]	0.95	0.59	0.71	0.86	1.11	1.49
URUGUAY 2005	National	I	II	III	IV	V
Fixed-line telephony	0.73	0.48	0.75	0.85	0.91	0.98
Mobile phone	0.33	0.32	0.33	0.33	0.34	0.36
Internet	0.14	0.01	0.06	0.15	0.26	0.51
Personal Computer	0.24	0.05	0.16	0.29	0.42	0.62
How much of the 'ICT access packet' can be bought: [indiv.spending] / ∑[penetration rate * price]	0.76	0.39	0.69	0.77	0.88	1.07
BRAZIL 2003	National	I	II	III	IV	V
Fixed-line telephony	0.50	0.16	0.37	0.55	0.73	0.89
Mobile phone	0.39	0.13	0.27	0.38	0.54	0.79
Internet	0.11	0.00	0.01	0.04	0.14	0.46
Personal Computer	0.15	0.01	0.03	0.08	0.21	0.55
How much of the 'ICT access packet' can be bought: [indiv.spending] / ∑[penetration rate * price]	0.84	0.47	0.71	0.92	0.98	1.13
COSTA RICA 2004	National	I	II	III	IV	V
Fixed-line telephony	0.66	0.42	0.56	0.66	0.75	0.86
Mobile phone	0.45	0.17	0.28	0.39	0.55	0.80
Internet	0.21	0.01	0.04	0.09	0.21	0.57
Personal Computer	0.25	0.06	0.10	0.16	0.34	0.57
How much of the 'ICT access packet' can be bought: [indiv.spending] / ∑[penetration rate * price]	1.34	1.08	1.42	1.50	1.28	1.41

Source: own elaboration; based on OSILAC, 2009.

Table also shows the result of the ratio between the average US$ spending per household member and the sum of the individual price of our 'ICT access packet' multiplied with the respective penetration rate (comparing real and expected spending). The national figures show that our price estimations have been quite reasonable. In the case of Mexico 2002, our estimations have only been 3% off the actual spending levels for the national average (1.03). However, taking a closer look at how this is distributed among the different income-quintiles, it can be seen that the richest 20% of the Mexican population seems to spend more than what would be expected with our 'ICT access packet' (i.e. 64% more; ratio [real spending]/[expected spending to purchase 'ICT access packet] = 1.64). This is not surprising, considering the large variety of expensive high-tech equipment and services available (including 3G and 4G mobile phones and expensive computer systems). Rich Mexicans buy much more ICT than are included in our packet. At the same time, multiplying penetration rates with the respective costs of the components of our packet shows that the average member of Mexico's 2002 poorest quintile can only buy 80% of our 'ICT access packet'. In agreement with what we have anticipated, we can conclude that those people make less intense use of ICT than what we expect with our minimum 'ICT access packet'. Those who have mobile phones do not use it every day for one minute and/or those who have a computer at home can be expected to have obsolete equipment, among other reasons.

The evolution of the digital divide in Mexico between 2002 and 2007 shows us that this tendency has become more pronounced in the poor segments over time (the ratio of [real spending]/[expected spending to purchase 'ICT access packet] in the poorest quintile falls from 0.80 to 0.59, implying that the average member of the poorest quintile

can only by 59% of our 'ICT access packet' in Mexico 2007). While more of the poor are connected, the poor spend on average less on digital communication. In other words, while penetration rates have expanded (compare Table), it seems that this has, at least partially, been on the expense of the quality of the services purchased by the user in the low-income segment, while high-income segments proceed to higher quality services. As a consequence, the qualitative dimension of the digital divide widens.

Comparing Tables, the data show nicely how income structures contribute to create ICT diffusion patterns. For example, looking at the other quintiles of Mexico between 2002 and 2007 shows why connectivity has almost exclusively increased in the high-income quintile. As shown by Table, Internet access in quintile I, II, III and IV has only increased marginally (by 2, 3, 5 and 1 percentage points), while the high-income segment increased from 22% to 44% Internet penetration during this period. This is because Internet access (requiring a computer and connectivity) represents the largest part of ICT spending (50% of our 'ICT access packet', see Table) and those segments only have part of the required spending power. Mobile phone, on the contrary, has increased substantially also in the poorer quintiles, which is not surprising, considering that our mobile phone sub-packet has fallen from US$99 to US$57 (see Table, making that around 20% of our packet). It is therefore within the possibilities of most income groups (we will present the yearly personal spending per quintile in US$ in Table 4).

A special case is Costa Rica. Table shows that all segments actually do spend more than what we would expect with our 'ICT access packet', and that despite the fact that it is the poorest country of our sample. Costa Rica counts with a public telecommunications provider (GRUPO ICE: soluciones de electricidad e Infocomunicaciones para la

inversión en Costa Rica), a state owned monopoly created in 1963. It has survived various attempts of privatization and, as can be verified in Table, is providing exceptionally low fixed and mobile tariffs (Internet tariffs have also become among the lowest in the region by 2008; see ITU, 2009). This leads to the paradoxical fact that the poorest quintile of the (low-income) Costa Rican society (who spend 8% more than the cost of our 'ICT access packet') can buy more access than the richest quintile in (relatively wealthy) Uruguay (who only spend 7% more than our packet). Uruguay has a history of inadequate international connectivity and therefore traditionally high costs for Internet services, especially around 2005 (as can be verified in Table).

This closes our descriptive analysis. While our data do not give us a perfect description of reality–which is not surprising remembering all the previously analyzed factors that we have decided to leave out of our modeling effort—we have seen how income patterns relate to ICT diffusion patterns and that we can roughly model the digital access divide in this way.

What does our model tell us about future scenarios?

In this section we will apply the previously used logic to create three future scenarios of the domestic digital access divide in the analyzed countries. The two basic alternatives to bridge the income dimension of the digital access divide consist of either reducing technology prices to the level of available income (supply side policy), or increasing the purchasing power of the poor (demand subsidy, for example by public subsidies, international development aid or private philanthropic donations). We can analyze both alternatives with our model by changing the penetration levels to the desired

level, and by multiplying these desired levels of connectivity with futuristic prices for our 'ICT access packet'. Scenario 1 focuses exclusively on reducing prices and explores how much we would have to cut the price of our 'ICT access packet' to reach a desired level of penetration. Scenario 2 supposes stable prices and estimates the amount of resources (as % of GDP) that would be needed in order to connect the desired percentage of population. Scenario 3 is more realistic and combines both of these approaches.

First we have to choose a diffusion level that we can reasonable consider as our "universal service" benchmark. We have to determine at which point the divide can be considered as being bridged. It would be slightly naïve to suppose 100%, as in reality there are always segments of society that fall between the cracks, especially in the developing world. A more realistic approach would be to strive for lifting ICT connectivity levels to the current levels of electricity services, supposing that, at least in Latin America, electricity is generally accepted to be universally available (Mexico: 95.7%; Uruguay: 98.5%; Brazil: 96.6%; Costa Rica: 99.1%). Table shows electricity penetrations per income quintile. The difference between current levels of ICT penetrations and current levels of electricity penetration constitute our digital divide.

Scenario 1 in Table shows the levels of required price cuts to reach the electricity penetration level. Scenario 2 in Table shows the required subsidies (as % of GDP), if we would wish to enable these unconnected income segments to purchase our 'ICT access packet' at the current price level from Table. Those figures are shown as national aggregate and per income segment, whereby the poorest quintile has been divided into deciles. Table also shows the personal spending levels in US$ per income segments.

Based on the data of Brazil 2003, for example, prices would have to be cut down to 3% of 2003 prices (to less than US$7 per year) to connect the unconnected of the poorest decile (Scenario 1), or alternatively 6.46% of GDP would have to be spent to subsidize missing connectivity at current prices (Scenario 2). As also shown by Table, this would be equal to Brazil's total public spending in health (4.8% of GDP), plus national spending on Research and Development (R&D, 1.0% of GDP), plus public spending on tertiary education (0.8%). In the case of Uruguay 2005, ICT prices would have to be cut down to 6% of the 2005 prices (Scenario 1), because the poor have around US$20 per year to spend on ICT, making that around 40 cents per week in one of Latin America's richest countries. Alternatively (Scenario 2), the required amount of resources to bridge the digital divide (6.23% of GDP) would equal the amount of Uruguay's public spending in health (3.6% of GDP) and education (2.6% of GDP).

When evaluating the results of the model, we have to remember one complementary factors that dynamically influences the evolution of the income dimension of the digital access divide: growing spending levels. Spending levels would increase if households start to spend a larger amount of their spending on communication. However, the time series of Mexico 2002-2008 in Figure seems to suggest that relative portions of spending on communication seem to fluctuate back and forth, but without a clear tendency toward increased proportions[35]. Another catalyst of increased spending levels would be economic growth. If the absolute income of households increases, so does spending on communications. Reflecting on this possibility we have to remember that, first, household spending does usually not grow as fast as economic growth would suggest, and second,

[35] National household spending levels on communication as % of total household spending in Mexico: 2002: 3.01%; 2004: 2.89%; 2005: 3.20%; 2006: 3.08; 2008: 3.15%.

traditionally only a very small portion of this trickles down to the lowest income segments. The Mexican economy has grown at an average GDP growth rate of 6.46% per year between 2002 and 2007 (CEPAL, 2009). This had some noticeable effects on the communications spending of high-income segments. Table shows that the highest income quintile has increased spending on communication from US$306 in 2002 to US$374 in 2007. This is lower than what economic growth would suggest ($306*[1.0646]^5$ = US$418), but it is still an important increase. However, the trickle down effect of this economic growth to the poorest 20% of Mexican society, has only led to an increase from US$34 in 2002 to US$35 in 2007 of personal spending per year (far from what should be expected considering economic growth: $34*[1.0646]^5$ = US$47). Income levels in poor segments grow very slow, which is the main causes for the persistence of worldwide poverty and the reason why 22% of Latin America still lives with less than US$2 per day. As a conclusion of this observation, we can place some (uncertain) hopes on economic growth. On the bright side, we can hope that economic growth (which would partially be also based on ICT-enabled productivity gains) would lift higher income segments to the required levels of spending. On the down side, history has taught us that that spending levels at the so-called "bottom of the pyramid" can be expected to move very slowly beyond the presented levels.

This observation allows us to fine-tune our interpretation of Table. Expecting economic growth to lift the richest 60% of Brazilian society up to the required spending levels, "only" 2.84% of GDP (0.68%+0.70%+1.46%) would have to be spent to subsidize the remaining 40% (see Scenario 2 in Table). This is more than the country receives annually in Foreign Direct Investments (FDI). Expecting economic growth to lift the

richest 60% of Uruguayans up to the required spending levels, “only” 1.15% of GDP (0.59%+0.56%) would have to be spent to subsidize the remaining 40%. This is more than twice as much as Uruguay’s public spending on tertiary education.

Table 5 Required price reductions and subsidies for scenarios 1, 2 and 3; personal communication spending; comparison to other national expenditures; weekly minutes in public access center; all as national average and per income quintile

MEXICO 2002		National	Decile 1	Decile 2	Quintile II	Quintile III	Quintile IV	Quintile V
Electricity penetration		95.7%	93.9%	94.7%	96.7%	96.8%	98.4%	98.6%
Scenario 1:	Required price cuts to reach electricity levels (% of current price)		8%	12%	15%	20%	28%	64%
Personal spending per year in US$		$118	$ 34		$54	$78	$119	$306
MEXICO 2007		National	Decile 1	Decile 2	Quintile II	Quintile III	Quintile IV	Quintile V
Scenario 1:	Required price cuts to reach electricity levels (% of current price)		13%	15%	21%	31%	46%	98%
Scenario 2:	Required subsidies to reach electricity levels (% of GDP2007)	1.86%	0.20%	0.18%	0.41%	0.39%	0.40%	0.27%
Personal spending per year in US$		$143	$35		$59	$93	$154	$374
Scenario 3:	Reduced price packet	$145	$118		$134	$145	$162	$190
	Percentage of society that can afford reduced price packet	46.7%	29.8%		44.1%	64.5%	95.2%	everybody
	Remaining required subsidy (% of GDP)	0.42%	0.16%		0.15%	0.10%	0.01%	no subsidy required
Other expenditures as % of GDP Mexico (2002-2005):			Public health: 3%	Public educ: 5.4%	Tertiary educ: 0.9%	Research & Develp: 0.4%	Official develop assist.: 0.0002%	Foreign direct invest. inflow: 2.4%
Weekly minutes in public access center		83	20		34	54	89	

URUGUAY 2005		National	Decile 1	Decile 2	Quintile II	Quintile III	Quintile IV	Quintile V
Electricity penetration		98.5%	96.4%	97.6%	98.5%	99.2%	99.6%	99.7%
Scenario 1:	Required price cuts to reach electricity levels (% of current price)		6%	10%	18%	25%	35%	60%
Scenario 2:	Required subsidies to reach electricity levels (% of GDP2005)	6.23%	0.59%	0.56%	1.31%	1.36%	1.35%	1.06%
Personal spending per year in US$		$155	$29		$79	$122	$193	$355
Scenario 3:	Reduced price packet	$242	$176		$229	$265	$306	$332
	Percentage of society that can afford reduced price packet	32.0%	16.4%		34.5%	45.9%	63.0%	everybody
	Remaining required subsidy (% of GDP)	2.18%	0.57%		0.59%	0.57%	0.45%	no subsidy required
Other expenditures as % of GDP Uruguay (2002-2005):			Public health: 3.6%	Public educ: 2.6%	Tertiary educ: 0.5%	Research & Develp: 0.3%	Official develop assist.: 0.1%	Foreign direct invest. inflow: 4.2%
Weekly minutes in public access center		90	17		46	70	111	

BRAZIL 2003		National	Decile 1	Decile 2	Quintile II	Quintile III	Quintile IV	Quintile V
Electricity penetration		96.6%	87.8%	94.6%	97.2%	98.4%	99.1%	99.8%
Scenario 1:	Required price cuts to reach electricity levels (% of current price)		3%	5%	12%	22%	37%	73%
Scenario 2:	Required subsidies to reach electricity levels (% of GDP2003)	6.46%	0.68%	0.70%	1.46%	1.52%	1.28%	0.81%
Personal spending per year in US$		$96	$9		$32	$69	$117	$254
Scenario 3:	Reduced price packet	$136	$113		$125	$145	$149	$166
	Percentage of society that can afford reduced price packet	32.0%	8.1%		25.7%	47.2%	79.0%	everybody
	Remaining required subsidy (% of GDP)	1.89%	0.61%		0.59%	0.49%	0.20%	no subsidy required
Other expenditures as % of GDP Brazil (2002-2005):			Public health: 4.8%	Public educ: 4.4%	Tertiary educ: 0.8%	Research & Develp: 1.0%	Official develop assist.: (.)%	Foreign direct invest. inflow: 1.9%
Weekly minutes in public access center		56	5		19	40	68	
COSTA RICA 2004		National	Quintile I		Quintile II	Quintile III	Quintile IV	Quintile V
Electricity penetration		99.1%	97.3%		98.8%	99.6%	99.8%	99.9%
Scenario 1:	Required price cuts to reach electricity levels (% of current price)		8%		18%	28%	40%	87%
Scenario 2:	Required subsidies to reach electricity levels (% of GDP2004)	3.74%	0.87%		0.84%	0.80%	0.74%	0.49%
Personal spending per year in US$		$92	$17		$39	$61	$97	$248
Scenario 2008:	2008 price packet	$135	$123		$126	$126	$142	$165
	Percentage of society that can afford 2008 price packet (equal to required price cuts of 2008 price to reach everybody)	32.2%	13.9%		30.6%	48.8%	67.9%	everybody
	Required subsidy to reach electricity levels (% of GDP2008)	0.85%	0.29%		0.25%	0.18%	0.13%	no subsidy required
Other expenditures as % of GDP Costa Rica (2002-2005):			Public health: 5.1%	Public educ: 4.9%	Tertiary educ: n.a.	Research & Develp: 0.4%	Official develop assist.: 0.1%	Foreign direct invest. inflow: 4.3%
Weekly minutes in public access center		53	10		22	35	56	

Source: own elaboration; based on OSILAC, 2009; CEPALSTAT, 2009; UNDP, 2009; respective national household spending reports.

At this point it becomes clear that neither real price reduction of ICT nor demand subsidy can be a solution by itself. The challenge has to be faces with a sophisticated

combination of different options. We start with the assumption that the market still has potential to reduce ICT prices, which will enable more people to afford connectivity. As long as this price reduction does not go as far as identified in Scenario 1, we will still require a reduced subsidy. Much in the same line of thought, a recent study by Latin American telecom regulators (Regulatel, 2007) discusses the "market efficiency gap" versus the "access gap." The first concept denotes the difference between the current level of service penetration and the level achievable in a hypothetically well-functioning competitive market under a stable regulatory environment. The "access gap" takes note of those segments of society that continue to be unable to afford access even under best-case market conditions.

So let us become a little futuristic and explore Scenario 3. Let us start with the assumption that eventually it would be possible to create the US$100 laptop (or any other comparable device at that price, such as an evolved multimedia mobile or digital TV device). Let us furthermore suppose that this connectivity would be enough to provide voice services (such as Voice-over-IP) and that through some futuristic 4G wireless connectivity, the device could be moved around as a mobile phone, constantly connecting to the closest base-station to provide Internet service to each individual, while the price of this Internet connectivity would still be shared by all members of the household (a kind of joint family plan for mobile Internet services). This would reduce prices to the plain price of equipment (US$100 per person for three years equipment lifetime, making it US$33 per year) and a household-shared Internet connection (based on current prices), eliminating fixed and mobile phone costs. Let this be our 'reduced price ICT access packet'.

Table shows the result of this Scenario 3. In Mexico 2007, 47% of society could buy such "reduced price access packet", which is a clear improvement from the 12% of society that has access to the Internet in 2007 (compare to Table). However, in order to connect the ones that still remain unconnected, still 0.42% of GDP would be required as subsidies. This is equal to the amount Mexico spent on Research and Development (R&D) and half of Mexico's public spending on tertiary education (see Table). In Uruguay, Internet connectivity could be increased from 14% (see Table) to 32% of society (Scenario 3 Table), but the amount required to bridge the digital divide for the remaining unconnected (2.18% of GDP) would be 22 times the total amount of international Official Development Assistance (ODA) the country receives per year (see Table).

As already indicated, these scenarios depend on the future development of prices and spending levels. While we do not have more recent statistics on spending, we do have the price figures for 2008 (ITU, 2009). Uruguay and Costa Rica have been able to reduce the price of their 'ICT access packet' from US$ 468 in 2005 to US$275[36] in 2008 and from US$ 237 in 2004 to US$135.3 in 2008 respectively (in Uruguay mainly due to reductions in Internet and mobile prices, and in Costa Rica due to lower mobile prices). The 2008 prices in Uruguay come close to the envisioned prices of our 'reduced price packet' (US$242). If we could now also suppose that Uruguay's economic growth at least benefits the three higher income quintiles so that market forces would eventually enable them to connect, we could conclude that in these cases the required subsidy would be

[36] Uruguay's 2008 'ICT access packet' is the sum of [US$77.4fixed]+[US$39.6mobile]+[US$100.7Internet]+[57.5PC].

limited to the two lower income quintiles (which reduces subsidies to a little more than 0.57%+0.59% = 1.16% of GDP, see Scenario 3 in Table).

In the case of the public telecom operator in Costa Rica, prices in 2008 turn out to be even lower than our 'reduced price' Scenario 3 (which would have turned out to be US$184). Due to this impressive price cut in Internet and telephone tariffs, Table does not show a Scenario 3 for Costa Rica, but a Scenario2008 (see Table). It takes 2008 prices and 2004 spending levels (unfortunately the last available spending levels). This price reduction lowers required subsidies effectively to 0.85% of GDP, equal to "only" twice the spending in R&D (see Scenario2008 in Table). In case that Costa Rica's economic growth had positively affected communication-spending levels between 2004-2008, these required subsidies would accordingly be reduced.

This encouraging outlook, however, cannot be transferred to Mexico and Brazil. In both countries the price of our 'ICT access packet' has risen in recent years, from US$ 307 in 2007 to US$341 in 2008 in Mexico (mainly due to increases in Internet and fixed-line prices), and from US$294 (2003) to US$ 462 in Brazil (due to the same reasons)[37]. These unfortunate tendencies might be explained with two already observed facts: first, high income segments have more spending power than required to purchase our minimum 'ICT access packet' (see Table); and second, market expansion in high income segments is still ongoing and has not even reached saturation for the 'minimum access packet' (see Table). Therefore, the natural business strategy for private enterprises consists in creaming off existing spending power in high-income segments. Proof of this

[37] Mexico's 2008 'ICT access packet' is the sum of [US$137.1fixed]+[US$39.6mobile]+[US$116.8Internet]+[47.4PC]; and Brazil's [US$146.0fixed]+[US$99.0mobile]+[US$172.1Internet]+[45.0PC].

is the fact that increases in penetration rates can mainly be attributed to high-income segments (compare Mexico2002 and Mexico2007 in Table). Combine this tendency with the already mentioned fact that ongoing economic growth tends to favor the high-income segments, and the result is a clear economic incentive for private enterprises to focus their business model on the spending power of high-income segments. Considering that in all Latin American countries, the richest 20% receive more than 50% of the national income, it becomes beneficial to adjust commercial prices to the constantly increasing spending power in this high-income segment. This also includes the constant introduction of new high-quality ICT (broadband, 4G, etc), which can be expected to constitute a large portion of the revenues of private enterprises. A consequence is increasing, not decreasing ICT prices.

These mixed results show that the heterogeneity in access prices among countries prohibits reaching a general conclusion. However, even in the most favorable cases, the bridge over the digital access divide for the poorest of the region would still be a heavy financial burden. It is actually quite utopian to think that the region's finance ministers could be convinced to take out even 0.5% of GDP from the general public budget to reduce the digital divide in households. And even if developing countries would have the resources to do so, one would have to ask if this step would be justifiable, or if this money would rather be spend on other urgent issues, such as modernizing hospitals, schools and municipalities, which can of course also be done by introducing ICT in these entities. Such a policy would indirectly benefit citizens, who would remain unconnected at their homes, and as such, would remain victims of the digital divide.

Table also shows that the required funds are currently not available with the international development community in forms of Official Development Assistance (ODA). The required amount of yearly subsidies for the reduced price Scenario 3 in Mexican 2007 only, would be almost twice as much (US$4.3 billon) as the annual net budget of the United Nations (US$2.5 billon in 2009). In other words, even if market forces would drastically reduce ICT prices, the domestic and international financial mechanisms would stop far short from enabling universal service.

Before going on to drawing conclusions, we should once again point to the limitations of our modeling effort. Table shows us that the 'ICT access packet' in Mexico's highest income segment has decreased from US$481 in 2002 to US$388 in 2007 (see Table) and Table confirms that spending levels have increased from US$306 to US$374, thanks to economic growth. As a result, in theory, almost every member of the highest income segment in Mexico should have had enough resources to buy our 'ICT access packet' in 2007. Table confirms that Internet penetration has indeed risen in this segment during these five years from 43% to 63% and mobile phone penetration from 27% to 91%. However, still not everybody is connected in 2007, despite the economic capacity to do so. This is proof of the fact that our model is simplified and ignores other important explanatory variables, such as discussed in the second section of this article. As previously shown, the correlation between access and income is high, but not perfectly 1-to-1.

What are the odds for the digitally excluded?

The underlying question of this paper was as simple as it is direct: How much would it cost and how far would ICT prices need to be reduced to bridge the domestic digital divide in the Latin American context? The answer has been modeled on basis of household spending statistics and adjustable ICT penetration rates and access prices. The results turn out to pose an extremely challenging task, constrained by the reality of Latin American income levels. Any realistic bridge over the digital divide will need to be constructed as a combination of various solutions, including price reduction and sophistically distributed subsidies in close public-private cooperation, and hopefully alleviated by substantial (ICT-enabled) economic growth that trickles down to the poorest segments. We will discuss some examples of the available alternatives in this concluding section.

Given the fast and unforeseeable technological progress of ICT, it does not seem advisable to limit price reduction strategies to a specific technological solution. New technology is being developed at this moment and this innate uncertainty has to be taken as an opportunity, not a threat. It is definitely easier to change technology than it is to change the present reality of income levels. The development of cheap (or free) source software, as well as of cheap hardware equipment makes part of this approach. The US$ 100 laptop set off a debate that moves into the right direction. Another area with great potential is the introduction of digital TV. Converter “set-up boxes” can upgrade analogue television sets with digital interactivity and have been manufactured for less than US$40. However, the eventual provisions of e-government, e-health and e-business services through a converted analogue TV set still remain to be seen. Besides equipment

and software, traffic prices also need to be reduced. The use of unlicensed radio frequency spectrum, in combination with cheap broadband wireless technology, such as the popular Wi-Fi, is part of this challenge.

Regarding public subsidies, our model has clearly shown that income levels of the developing world are simply too low to strive for "universal service" in the short-term. Household connectivity is a viable option for the high-income segments, but low-income segments will have to be satisfied with a voice- and short-message based mobile telephony. While mobile phones are an important first step, they do not convert the poor into full-fledged members a true Information Society. In order to provide e-government and other e-services to the poor, the provision of "universal access" seems much more realistic than the ambitious goal of "universal service". The economic model behind this strategy is an old one. It is the same that gave birth to Thomas Jefferson's ideal of giving access to books to all people by sharing their fixed price through the establishment of public libraries. Fitness clubs and the public transportation system follow the same line of reasoning. The benefit lies in sharing the fixed cost, while covering the variable cost. Even more than 125 years after the commercialization of the automobile, not everybody in the developing world posses a car. But most people have nevertheless access to automated mobility, thanks to decades of massive public and private investments in public transportation. Special machines have been built for collective access to transportation—such as busses, metros, auto rickshaws, "guaguas" and "tuk-tuks"—and micro entrepreneurs provide transportation services and offer to share their motorcycles, often resulting in breathtaking acrobatic acts. The logic of collectively sharing the access price to technology becomes obvious when looking at the reality of transportation

systems in developing countries even 125 years after the "mobility-revolution". Of course, this still leaves a qualitative dimension of the "mobility divide" (some have more mobility than others, and the well-off have better cars and even go by helicopter), but the "minimum access divide" to mobility has been bridged.

The same reasoning is behind the massive sprouting of the so-called "*info-centros*", or public ICT access centers. More than 140,000 of these public access points have been identified throughout Latin America in 2006 already (Maeso and Hilbert, 2006). The only viable solution for an important part of the region's society might be to buy some minutes in a public Internet access point. Table shows that the poorest 20% of the analyzed Latin American societies have between US$ 0.18 – 0.67 per week to spend on ICT (Mexico2007: US$ 0.67 per week; Uruguay2005: US$ 0.55; Brazil2003: US$ 0.18; Costa Rica2004: US$ 0.33), while 40% of society has less than US$ 1.50 per week. Supposing an average cost of US$2 per hour for Internet access at a commercial Internet café[38], the poorest 20% of Costa Rica2004 could buy some 10 minutes of access per week. Generally speaking, Table shows that the poorest half can afford around half an hour of Internet access at a public access place at a price of US$2 per hour. This is not a lot, but could enable them to take care of an urgent transaction with the government or make a reservation at a far away hospital, for example. One additional benefit of public access places is the frequent updating of equipment and service (usually broadband connectivity is available and the equipment is being maintained by the owner), while there is always help around to assist the user to overcome skill limitations.

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[38] Prices for commercial cyber-cafes in 2008/9 range between US$1 per hour (Brazil and Uruguay) up to US$3 per hour in Mexico.

While shared access seems to be a viable solution to "bridge" the divide, the financial sustainability of the applied business models is a mayor concern (e.g. Celedon and Razeto, 2009). The results of the analysis presented here show a reality in which it does not seem likely that the poor will gain sufficient purchasing power to attain personalized access in the short term. The logical conclusion is to prepare for a long period in which public access is the only viable access solution to assure quality and up-to-date access for these income segments. An apparatus would be comparable to the institutional structure of today's public transportation system, which might of course consist of public and private components (similar to public transportation). Notwithstanding, any sustainable solution of such institution requires a reliable stream of resources. Currently, few financial mechanisms are in place to support such an institutional structure of public access to information.

Throughout Latin America, public Universal Access Funds have started to support those shared access initiatives. Most Latin American countries maintain such Universal Access Funds, which are alimented by an earmarked tax on the telecommunications industry (and are therefore highly polemic, given their interventionist nature). These funds have their historical roots in the days of public pay phones and usually charge telecom operators around 1% (up to 5%) of their revenues, in order to finance connectivity in underserved populations. Until 2006, these funds have collected US$2.7 billion throughout Latin America (Regulatel, 2007). The Brazilian FUST (Fundo de Universalização dos Serviços de Telecomunicação), has collected a yearly average of US$ 354 million between 2001 and 2006. This constitutes 3.4% (or $^{1}/_{30}$) of the subsidies that would be required to provide individual universal service in the case of our 'reduced

price access packet' (see Table). In other words, if prices could be reduced to the aspired level of our reduced price scenario and if the fund would be modernized to actually subsidize public ICT access initiatives, then the Brazilian Universal Access Fund could provide one shared connectivity packet per 30 unconnected inhabitants. This does not lead to "universal service", but to "universal access" and 30 people per station is not overly crowded for a public access cyber café. This scenario enables to end our analysis on a "glass-half-full" outlook. It seems that the innovative combination of public and private efforts to reduce prices, together with public and private efforts to provide shared access provide at least one viable path to follow.

It is important to point out that not all countries around the world have such funds, and many of the existing funds face fierce opposition from groups that defend free-market mechanisms. Others have suggested exploring the possibility to extend this model to the international level and hold the globally connected responsible to connect the global poor. This fits the global nature of digital networks and it would also enable to expand the logic of digital solidarity from telecom, to hardware and software services. As already mentioned, most ICT are tradable goods. In the established Universal Access Funds, however, only the non-tradable telecom services are subject to contributions. National authorities only tax non-tradable national telecommunications service companies, and do not place a tax on imported hardware or software products. This does not only result in indirect subsidies from telecom companies to hardware and software

companies[39], but is also difficult to justify ideologically, because "ICT access" requires hardware and software just as much as telecom services.

During the 2003-3005 World Summit on the Information Society, Heads of States and governments have proposed the creation of a public-private "Digital Solidarity Fund", "as an innovative financial mechanism of a voluntary nature" (WSIS, 2005). The initial idea of some participants was to establish global contribution system, similar to the national Universal Access Funds in Latin America, which will then be alimented by the global ICT industry. A contribution of 1% of the revenues of the world's ten largest non-telecom ICT enterprises[40] (Fortune, 2008) would have provided US$ 4.6 billion to provide connectivity to the world's poor in 2008. Used for public access or for R&D to develop cheap equipment suitable for the poor, such a constant source of yearly resources would surely have a significant and sustainable impact. Notwithstanding the potential of the idea, the voluntary nature of the Digital Solidarity Fund has raised less than US$10 million during the entire period of its first five years of existence (until 2009), with a substantial part of the donations coming from developing country governments in a good-will effort to show their sympathy for the idea. This reality shows the "glass-half-empty" side of the current challenge: the low degree of commitment to the overcome of the digital abyss. Many more innovative and creative ideas—and their practical

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[39] By forcing telecom operators to expand their networks to underserved areas, new markets are consequently opened for hardware and software producer in the developing world. Telecom operators have to chip in to make this step possible, while hardware and software producers are under no regulation to provide cost-effective solutions to marginalized populations. Additionally, if public access centers are financed by the universal service funds, these centers need to buy hardware and software equipment, which in some cases is financed with the resources that are collected from the telecom operators through the fund.

[40] In 2008 this included: Hewlett-Packard, IBM, Dell, Microsoft, Intel, Cisco Systems, Apple, Oracle, Xerox and Google.

implementation—will have to be explored to find sustainable solutions for the digital excluded.

Let us relativize these findings with a final word of caution on the limitations of the presented approach. It has to be remembered that the presented numbers will inevitably change over time as new household spending surveys become available. What will not change as easily, however, is the general logic of combining the structural characteristic of the highly skewed income distribution in low-income countries with tradable ICT equipment, whose prices are internationally defined. While the numbers have to be checked in the future, it can be expected that the digital divide will persist over the coming years. Besides new statistical input, the current model can and should also be refined (which will happen at the cost of increasing complexity). Two of the most straightforward improvements would include estimations on future spending levels (considering estimations for economic growth and its trickle down effect to different income levels) and the inclusion of explanatory variables beyond income distribution (education levels seems especially promising).

Summing up, by putting numbers and quantities to the omnipresent rhetoric about the digital divide, this paper has shown that, once again, long-standing structural characteristics of the developing world could be about to deepen the vicious circle between inequality and technology diffusion. The numbers have shown that the challenge of breaking this circle is a formidable one. The presented model allows for a quantification of the challenge and the identification of normative goals to break it. The development of such normative models is an important first step, but not sufficient. The exploration of practical policy tools requires complementary further research in the light

of the presented findings. This research will have to be realistic and convincing enough to motivate national and international public and private sectors to take up those concepts and implement sustainable solutions that enable the world's unconnected to become full-fledged members of a truly global Information Society.

Digital Gender Divide or Technologically Empowered Women in Developing Countries? A Typical Case of Lies, Damned Lies, and Statistics[41,42]

The discussion about women's access to and use of digital Information and Communication Technologies (ICT) in developing countries has been inconclusive so far. Some claim that women are rather technophobic and that men are much better users of digital tools, while others argue that women enthusiastically embrace digital communication. This article puts this question to an empirical test. We analyze data sets from 12 Latin American and 13 African countries from 2005-08. This is believed to be the most extensive empirical study in this field so far. The results are surprisingly consistent and revealing: the reason why fewer women access and use ICT is a direct result of their unfavorable conditions with respect to employment, education and income. When controlling for these variables, women turn out to be more active users of digital tools than men. This turns the alleged digital gender divide into an opportunity: given women's affinity for ICT, and given that digital technologies are tools that can improve living conditions, ICT represent a concrete and tangible opportunity to tackle longstanding challenges of gender inequalities in developing countries, including access to employment, income, education and health services.

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[42] The author would like to thank the support of Canada's International Development Research Centre (IDRC), which has been the driving force behind the creation of important statistics throughout the developing world for decades. Without the long-term vision, dedication and trust of its professionals, like Ben Petrazzini, this, and many other studies of this kind, would not exist

During the second half of the last century, human kind has turned to the "massive task of making our bewildering store of knowledge more accessible" (Bush, 1945). The result has brought on irrevocable social, productive, political and cultural transformations, which are based on a global communication infrastructure that includes innovations like the Internet, mobile telephony and social networking applications in all shapes and sizes. During the beginning of this new century, society at large is starting to embrace these new tools, changing forever the way we communicate, coordinate our activities and organize social interactions (Bell, 1973; Perez, 1983; Webster, 1995; Negroponte, 1995; Castells, 1996; Freeman and Louça, 2001). At the core is the question of access to digital networks, and, in particular, who gets empowered and who is informationally marginalized by use of these new tools.

As a contribution to this ongoing discussion, this article analyzes the differences between men's and women's access to and use of Information and Communication Technology (ICT) in developing countries. We start with a literature review that shows that some see digital technologies as practical and tangible tools for women to overcome longstanding inequalities. ICT can help women to gain employment (for example through telework or newly created information jobs), obtain cost-effective health services and education (such as through online courses or software-based literacy programs) and to increase their income (such as through e-business channels and online transactions). In contrast to this glass-half-full outlook stands the pervasive and persistent counterargument that women are at a natural disadvantage to benefit from the digital revolution because they are less tech savvy, and more technophobic, and because the technology is not built for their needs and intuition. If this were the case, the increasing

socio-economic importance of ICT would add a new dimension to the already existing vicious circle between discrimination and women's backwardness, which can be expected to be particularly severe in developing countries, where four out of five women live worldwide. Unfortunately very few of the related studies control for potentially confounding variables.[43] We know that the lack of employment, income and education affect ICT usage negatively (e.g. NTIA, 1999; Cullen, 2001; Warschauer, 2003; Mossberger, et.at., 2003; OSILAC, 2007). We also know that women are discriminated against in many aspects of social life, including employment, income and education. Given these potential confounders, it is not clear if being a woman per se has a negative, neutral or positive effect on ICT usage. In the first case, the digital revolution would pose a severe threat to women. In the latter case, the increasing socio-economic importance of ICT would pose a unique opportunity: the new tools would be a perfect tool to fight existing inequalities between men and women.

To this point, lack of adequate statistical data had prevented us from testing this question empirically. Arguments were often based on anecdotal evidence from case studies or uncontrolled correlations, which sometimes lead to contradictory results. In recent years, statistical institutes and academic research centers in the developing world have made a significant effort to collect adequate statistical information. For this study we employ 25 datasets from 12 Latin American and 13 African countries (total of 1,176,816 observations), which allows us to execute a series of uncontrolled and controlled empirical tests that will provide further insight into this unresolved question.

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[43] A notable exception for the case of the United States is Rice and Katz (2003), which, after control, do not detect any significant digital divide between men and women. The author is not aware of any controlled studies for the digital gender divide on the international level.

What is the digital divide?

The unfolding of the digital revolution is happening at unprecedented speed (for ICT penetration rates during the past 15 years, see ITU, 2010). However fast, it is not immediate and the related diffusion process follows the form of a well-known S-shaped curve, which distinguishes between early adopters and latecomers (Rogers, 2003). While this process unfolds, a new form of inequality is added to all the existing forms of discrimination: an inequality in the power to communicate and to process information digitally. The term "digital divide" has been coined to refer to this concept (e.g. NTIA, 1995, 1999; OECD, 2001).

Studies on the digital divide differ in their focus and methodological approach. Despite their differences, all of them answer (part of) the following questions: who (individuals vs. organizations/communities, vs. societies/countries/ world regions, etc.), with which attributes (income, education, geography, age, gender, or type of ownership, size, profitability, sector, etc.), connect how (pain access vs. usage vs. real impact), to what kind of technology (phone, Internet, computer, digital TV, etc.) (see Hilbert, 2011). In this article we test for one specific attribute of ICT users: their gender.

The main focus of this article is set on analyzing access to ICT in Latin America and Africa, while we also sneak an exploratory peak into how men and women use the Internet in Latin America. This is important because literature has shown that access and usage foster the well-being in multiple aspects of life (e.g. Castells, 1996; Webster, 1995; Waverman, et.al. 2005; Cimoli, et.al, 2010; Hilbert and Peres, 2010). Previous research has shown that ICT adoption patterns are characterized by the same long established determinants of inequality as other aspects of social life, such as those related to income,

education, skills, employment, geography, age and ethnicity, and gender, among others (e.g. Cullen, 2001; Compaine, 2001; OECD, 2002; Warschauer, 2003; Mossberger, et.at., 2003; van Dijk, 2005; OSILAC, 2007; Hilbert, 2010).

What do we know about the digital gender divide?

Let us begin with clarifying that most literature in this field refer to ICT access and usage patterns among biologically identifiable men and women (sex), not the self-identified gender identity of an individual, such as understood in the field of gender studies. While it would be very interesting to explore the relationship between the digital divide and gender identity, the paucity of data on the last variable forces us to follow most existing research and equate gender with sex in this article.

During the 1990s, researchers were quick to observe that women tend to be latecomers to the digital age (e.g. Dholakia, 1994; NTIA, 1999). As a consequence, the new technology was popularly portrayed as a male domain (Badagliacco, 1990). Bimber (2000: 2) concluded that the gap in ICT usage between women and men "is the product of both socioeconomic differences and some combination of underlying, gender-specific effects". Researchers claimed that those gender-specific differences had their origins in the fact that women underestimated their actual usage skills, which lead to lower self-efficacy to use ICT (Busch, 1995; Joiner, et.al, 1996; Hargittai and Shafer, 2006), as well as in their general attitudes toward computers (Shashaani, 1994). It was concluded that "men are more interested in technology than women, and they are also more tech savvy" (Fallows, 2005: 5). In short, women were seen as being more likely to be technophobic and were ascribed a certain computer anxiety. This type of reasoning is in line with a

longstanding argument that technology is gendered (Lohan and Faulkner, 2004; Puente, 2008). ICT are seen as yet another "toy for the boys" (Faulkner, 2001).

As more statistics became available and Internet and mobile telephony penetration rates began to rise, women started to catch up in many developed countries (Rice and Katz, 2003). In the United States, most new users were women around the year 2000 (Cummings and Krout, 2002). Gender differences remained, but were smaller (Leggon, 2006) and mainly concentrated on marginalized groups, such as ethnic minorities (Tolbert, et.al., 2007). However, once online, women remained less frequent and less intense users of the Internet (Ono and Zavodny, 2003; Wasserman and Richmond-Abbott, 2005). The focus of attention started to shift towards differences in how men and women use ICT (Bonfadelli, 2002). For example, it was found that girls use the Internet for instant messaging and chat-rooms, whereas boys downloaded games and music, engaged in online trading, and created Web pages (Lenhart, Rainie, & Lewis, 2001; Roberts and Foehr, 2004). Fallows (2005: 1) summarized a survey in the United States with the conclusion: "men like the internet for the experiences it offers, while women like it for the human connections it promotes". As already mentioned, we will look at both aspects in our subsequent analysis: access and usage, with a focus on the first one.

Statistical data from the USC led World Internet Project (2009) reconfirm these findings. In Canada, 79% of men and 75% of women were online in 2007. This difference grows to 56% to 46% for citizens of 60 years and older. The study also confirms differences in usage. In 2004, Canadian men spent on average more time online than women (14.3 to 12.0 hours per week). This difference increased from 2.3 to 3.5 hours in 2007 (18.8 hours to 15.3 hours). As the main reasons for non-usage, Australian

women state lack of interest (35%), not having a computer or Internet connection (26%) or lack of skills (16%). The percentage of men to women who use the Internet is reported for the following developed countries: Australia: 74% to 71%. Czech Republic: 55% to 46%; Hungary: 45% to 39%; Israel: 71% to 64%; New Zealand: 78% to 77%; Singapore: 69% to 54%; United Kingdom: 68% to 65%. The two exceptions to this trend seem to be Sweden (with 75% of men online and 78% of women) and the United States (71% to 73%). However, even in these countries, men are more frequent and more intense users. In 2008, men from the U.S. are more likely than women to surf the web "at least daily" (54 to 41 percent) and men spend 1.5 hours more than women at their monitors reading. In short, differences have become smaller in developed countries, but still remain, especially in usage.

What about women and ICT in developing countries?

Due to the paucity of adequate statistics about the world's poor, technology-related research and respective policy-advice is often exclusively focusing on the roughly 20 % of the world population living in the most industrialized countries[44], while the remaining 80 % of the global population is frequently ignored or inappropriately subsumed under these findings. This is delicate, because living conditions, opportunities and threats differ decisively in developed and developing countries. The vast majority of women live in developing countries and they often suffer even more gender related discrimination than their counterparts in developed countries. At the same time, if ICT were to hold a

[44] In 2006, the countries member countries of the Organisation for Economic Co-operation and Development (OECD), which represents the world's "industrialized countries", was home to 1,184 million inhabitants, within a world population of 6,555 million (18 %).

promise to empower women, than this promise is much larger in the developing world, given that the lower starting point provides for greater potential gains.

ICT: a threat for women

Similar to the above-cited data from developed countries (World Internet Project, 2009), existing data from developing countries show that women are less likely than men to use ICT. This leads related research to the conclusion that a digital gender divide clearly exists and is a severe threat to women: "In many countries such gaps become dramatic, putting women at a significant disadvantage" (Hafkin and Huyer, 2007: 33). Similar to findings in developed countries, this divide applies to access and to the frequency and intensity of usage (Park, 2009). Looking for reasons, researchers normally fall back on anecdotal case studies and local evidence, which found that women face barriers that include lack of access and training, and that they were confronted with software and hardware applications that did not reflect their female interests and needs (Arun and Arun, 2002; Ng and Mitter, 2005; Best and Maier, 2007). In this sense, the same technophobic arguments that had been raised in the developed world during the 1990s, have been transferred to women in the developing world in recent years. It is argued that women have a negative attitude toward ICT (Varank, 2007) and that the introduction of technologies has often implicitly been designed to meet the needs of men, not of women (Basu, 2000; Hafkin, 2000).

ICT: an opportunity for women

In contrary to these findings, some case studies and anecdotal evidence show that ICT can and are empowering women in developing countries. For example, ICT provide women entrepreneurs with access to worldwide e-business channels, which and can be operated 24 hours a day from home in real-time (Heeks, et.al. 2004; Schaefer Davis, 2007; Brodman and Berazneva, 2007). Ng and Mitter (2005) look beyond ICT's contributions to economic well-being, and show how ICT are used by women for the purposes of community building and political organization. ICT enable meaningful participation and make female voices heard, as proven by the role of digital networks in feminist movements (Harcourt, 1999). Others have argued that ICT have the potential to completely redefine traditional gender roles, especially for women who have limited skills or who lack the resources to invest in higher education (Kelkar and Nathan, 2002). In short, ICT can be "powerful tools for women to overcome discrimination, achieve full equality, well-being and participation in the decisions that determine their lives and the future of their communities. […] ICT [...] opens up a direct window for women to the outside world. Information flows to them without distortion or any form of censoring, and they have access to the same information as their counterparts" (Sharma 2003: 1). However, this potential to empower women in the developing world depends on access to and actual usage of these technologies, which is a necessary first step (see e.g. Scott, 2001).

How can misleading statistics mask the reality about the gender divide?

We have seen that the literature is inconclusive. We do not know if ICT are a severe threat or an opportunity for women. What could be the reason for this apparent contradiction?

There is a subtle message that can often be read between the lines of research related to the digital gender divide. For example, Sharma (2003) points out that "women have less online access than men, for all the usual gender-related reasons—time, money, control, learning opportunities, other commitments, prioritising others' needs". Arguing that longstanding gender-related inequalities are the reason for less usage is very different from arguing that women are naturally technophobic. It has widely been measured that women around the world are discriminated in fields like employment, income and education (see e.g. Anand and Sen, 1995). It is therefore not clear if these existing inequalities lead to the fact that women make less usage of ICT or, if being a woman per se has a negative effect on ICT usage. This problem is well known in statistics and is treated under the topic of so-called "confounding variables" (e.g. Freedman, et.al., 2007).

Often the confounder is easy to spot. For example, if somebody would realize that children's ICT usage is positively correlated to the size of their shoes, most people would become suspicious and reason that age, and therefore literacy skills, might confound this relation. There is no reason to believe that the shoe size of children with the same level of schooling would make any significant difference. Often it is not as easy. But the cure remains the same: as soon as there is a suspicion of confounding variables, it is wise to control for them and to compare subjects on the same level of such variables. If the result

still makes a difference, it is more probable that the original variable has explanatory power. If not, the confounder made the difference.[45]

What does the data say?

The most frequently analyzed statistics so far have been collected by telecommunication administrative authorities and have been harmonized by the United Nations Telecommunications Union (e.g. ITU, 2010). Traditionally, these administrative registers collect the national aggregates of the numbers of subscriptions, connections and devices and therefore do not allow detailed cross-tabulations with user attributes (like gender, income, employment, education, etc). Those are provided by the household surveys that we will use.

Our databases are both products of the initial seed funding of Canada's International Development Research Centre (IDRC). In Latin America, IDRC has cooperated since 2002 with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) to operate OSILAC (Observatory for the Information Society in Latin America and the Caribbean)[46]. During the last decade, OSILAC has successfully worked with National Statistics Offices all over the region to include ICT indicators in existing household surveys. Given the large samples of official household surveys, this data is very robust (all used sample sizes are between 21,000 and

[45] This does not change the fact that children with larger shoes will have better ICT usage scores. Same accounts for the case of ICT and women: might be that women use ICT less than men, but the question is why: because they are women, or because of some other reason that come with being a woman?

[46] OSILAC: http://www.eclac.org/SocInfo/OSILAC/

408,000)[47]. Parts of these databases are publicly available (OSILAC, 2009). In Africa, IDRC is cooperating with the Research ICT Africa Network[48], which has conducted their own household and individual user surveys of ICT access and usage between 2007 and 2008 (sample sizes between 819 and 2,355).[49] Despite the smaller sample size, this is nonetheless an important effort, as Africa is normally considered a black hole for technology related statistics (for overview of these surveys see Gillwald and Stork, 2008).

Controlling correlations in Latin America

Let us start with a series of simple correlations between gender and both, Internet usage and mobile phone usage. It is important to underline that we use the question of active usage by a specific person as an indicator for access, not the plain existence of equipment in a household. We use the Pearson correlation coefficient to measure the degree of association between two correlation coefficients (e.g. Williams and Monge, 2001; Freedman, et.al., 2007), in our case between being a woman and using the Internet. We code in a way that a negative correlations ($r < 0$) means that women use less Internet

[47] Sample sizes: Brazil 2005: 408,148; Chile 2006: 268,873; Costa Rica 2005: 43,682; Ecuador 2006: 55,666; El Salvador 2006: 68,312; Honduras 2007: 100,028; Mexico 2007: 21,292; Nicaragua 2006: 40,190; Panama 2007: 48,295; Paraguay 2007: 21,053; Dominican Republic 2005: 20,610; Uruguay 2006: 64,164.

[48] Research ICT Africa: http://www.researchICTafrica.net/

[49] Sample sizes: Benin: 1101; Botswana: 818; Cote d'Ivoire: 1112; Ethiopia: 2355; Ghana: 1092; Kenya: 1461; Mozambique: 1131; Namibia: 885; Rwanda: 1078; Senegal: 1081; South Africa: 1771; Tanzania: 1490; Uganda: 1127.

than men, while $r < 0$ implies that Internet usage is positively correlated with being a woman.[50]

A first look at the upper two rows of Table reveals that most of the correlations between ICT usage and being a woman turn out to be negative. In agreement with previous findings, the overall data show that women are less likely than men to use the Internet or a mobile phone. In Brazil, for example, the region's largest country with over a third of the region's GDP and population, being a women is negatively correlated with using the Internet (with a correlation coefficient of $r = -0.022$), and with using a mobile phone (with $r = -0.029$).[51]

In the following rows of Table show two kinds of the inequalities between men and women in percentage points. It is shown that there are real inequalities between men and women regarding their working status (being employed or self-employed) and their current attendance at an educational institution. Continuing with the example of Brazil, 92.2% of all men are actively working, compared to only 83.7% of women, and 31.6% of all men currently attend an educational establishments, compared to 30.8% of all women. These differences do not seem to be very large, but let us see what happens when we control for them. This can be done with a partial correlation, which measures the degree of association between two variables when the effects of a third variable are removed (see

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[50] Pearson's r is normalized between +1 and -1, where +1 is a perfect positive association and -1 is a perfect negative association. A correlation near zero indicates that there is no relationship between the two variables.

[51] A second look at the data reveals that the identified correlations are not very strong (even though they are all statistically significant, weighted and stratified samples with $p < .001$). Squaring Pearson's correlation coefficient tells us how much of the variation in ICT usage can be explained by variation in being male or female. In all cases, less than 0.5% of the variation in ICT usage can be explained by gender (for example, in Chile $r^2 = -0.047^2 = 0.2\%$). There must be much more powerful explanatory variables that determine ICT usage than gender.

e.g. Williams and Monge, 2001). To be more precise: what is the relationship between being a women and ICT usage when the effect of work or current schooling is removed?

Table shows that in the controlled environment, being a woman is positively correlated with using the Internet (for Brazil r = +0.056) and with using a mobile phone (for Brazil r = +0.033). While this correlation is still very low, it is striking that this turn-around effect is consistent throughout almost all analyzed countries, which represent a very heterogeneous group of socio-demographic and cultural societies. There are some countries in which women are more active Internet users to begin with (Panama, Honduras, Nicaragua) or more active mobile phone users (Dominican Republic, Panama, Nicaragua), which of course naturally argues in favor of women being more active ICT users to begin with. There are also cases in which women are not discriminated in the fields of employment status (Nicaragua) or current attendance at an educational establishment (Panama and Ecuador). This does not affect the logic of our result. The overwhelming majority of the cases show that, when controlling for working and educational enrollment conditions, women make more use of digital ICT than men. The only exception in the 20 changes in tendency that can be observed in Table is mobile phone usage in Ecuador: the correlation coefficient becomes weaker in the controlled test, but continues to stay negative (r = -0.037). This reminds us of the fact that social science is not an exact science.

Table 6 Correlations and controlled correlations of gender with ICT usage in Latin America; working and studying populations by men and women.

			Chile 2006	Brazil 2005	Uruguay 2006	Mexico 2007	Paraguay 2007	El Salvador 2006	Costa Rica 2005	Dominican Rep. 2005	Panama 2007	Honduras 2007	Nicaragua 2006	Ecuador 2006
Correlation coefficient, r	Internet use with being a woman		-.047	-.022	-.024	-.045	-.002/	-.023	-.032	-.033	**.020**	**.008**	**.004**	-.026
	Mobile use with being a woman		-.004	-.029	n.a.	n.a.	n.a.	n.a.	-.044	**.009**	**.011**	-.029	**.013**	-.070
Real world inequalities (in %)	Actively working	**% of Men**	**98.0**	**92.2**	**98.7**	**95.1**	**88.0**	**89.3**	**98.3**	**93.7**	**95.8**	**87.3**	88.3	**86.5**
		% of Women	**98.0**	83.7	96.3	90.4	74.0	79.3	96.5	78.0	85.0	81.3	**91.7**	64.8
	Attending educational establishment	**% of Men**	**31.1**	**31.6**	**29.6**	**33.0**	**44.2**	**34.5**	**35.0**	**34.2**	28.6	**31.4**	**34.7**	10.8
		% of Women	28.2	30.8	27.6	29.3	44.1	30.3	34.2	34.3	**29.9**	31.2	33.1	**11.3**
Correlation coefficient, r: being a woman, controlled for working and assisting educ. establishment	Internet use		.050	.056	.047	.048	.088	.030	.047	.082	.148	.093	.066	.007
	Mobile use		.039	.033	n.a.	n.a.	n.a.	n.a.	.019	.094	.139	.069	.085	**-.037**

Source: own elaboration, based on OSILAC, 2009.

Let us dig deeper into this question and open up this statistical black box to see what actually accounts for these results. The first two rows of Table show the actual percentages that lead to the previous finding that in most countries more men than women use the Internet. Continuing with our example of Brazil, 22.0% of men use the Internet compared to 20.2% of women. In mobile phone usage the divide is at 38.5% to 35.4%. In agreement with the results from Table, the notable exceptions for Internet usage are Panama, Honduras and Nicaragua, and for cell phone users, Dominican

Republic, Panama and Nicaragua. The following rows show what happens if we put men and women on “equal footing” regarding their working condition. We only consider men and women who are either employed or self-employed, neglecting those who are unemployed, retired or stay at home without salary. Based on this condition, it turns out that in all countries more women than men use ICT actively, again with the sole exception of mobile phone usage in Ecuador. In Brazil, only 22.8% of all working men use the Internet, while 28.5% of all working women are online. Only 47.0% of all Brazilian working men use a mobile phone, while 50.6% of all working women telecommunicate on the go. The same general change in direction accounts for ICT when controlled for current attendance at an educational establishment. Once in school, women turn out to be more active users of digital opportunities (35.6% to 36.2% for Internet use in Brazil; 32.5% to 39.9% for mobile usage). The exceptions to the general rule for Internet usage are again Ecuador, as well as Costa Rica and Dominican Republic. Generally speaking, the differences are much more pronounced for mobile phone usage than for Internet use. Once set on equal footing in terms of employment and education, women seem to embrace mobile voice communication quite a bit more enthusiastically than men.

Table 7 Percentage of man/women that use the Internet and own a mobile phone in Latin America; place of Internet usage, Internet use frequency.

			Chile 2006	Brazil 2005	Uruguay 2006	Mexico 2007	Paraguay 2007	El Salvador 2006	Costa Rica 2005	Dominican Rep. 2005	Panama 2007	Honduras 2007	Nicaragua 2006	Ecuador 2006
Overall ICT inequalities	Internet use	**Men**	**39.6**	**22.0**	**30.5**	**24.3**	**11.3**	**5.6**	**23.4**	**17.1**	22.8	9.7	11.6	**7.9**
		Women	35.1	20.2	28.3	20.6	11.1	4.6	20.8	14.7	**24.5**	**10.2**	**11.9**	6.6
	Mobile use	**Men**	**54.2**	**38.2**	n.a.	n.a.	n.a.	n.a	**35.0**	56.6	45.0	**26.1**	40.9	**41.6**
		Women	53.8	35.4	n.a.	n.a.	n.a.	n.a	30.9	**57.4**	**46.1**	23.6	**42.1**	34.8
Men and women actively	Internet use	Men	31.0	22.8	30.9	21.0	10.6	4.6	24.0	17.0	21.1	8.9	10.7	7.3-
		Women	**36.6**	**28.5**	**37.3**	**25.8**	**15.1**	**5.7**	**30.4**	**24.7**	**37.2**	**15.4**	**15.1**	**8.2-**
	Mobile phone	Men	68.9	47.0	n.a.	n.a	n.a.	n.a.	44.2	62.5	53.7	41.3	49.2	**49.0**
		Women	**73.1**	**50.6**	n.a.	n.a	n.a.	n.a.	**46.8**	**71.9**	**68.3**	**47.6**	**56.4**	45.2
Men and women attending	Internet use	Men	70.2	35.6	49.8	39.2	19.9	11.5	**35.8**	**32.6**	42.4	16.9	19.1	**26.8**
		Women	**70.3**	**36.2**	**53.1**	**41.2**	**23.8**	**12.6**	35.5	29.6	**48.5**	**18.8**	**22.0**	26.1
	Mobile use	Men	39.1	32.5	n.a.	n.a.	n.a.	n.a.	29.4	60.7	37.4	13.6	37.7	58.9
		Women	**44.2**	**39.9**	n.a.	n.a.	n.a.	n.a.	**33.6**	**66.8**	**49.7**	**17.0**	**41.8**	**60.5**
Place of Internet usage, given that the person is actively working	At home	Men	14.3	11.7	13.6	7.9	3.3	1.4	7.9	3.8	6.7	1.9	0.7	n.a.
		Women	**16.4**	**14.2**	**16.4**	**10.2**	**4.4**	**1.5**	**9.4**	**5.5**	**11.5**	**2.9**	**0.8**	n.a.
	At work	Men	14.5	14.8	15.4	9.8	4.6	2.0	12.3	7.8	9.8	3.8	4.3	n.a.
		Women	**18.1**	**17.8**	**18.3**	**12.9**	**5.1**	**2.8**	**15.5**	**13.2**	**19.9**	**6.3**	**6.6**	n.a.
	Communal public access	Men	0.3	1.6	0.5	**0.8**	n.a.	0.1	0.1	1.7	0.7	0.01	0.0	n.a.
		Women	**0.3**	**2.3**	**0.8**	0.6	n.a.	**0.01**	**0.1**	**1.2**	**1.3**	**0.01**	**0.1**	n.a.
	Commercial public access	Men	6.9	4.2	12.3	**7.0**	3.5	0.9	9.3	7.1	6.9	5.7	5.8	n.a.
		Women	**7.6**	**4.3**	**14.9**	6.9	**5.8**	**1.0**	**12.1**	**7.5**	**10.3**	**10.1**	**7.7**	n.a.
	Other person's home	Men	n.a.	6.2	2.6	0.2	0.2	**0.01**	1.1	4.9	1.1	n.a.	**0.2**	n.a.
		Women	n.a.	**7.4**	**2.8**	**0.4**	**0.5**	**0.01**	**1.2**	**5.7**	**1.5**	n.a.	0.1	n.a.

Source: own elaboration, based on OSILAC, 2009.

These results seem to indicate that women are the more enthusiastic ICT users. However, one could argue that this tendency originates in the fact that women are more likely to be forced to use computers at work for unsophisticated and repetitive secretarial tasks (e.g. Kaplan, 1994). In this case, force, not enthusiasm would be the reason for our results. Saying it very bluntly, the argument would be that men at construction sites do

not need Internet access, while female secretaries are forced by their employers to execute trivial typing jobs and routine office activities, such as banal word processing and spreadsheet work. This general tendency could also affect ICT-enthusiasm in school, since girls and boys often already anticipate their future job. While this sounds like a possible hypothesis, this argument cannot explain the detected differences in mobile phone usage. Besides, as shown by the lower rows in Table, working women do not only access the Internet when forced to do so by their employers in their working environment, but women are also more active online users at home, at public access centers or commercial cyber cafes, and even at other people's homes. Continuing with our example of Brazil, Table confirms that more working women use the Internet at their job than men (14.8% to 17.8%), but at the same time more women also go online at home (11.7% to 14.2%) at a communal access center (1.6% to 2.3%), a commercial public access center (4.2% to 4.3%) or at the home of family and friends (6.2% to 7.4%). While ICT access at work might still have a catalyzing role, it can be seen that working women also make use of their digital skill outside the working environment. Rather than being forced to ICT usage against their will by an external force, it seems that women naturally enjoy the use of digital communication wherever they get the opportunity to do so.

Women and ICT in Africa

Let us now compare uncontrolled and controlled usage rates in Africa (see Table). Sample sizes are much smaller in these surveys and ICT usage rates in Africa are lower, making it more difficult to detect differences. While all results of the weighted samples turn out to be significant (weighted stratified samples with $p < .01$), they are less robust

than the ones from Latin America. Having said this, the general tendencies are the same. In agreement with the traditional findings of literature, the overall correlation between gender and ICT usage shows that in 11 of the 13 countries, a larger percentage of men use the Internet than women (with the exception of Rwanda and Tanzania, in which women already represent the larger share). In Kenya, for example, one of the larger and technologically most advanced African countries of our sample, 21.1% of all men have been online in 2007/8, while only 11.5% of all women use the Internet. 56.0% of all men use a mobile phone, versus only 46.9% of all women.

Notwithstanding, the following rows of Table show that, in general, African women are also less literate[52] (in Kenya 77.2% of men to 68.0% of women), and that fewer women are actively working or studying (employed, self-employed or full-time student) (81.4% of Kenyan men to 49.9% of women). Women also have less income (29.8% of all Kenyan men belong to the top 25% income group of the country, while only 16.6% of all women do).

On the basis of these characteristics, a new group was created. We will refer to it as "women on equal footing", simply for the sake of giving it a name. In this group we only consider men and women who are literate, are actively working or studying and who belong to the top 25% income group[53]. Controlling for these three inequalities, we can see that the gender divide disappears in most African countries for women "on equal footing". In the case of Kenya, the divide in Internet usage is erased at 29.7% for both

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[52] Literacy was defined by including all respondents that claimed to be able to read the newspaper easily and to write a letter easily.

[53] In the case of Africa it is necessary to focus on this high-income group of the top-25%, since income levels in general are relatively low (in absolute terms) and ICT are tradable goods with prices levels that are only accessible to segments that reach a certain absolute level of income (see Hilbert, 2010).

men and women, while women on equal footing turn out to be more active mobile phone users (90.0% to 92.7%). When placed on equal footing, the ratio of women versus men turns around for Internet usage in four of the 13 analyzed countries (Namibia, Ethiopia, Mozambique, Senegal). For another six countries, men continue to use the Internet more, but the relative difference diminishes in all cases (South Africa, Benin, Botswana, Ghana, Uganda, Cote d'Ivoire). For example, in South Africa, in the uncontrolled environment, the share of men online is almost twice as large (20.2% of men to 11.3% of women), while it shrinks to a difference of merely five percent for men and women on equal footing (39.9/37.7 = 1.05).

This observed change in tendency is again much more pronounced for mobile phone usage. In nine of the 13 countries, these controls turn the inequality around. With the exception of Senegal and Tanzania, women on equal footing tend to embrace mobile telephony more than men.

Table 8 Percentage of man/women that use the Internet and own a mobile phone; literacy, working and income inequalities; in Africa 2007/08.

			Kenya	Namibia	Ethiopia	Rwanda	Mozambique	Senegal	Tanzania	South Africa	Benin	Botswana	Ghana	Uganda	Cote d'Ivoire
Overall ICT inequalities	Internet use	**Men**	**21.1**	**11.2**	**0.9**	1.8	**1.1**	**14.4**	1.9	**20.2**	**11.9**	**8.1**	**7.9**	**10.1**	**3.7**
		Women	11.5	7.2	0.4	**2.1**	0.9	6.7	**2.3**	11.3	5.3	4.0	3.2	4.0	1.1
	Mobile use	**Men**	**56.0**	**53.3**	**3.7**	**11.8**	21.9	**55.1**	**26.2**	56.3	**37.9**	**42.5**	**60.7**	**59.4**	**26.3**
		Women	46.9	45.4	2.5	7.5	**32.4**	26.2	17.6	**64.9**	20.5	37.9	57.2	58.9	12.2
Real world inequalities	Literate	**Men**	**77.2**	56.2	**33.5**	**47.1**	**38.9**	**33.4**	**72.5**	**75.9**	**42.0**	**45.1**	**49.1**	**77.5**	**49.9**
		Women	68.0	**58.5**	26.5	40.0	23.5	19.9	67.7	74.4	21.2	38.0	39.8	72.5	25.2
	Actively working/ student	**Men**	**81.4**	**58.3**	**93.0**	**79.4**	**86.6**	**84.4**	**77.5**	**66.4**	**94.0**	**86.7**	**89.0**	**64.8**	**87.5**
		Women	49.8	42.5	32.3	62.8	35.8	53.6	53.9	38.5	49.7	51.6	80.7	43.4	47.0
	Top 25% income	**Men**	**29.8**	**34.2**	**50.1**	**30.5**	**27.2**	**44.4**	**39.2**	**37.0**	**38.3**	**32.6**	**31.3**	**34.5**	**32.2**
		Women	16.6	17.9	10.7	21.0	15.2	9.3	20.9	17.4	14.5	9.0	19.0	21.1	10.6
	Equal footing	**Men**	**25.3**	**21.4**	**13.9**	**16.5**	**13.8**	**18.1**	**25.1**	**28.5**	**18.1**	**14.8**	**15.0**	**31.1**	**21.7**
		Women	13.6	12.2	4.4	8.0	2.7	3.0	10.5	12.8	3.8	3.9	8.1	17.8	6.3
Man and women on equal footing	Internet use	Men	**29.7**	26.9	3.8	6.2	2.8	31.0	4.0	**39.9**	**27.6**	**23.9**	**26.7**	**23.9**	**13.5**
		Women	**29.7**	**37.8**	**6.3**	**7.6**	**14.2**	**37.4**	**12.6**	37.9	26.9	17.5	11.7	17.5	7.4
	Mobile phone	Men	90.0	90.3	18.7	39.9	57.7	**91.1**	**56.4**	89.9	86.9	84.4	82.3	84.4	62.6
		Women	**92.7**	**93.1**	**34.3**	**43.4**	**92.5**	87.9	47.8	**94.8**	**95.9**	**94.9**	**94.7**	**94.9**	**71.4**

Source: own elaboration, based on Research ICT Africa, 2008.

How do men and women use the Internet

As seen during the literature review, studies from developed countries reported that men and women use the Internet for different ends, which can lead to diverse definition of the digital divide. Let us now take a look at the kind of online services used in Latin America. This is of particular interest because we have already seen that women welcome the use of digital tools; therefore, the kinds of services they use might give us hints about possible digital opportunities for women (Table). The first row confirms the previously

mentioned finding from developed countries that men seem to be more frequent online users than women. This accounts for Chile, Uruguay, Costa Rica, Dominican Republic and Nicaragua, while in Mexico and Honduras more women tend to be online every day. When evaluating these statistics, we have to remember that usage frequency does not tell us anything about the length of each session. Longer sessions could by far offset lower frequency. Unfortunately the available statistics do not give us insight into the overall intensity of usage.

When asked about the kinds of services used online, men reveal that they are much more enthusiastic about using the Internet for entertainment reasons than women. When it comes to using digital channels for education and training, the data is clear that women tend to make much better use of the existing opportunities than men. This is especially encouraging when considering the previously presented results of female disadvantages in terms of literacy and educational attendance throughout the developing world (see Tables). It shows that women already started to make use of the digital opportunities to fight those existing inequalities.

Table also shows that women still do not yet fully exploit many of the other opportunities the digital world provides for them. Women are less enthusiastic about applications of e-business and e-government. The use of e-business and online banking channels could provide women with important steps to improve their financial independence, while e-government services facilitate necessary, but often burdensome interactions with public authorities. The use of the Internet for plain communication purposes provides a mixed picture, as do the statistics on health services. Women from Mexico and Dominican Republic are already using online networks to improve the health

conditions for themselves and those close to them. Overall, there still seems to be a large potential to take advantage (or maybe create) adequate online content to improve living conditions for women in Latin America.

Table 9 Frequency of Internet usage; online service used by men and women in Latin America.

			Chile 2006	Brazil 2005	Uruguay 2006	Mexico 2007	Paraguay 2007	El Salvador 2006	Costa Rica 2005	Dominican Rep. 2005	Panama 2007	Honduras 2007	Nicaragua 2006
Internet users that use daily		Men	**39.5**	n.a.	**25.2**	34.3	n.a.	n.a.	**35.8**	**36.7**	n.a.	33.8	**35.6**
		Women	34.3	n.a.	22.6	**34.5**	n.a.	n.a.	33.1	30.1	n.a.	**34.2**	29.0
Given that the person uses the Internet	Entertainment	**Men**	**54.7**	**74.1**	**49.5**	**19.9**	**11.0**	**5.7**	**51.5**	**60.7**	**4.9**	**41.7**	**61.8**
		Women	50.5	67.2	34.5	14.2	4.9	1.9	43.2	51.1	1.9	32.8	56.1
	Education and training	Men	12.1	68.4	41.4	41.5	39.7	53.7	58.5	67.6	1.3	60.9	58.7
		Women	**12.4**	**75.0**	**46.5**	**44.9**	**49.3**	**65.0**	**66.8**	**72.5**	**1.8**	**63.0**	**62.3**
	Buying and contracting	**Men**	**7.3**	**16.5**	**5.8**	**7.2**	**2.3**	**3.7**	**9.9**	**10.7**	**1.4**	**5.0**	**3.5**
		Women	5.5	10.8	2.6	3.3	1.2	2.5	5.7	5.7	1.2	3.3	2.2
	Online banking	**Men**	**7.1**	**21.7**	**4.6**	**2.4**	n.a.	**2.2**	**21.8**	**14.8**	0.8	n.a.	**5.3**
		Women	5.6	16.4	3.0	1.2	n.a.	**2.2**	17.3	11.4	**0.9**	n.a.	4.3
	Government interaction	**Men**	**9.9**	**29.4**	n.a.	**3.4**	n.a.	**0.7**	n.a.	**13.2**	**0.5**	n.a.	n.a.
		Women	8.9	25.5	n.a.	2.3	n.a.	0.01	n.a.	9.2	0.2	n.a.	n.a.
	Communication	Men	58.8	**68.8**	79.0	48.4	51.8	**18.1**	73.5	**63.1**	17.9	69.6	**77.8**
		Women	**60.2**	68.5	**81.1**	**49.5**	**55.7**	13.9	**74.3**	55.0	**18.4**	**71.5**	77.6
	Health	Men	n.a.	n.a.	n.a.	6.3	**1.8**	**1.8**	n.a.	18.7	n.a.	n.a.	n.a.
		Women	n.a.	n.a.	n.a.	**8.9**	0.9	1.5	n.a.	**25.1**	n.a.	n.a.	n.a.

Source: own elaboration, based on OSILAC, 2009.

A word of caution on the presented statistics

The humorist Mark Twain (1835-1910) has popularized the wisdom that "there are three kinds of lies: lies, damned lies, and statistics". This does not only apply to the statistical practices of not controlling for confounding variables, such as criticized in this

article, but a word of caution is also in order when interpreting the statistics in the presented Tables.

Given the large sample sizes of the weighted household samples, all results turn out to be statistically significant. However, all results are based on stratified samples, meaning that the survey organizers took the sample according to their knowledge about how the population is distributed in a particular country. Once collected, stratified samples are weighted according to the proportions of the actual society. The answers of one survey correspondent from a more common socio-demographic group might be multiplied with a factor much larger than a person from a minority. This weighting turns a small sample into the representative of a large population. Nevertheless, it also affects significance tests. The theory of significance test is based on random sampling, not on stratified samples that are subsequently expanded. If the weighted number of cases exceeds the sample size, tests of significance tend to be inflated, which is our case. Therefore, even though all our results are statistically significant, meaning that it is very probable that the observed differences between men and women are real and not just due to chance, these tests are inflated.

As a consequence, results that are very close (such as 49.5% to 50.5% or a correlation of 0.008), have to be taken with a large grain of salt, as pure luck of sample drawing might play us a trick here. Given the much smaller sample size in Africa than in Latin America, the Latin American results are more reliable and stable than the African surveys (in the Latin American samples each observation was weighted with hundreds of people on average, while in Africa, factors of thousands were applied). Having said this, differences for one country on the decimal level surely would not make a strong case by

itself. However, the consistency of our results across a large number of very heterogeneous societies makes a relatively strong case: even though some results are close and might be influenced by chance, they tend to show the same direction in general. In other words, the presented results should be interpreted as a mutually confirming whole, while specific results for particular countries might be subject to small variations. Particularly close results from one specific country should not be used as a standalone argument and might require more detailed sampling and further analysis.

A small change in mindset can sometimes make a large difference

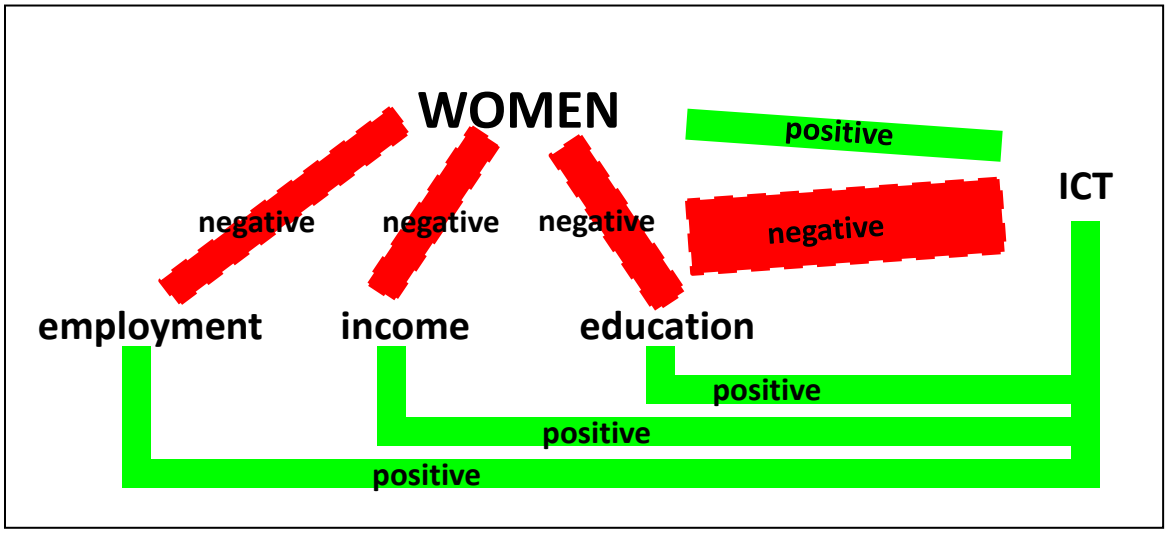
We have analyzed a very heterogeneous group of 25 countries, representing different levels of development, geography, culture and social structure. According to the United Nations Human Development Index (UNDP, 2008), Chile is the most developed country of our sample, reaching a rank 40 of the 179 countries included in the 2008 Index. Mozambique is the least developed with a rank of 175. Independent from these differences, our results have been surprisingly consistent: ICT per se does not have anything on them that might keep women and girls from using it in developing countries. In fact, when controlled for existing inequalities, it shows that women embrace digital technology more enthusiastically than men. One might be tempted to speculate that women are simply better communicators and that therefore the use of these technologies seems more intuitive for women than for men. Unfortunately, the presented data do not tell us why women use ICT more than men; they just tell us that this is the case.

Notwithstanding, women continue to be discriminated in many other aspects of social life, including employment, literacy and income. These inequalities also throw

their shadows on ICT usage. More specifically, being a woman is positively correlated with ICT usage, and negatively correlated with employment, income and education (see Tables). Uncontrolled correlations mix both effects, resulting in the fact that underemployed, underpaid and undereducated women use ICT less than men. Traditional discrimination in the fields of employment, income and education turn the positive correlation between women and ICT into a negative one. At the same time, as shown during the literature review, ICT have the potential to provide access to employment, education and income. Therefore, ICT provide women with a bootstrapping opportunity to pull themselves out of these unfavorable starting conditions. In other words, if woman are provided with ICT, digital tools represent an opportunity for women to fight longstanding inequalities.

The resulting logic is schematized in Figure. Traditionally, longstanding inequalities prevent women from accessing ICT, leading to a vicious circle between digital exclusion, unemployment, low income and lacking education. However, once having access to ICT, this vicious circle can be turned into a virtuous circle, whereas the identified positive attitudes of women toward ICT enable them to circumvent and fight existing inequalities.

Figure 11 Fighting longstanding discrimination with digital means



Source: author's own elaboration.

This finding is by no means the end, but leads to the question of how to provide more women with access to digital opportunities. For example, Table indicates that communal or commercial public access centers might be a viable option (see also Maeso and Hilbert, 2006). Others have pointed to the need of regulations and incentives to facilitate the actual usage of applications that would favor women, such as legislation to promote telework (see e.g. Boiarov, 2008). Besides, the development of adequate content becomes a major concern, especially in key areas such as education (see e.g. RELPE, 2008).

Summing up, the empirical evidence in this article argues for a re-thinking about women and ICT usage. This rethinking should also affect policy making, which is unfortunately still influenced by the superficial and unsustainable argument that women are technophobic. For example, in the final declarations of the United Nations World

Summit on the Information Society (2003-2005), heads of States and governments have recognized "that a gender divide exists as part of the digital divide in society" (WSIS, 2005) and declared a need for "enhancing communication and media literacy for women with a view to building the capacity of girls and women to understand and to develop ICT content" (WSIS, 2003). These statements seem to be based on the idea that women are less digitally capable. Based on the results here presented, this is not at all the case and a change in mindset seems appropriate. These policy statements should rather be reformulated to something along the following lines: "*a digital gender divide exists only as a direct reflection of existing gender-related inequalities and policy actions should make use of the natural communication skills and media capacities of women and their proven embrace of the new digital opportunities to overcome longstanding gender inequalities*". Such re-thinking is necessary to create policies and projects that truly allow girls and women to become equal members of an information society, digital society, network society, knowledge society, or simply equal members of society, independent from the forename it may be given.

Chapter Three: Magnitude and Growth of the Transition

Studies about digital social transformations, such as the ones from the previous Chapter, traditionally use proxies to measure the advancement of the ongoing digitization of information and communication processes in society, such as a headcount of the installed technological devices, or the amount of financial investments into these technologies. As with all proxies, the conclusions that can be drawn from these indicators are flawed, and, as it turns out, in the case of the transition toward information societies, these flaws can be severe. This Chapter presents a methodology to quantify the amount of information and communication in bits, therefore directly measuring the magnitude and growth of information in information societies. I applied this methodology by measuring the world's technological capacity to store, communicate, and compute information. This line of inquiry started with an application of this idea to a selected group of countries, with a selected list of technologies, studying their diverging informational capacities. A follow-up study was much more comprehensive and complete, and covered more than 60 technologies, for more than 20 years for the entire world.

Information Societies or "ICT Equipment Societies"? Measuring the Digital Information Processing Capacity of a Society in Bits and Bytes[54,55]

The digital divide is conventionally measured in terms of ICT equipment diffusion, which comes down to counting the number of computers or phones, among others. This article fine-tunes these approximations by estimating the amount of digital information that is stored, communicated and computed by these devices. The installed stock of ICT equipment in the consumer segment is multiplied with its corresponding technological performance, resulting in the "installed technological capacity" for storage (in bits), bandwidth (in bits per second) and computational power (in computations per second). This leads to new insights. Despite the rapidly decreasing digital equipment divide, there is an increasing gap in terms of information processing capacity. It is shown that in 1996 the average inhabitant of the industrialized countries of the OECD had a capacity of 49 kibps more than its counterpart from Latin America and the Caribbean. Ten years later, this gap widened to 577 kibps per inhabitant. This innovative approach towards the quantification of the digital divide leads to numerous new challenges for the research agenda.

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The far-reaching and profound impact of the digitization of information and communication processes has long been noted (e.g. Wiener, 1948; Machlup, 1962; Bell, 1973). It is widely recognized that the advancement of digital information and communication technologies (ICT) has led to a new mode of development (e.g. Perez, 1983; Freeman and Louça, 2001). With the arrival of digital systems, the storage, communication and computation of information became the omnipresent core of social and political activity, and of economic and cultural production (e.g. Webster, 1995; Castells, 1996). This has put the question of how to track and measure the diffusion and eventual impacts of these new technologies on the centre stage.

This article is a contribution to this discussion. We propose to improve the measure of traditional ICT access indicators by adjusting existing ICT equipment statistics with the corresponding quality of their performance. The stock of available technologies is multiplied with their corresponding performance measures. The result is three new aggregate indicators which represent the "installed information processing capacity": (1) how much information can be stored (in bits), (2) communicated (in bits per second), and (3) computed (in computations per second). This improvement contributes not only to the sustainability of the traditional ICT indicators (new ICT equipments emerge faster than indicators ever can), but it also consolidates the array of currently available indicators, merging them into three straightforward measures.

Multiple dimensions of technology diffusion

As with previous innovations, the nature of the ICT diffusion process is characterized by a well-known S-curve from centre-periphery, wherein the centre can be

depicted as being more developed and the periphery as underdeveloped (Rogers, 1962). As a result, technological revolutions create a divide between those who benefit from it first and those reached by it later on. In the case of ICT diffusion patterns, the term "digital divide" was coined to describe the reality where some can access and use digital tools, while others are excluded from the ensuing opportunities (NTIA, 1995-2000; ITU, 1999; UNDP, 2001 ITU, 2009).

The increasing importance of ICT in the socio-economic development has lead to a broad variety of proposals on how to adequately measure this process of diffusion, and thereby, how to conceptualize the digital divide. The most straightforward measures focus on a specific technological solution as a proxy of the vast bulk of digital technologies (such as Internet access or telephones) and compare the amount of equipment or services in different societies (international digital divide) or within different social segments of one society (domestic digital divide). More complex measures distinguish between three consecutive steps in the adoption of the technology: ICT access, use and impact (OECD, 2002). Even though there might be a positive relation between the amount of ICT equipment, its usage and its impact, one of them does not automatically imply the next. The determinants of the divide can be assessed in each stage of the adoption process and with regards to all of the diverse existing technologies, or their combination.

For example, on the access level it has been shown that the same long established determinants of socio-economic inequality also define the digital divide, including income, education, geography, age, gender, and ethnicity, among others (e.g. Cullen, 2001; Norris, 2001; Hilbert and Katz, 2003). Moving on to the usage stage of technology

adoption, the importance of computer skills and motivations has been emphasized (e.g. van Dijk and Hacker, 2003; Mossberger, et.al., 2003; Shelly, et.al., 2004). The final impact of the technology will ultimately be influenced by the purposeful application of the installed equipment, often requiring the readjustment of the general *modus-operandi* of the cultural and institutional setting, which leads to a complex dynamic of social change (e.g. Warschauer, 2003; van Dijk, 2006). Depending on the definition and the scope of the exercise, the results can be contradictory. Most typically, research that focuses on the access dimension (diffusion of technological equipment) argues in favour of a rapidly closing digital divide (e.g. Compaine, 2001; Howard, et.al, 2009), while research focusing on skill-related usage and impact indicators claims that the divide is still deepening (e.g. van Dijk, 2005; James, 2008).

In an attempt to create a coherent picture, various compound measures have been created, so-called e-Readiness indexes, such as the ICT Development Index (ITU, 2009). They integrate a number of variables into a single index (access indicators and others, such as skills). The weight of each component of the index, as well as the chosen statistics, differs among indices (see Barzilai-Nahon, 2006; Vehovar, 2006; Hanafizadeh, 2009). Minges (2005), who has personally designed some of these indices at the leading United Nations agency ITU, has evaluated twelve of them[56] and reconfirmed the predictable conclusion that—besides problems of transparency, data reliability and subjectivity—the weight of each ingredient predetermines the result to a large extent.

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[56] These include the twelve most widespread indices on a global level: Composite index of technological capabilities across countries (ArCo); Digital Access Index (DAI); Digital Opportunity Index (DOI); Economist Intelligence Unit (EIU) e-readiness; Index of Knowledge Societies (IKS); Knowledge Economy Index (KEI); Network Readiness Index (NRI); Orbicom Digital Divide Index; Technology Achievement Index (TAI); UNCTAD Index of ICT Diffusion; UN PAN E-Readiness Index; World Bank ICT Index.

This leads to the well-known problem of subjectivity in the creation of any kind of index and therefore does not solve the problem of adequately measuring the divide, but rather passes the buck on to the methodological level.

In short, the digital divide is one of the rare types of concept that flexibly adapts to the meaning that the analyst decides to give it. This can lead to much confusion, or, at least, to tedious semantic quarrels. Despite all differences, there is one feature that all of these studies and indexes have in common: the inclusion of the access dimension, such as the diffusion of telephony, computers and Internet, among others (mostly those harmonized by ITU, 2007). Access might not be sufficient, but it is a necessary first step. Without neglecting that the discussion of the digital divide can become much more complex, we will focus on improving the measurement of this indispensable dimension. At a later stage, the proposed measurement of ICT access could easily be integrated into more complex modular methodologies and indexes that—additionally to access measurements— might also include computer skills and cultural considerations, among others. In the meantime, we will limit our focus to the improvement of ICT access measures.

The article starts by reviewing the traditional measure of ICT access, which is usually done by counting the number of existing devices. We then propose an analytical framework for tackling the task of measuring the installed information processing capacity of a society, defined as the capacity to store, communicate and compute information with digital tools. This new framework is applied to one concrete example. We decided to compare the private consumer segment of the industrialized OECD (Organisation for Economic Co-operation and Development) with the one in Latin

America and the Caribbean (LAC), as representatives for developed and developing countries on both sides of the international digital divide. While the scope of this article only allows for one concrete example, it is important to underline that the chosen example is just one case out of many that could have been chosen. It represents the international digital divide (neglecting domestic differences among population segments), and—in agreement with the conventional thinking on the digital divide—the analysis is restricted to the private consumer segment (this is mainly due to the lack of coherent statistics beyond households at the time of writing). The selection of this particular example should not prevent future studies from applying the general framework of this article to analyse the domestic digital divide and to assess the "installed information processing capacity" of enterprises, public or private organizations or government agencies. The final section takes up the underlying methodological discussion, which is again independent from the concrete example that has been discussed before. The resulting differences between the traditional approach and the proposed approach are discussed, as well as the limitations and remaining challenges on the research agenda.

The closing digital equipment divide

After analyzing patterns of ICT equipment diffusion, some policy-related reports come to the delicate conclusion that the access dimension of the digital divide is closing rapidly and that underserved sections of the population are in an unprecedented process of catching-up (e.g. Compaine, 2001; ITU, 2006; UNCTAD, 2006; WEF-INSEAD, 2006; ITU and UNCTAD, 2007; Howard, et.al, 2009). In particular, it is argued that the divide diminishes rapidly as the markets in the developed countries get increasingly saturated.

Table shows that ICT equipment penetration rates in the 30 industrialized countries of the OECD (1 184 million inhabitants in 2006[57]) are relatively high. The numbers in Table also show that growth rates have been much higher in the 37 developing countries of Latin America and the Caribbean (LAC) (456 million inhabitants[58]). In accordance with these indicators, the theory of the diffusion of innovation, and the previously cited research, it can be expected that the typical S-shaped diffusion curve is starting to diminish in the more developed countries, while LAC seem to be on the upward slope of the S-curve. There seems to be an upper limit on the amount of equipment an individual possesses, even if one person can posses several devices of the same sort. The table shows that while in 1996 OECD countries had 8.1 times more mobile phones per hundred inhabitants than LAC countries, in 2006 the gap was reduced to a multiplication factor of 1.6. With regard to Internet users, the catching-up has even been more impressive, reducing the ratio between both groups of countries from 18.5 to 3.0 in ten years. Thus, analyses on the basis of these indicators seem to suggest convergence with a rapidly disappearing inequality in access to digital information.

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[57] Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary (starting 1996), Iceland, Ireland, Italy, Japan, Korea (Rep.) (1996), Luxemburg, Mexico (joined OECD in 1994, and is therefore considered a OECD member for the ten year time frame considered in the graphs, and not as Latin America), Netherlands, New Zealand, Norway, Poland (1996), Portugal, Slovak Republic (2000), Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

[58] Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Rep., Ecuador, El Salvador, French Guiana, Grenada, Guatemala, Guadeloupe, Guyana, Haiti, Honduras, Jamaica, Martinique, Neth. Antilles, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname, Trinidad y Tobago, Uruguay, Venezuela.

Table 10 ICT equipment diffusion per 100 inhabitants in OECD and Latin America and the Caribbean, 1996-2006

Technology per 100 inhabitants		**1996**	**2006**
Fixed phones	OECD	46.5	46.8
	LAC	9.8	17.2
	ratio OECD/LAC	**4.7**	**2.7**
Mobile phones	OECD	11.0	86.6
	LAC	1.4	54.7
	ratio OECD/LAC	**8.1**	**1.6**
Personal Computers	OECD	18.5	56.6
	LAC	3.0	16.7
	ratio OECD/LAC	**6.2**	**3.4**
Internet users	OECD	3.7	23.4
	LAC	0.2	7.8
	ratio OECD/LAC	**18.5**	**3.0**
Broad band subscribers (2000-2006)	OECD	3.0	16.8
	LAC	0.1	2.3
	ratio OECD/LAC	**30.0**	**7.3**

Source: ITU, World Telecommunications Database, 2007.

A resulting, but premature, policy conclusion of this analysis could be that public policies, such as market regulation and public access incentive programs, would be less and less necessary to close the access dimension of the gap. This seems to be emphasized by the success story of mobile telephony, which is the consumer technology with the fastest technological diffusion record in history. Competitive markets seem to take telecommunications networks and related hardware and software solutions to everybody around the globe, such as regularly pointed out by industry representatives (GSM Association, 2006; Frost and Sullivan, 2006).

Such conclusions are based on the simple accounting of equipment to assess the situation of access to the digital realm. One of the main limitations of the traditional equipment analysis is that technological progress is not considered. There are qualitative

differences in access. These differences vary with the calendar year under consideration and also the user segment. The importance is easy to see. For example, Internet users with a 56 kbps modem connection are not able to access the multimedia content broadband users are benefiting from. However, in a simplistic count, both would be considered as generic "Internet user" (see Table). The same applies to other ICT and also holds for difference within one society. One hard disk from 1995 is not equal one hard disk from 2005. Older equipment is much less powerful. Besides technological progress in time, there are also differences in performance of different technological gear in the same year[59]. While most mobile phones that are bought by the poor enable short-message-services (SMS) through a 14 kbps data communication, third and fourth generation mobile phones provide wealthy members of the Information Society with mobile videoconferencing capabilities of several hundred kbps. Even if both, rich and poor, would have the same quantity of equipment (by equipment headcount), their real "access to digital information" might be very unequal. The currently available statistics (such as shown in Table) do not show this difference.

This problem is recognized by recent literature, for example through the emphasis in broadband connectivity (for example NTIA, 2002-2004). The current solution is to simply add additional indicators (such as broadband), which cannot easily be compared with the previous indicator of dial-up Internet. The resulting grab bag of indicators can be expected to become more confusing as ICT-convergence continues. The ongoing substitution between various services renders many traditional indicators quickly obsolete. Voice services can be transmitted with Voice-over-Internet-Protocol (VoIP)

[59] The relevant statistics for this consideration are often more difficult to obtain than performance adjustment according to year-related technological progress.

over the Internet and WebPages can be accessed through mobile phones. Actually, the traditional separation into the aforementioned technologies according to their hardware and functionality (and not according to capacity) is not really helpful for understanding and coping with the ongoing dynamics.

In order to obtain a deeper insight into current developments, we measure the total sum of technological information processing capacity of diverse technological solutions. There are two major benefits of considering the bits and bytes that can be processed by the different solutions. One, it enables the consideration of technological progress in the performance of the different generations of equipment. It therefore recognizes the digital divide as a constantly moving target. Two, it permits harmonization of substituting technologies on a common unit of measurement (if two service substitute each other, as per definition of substitution, they provide the same performance measure, for example bits per second, which are jointly aggregated to sum up to the installed capacity).

Three steps are necessary. One, ICT systems need to be classified according to their informational functionality. The following section identifies three distinct groups of basic information operations (communication, storage, computation). Two, adequate measurement units for each of the three identified technological subsystems need to be developed, which are discussed in the subsequent section. Three, the evolving performance of each technology needs to be estimated for various years and respectively multiplied with the available technological equipment. This will result in the installed information processing capacity of a society.

The three subsystems of information processing

ICT systems do not represent a single technology, but are the result of a combination of symbiotic technological trajectories that converge into one larger technological system. As already mentioned, some of them might be potential substitutes (e.g. fixed and mobile voice-communication) and others serve different ends (e.g. hard disks and telephones). To avoid such confusion let us return to a basic definition of what is technology. Technology has been defined as patterns of solutions that are based on selected principles derived from the natural sciences and are applied to confront a specific question or promise (Dosi, 1988). Following this definition, ICT answers three different questions: (1) how to store information in some deposit for later usage; (2) how to convert and compute some kind of information in a meaningful manner into another kind of information; and (3) how to transmit and communicate information from one place to another. In order to adequately reflect existing technologies, we further subdivide this last function and differentiate between "transmission", which we define as being unidirectional (only down-link, such as broadcast), and "communication", which we define to be bidirectional (up-link and down-link, such as telecommunication)[60].

The scope of the technological system that is often loosely referred to as digital technologies is defined by the use of the "bit". It is based on the idea of representing and manipulating information through its most basic code, the binary digit[61]. The binary codification and processing of information has not only improved and amplified the

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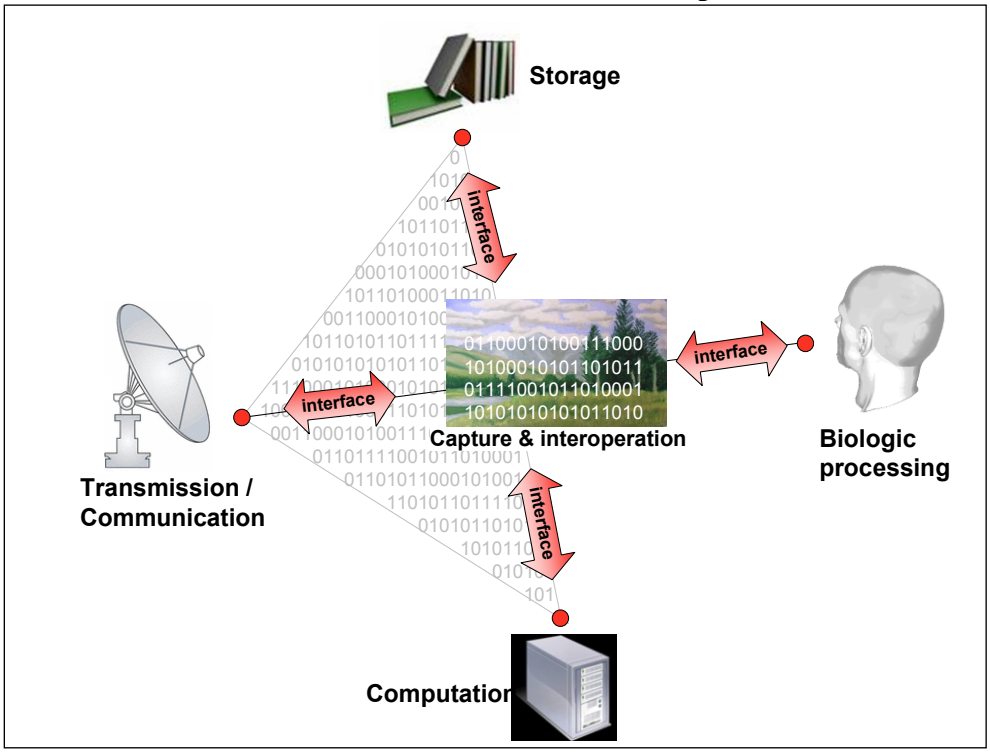
[60] For conceptual reasons the separation is justified, because communication is expected to have different socio-economic potential than mere transmission. For practical reasons this separation is necessary because, in terms of bit-rates, broadcasting technologies transmit a much larger amount of data.

[61] A common unit of storage is the byte, equal to 8 bits, that is, eight consecutive yes-no decisions resulting in a decision tree with $2^8 = 256$ possible combinations.

performance of each technological subsystem, it also meant that for the first time all three of them began to function according to a common logic: binary logic. This led to the integration of the three different technological subsystems into one system, a process colloquially referred to as ICT-convergence.

While the “frictionless” interconnection of storage, communication and computing devices has manifold advantages and leads to increased complementarities among the different tasks, the introduction of the bit has not changed the fact that each of the three operations has a distinct end. Figure depicts the basic schematization on the basis of which the following analysis is structured. ICT dynamics are the result of the interplay of all three technological subsystems, unified by the paradigm of the bit, which defines the scope of the technological system. Above and beyond the three technological information operations, the human brain is our indispensable recipient of, and contributor to, this dynamic process. We define the “information processing capacity” of an individual or a society as a construct comprised of these three informational operations.

Figure 12 Schematization of the three basic information processes



Source: own elaboration.

All three subsystems have experienced extraordinary growth rates in their performance development during recent decades (see Table). The Table shows, for example, that it would be deceiving to compare a hard disk from 1980 with another one from 2005. Actually, one hard disk in 2005 would be equal to 792 hard disks from 1995 and 750 000 from 1980. Sustained annual growth rates of 56-76% over 25 years are outstanding, which can be seen when compared to more common socio-economic rates of change (annual economic growth rates are traditionally between 3-4%). In a field of such

rapid change, it is essential to consider this constantly moving performance frontier in the measurement of the dynamics[62].

Table 11 Price decline and performance increase in the technological frontier of all three ICT subsystems, 1980-2005

Basic function/ representative of the technological frontier (US$ 2006)	**1980**	**1995**	**2005**	**Compound annual growth rate between 1980-2005**
Transmission telecommunication (kilobits / sec / US$)	0.0007 (Modem Apple II)	0.06 (US Robotics v.34 modems)	48 (WiMax)	56%
Storage (MB / US$)	0.0032 (hard disk 5MD HD)	3.03 (hard disk MC191AV)	2400 (hard disk 320GB, 7,200 rpm, 8MB)	72%
Computation (millions of computations / sec / US$)	7×10^3 (IBM4341)	1×10^8 (Dell Dimension XPS P133c)	1×10^{10} (Precision Workstation690)	76%

Source: own elaboration.

The amount of digital information

The amount of digital information that can be processed by the available technologies is calculated by multiplying the amount of equipment with its respective performance, i.e. with the amount of bits that each equipment can store, the amount of kbps it can communicate, and the amount of MCps is can compute. This approach is inspired by two groundbreaking studies done by the School of Information at the University of California, Berkeley in 2000 and 2003, that gauge the quantity of information that exists worldwide (Lyman, Varian and Swearingen, 2003). Working with proxies and assumption is unavoidable when working in this new field. Therefore we

[62] A second look on Table 2 reveals that the technological frontier in each subsystem has advanced at a different pace. It is interesting to note that the advancement of telecommunications, which is often celebrated as the epitome of the networked revolution, shows the slowest technological progress, when measured in terms of its price/performance relation.

have taken great care to be transparent with our estimations, enabling replication and improvements in the future. Our methodological details are presented in the Appendix.

The decision of the unit of measurement of information transmission and storage is straightforward: the BI-nary digi-T. The encoded bits represent information, which can reduce uncertainty with regard to a specified probability space[63]. From an engineering perspective, transmission and storage are conceptually similar: one transports information through space (bits per second through a transmission channel) and the other one transports information through time (bits on a storage device). Storage will be measured in bits and transmission in bits per second, or, to be more precise, in kbits and kibps (kibibit per second, equal to [2^10]=1024; while a kilobit per second remains be equal to [10^3]=1000).[64]

Computers also function according to binary logic (manipulating bits through Boolean logic gates). Unfortunately for us, the amounts of bits [1s and 0s] that are manipulated per second do not provide any interesting performance indicators. A computer with the universal design of a Turing machine consists of different information operations, such as reading from and writing on different storage devices and the speed of computation depends on the chosen architecture of the system. The diverse functionality of computers leads to a large variety of quantitative approaches to performance

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[63] The binary code is a kind of alphabet with only two letters that can represent all other kinds of alphabets. In the best of cases (in which a bit represents information entropy), one bit of information can reduce uncertainty by half (Shannon, 1948). Every bit represents information and has the potential to reduce uncertainty. In this technical definition of information, uncertainty and information are seen as opposites and the reduction of a possibility space by half is the most efficient way to communicate information.

[64] To solve the longstanding ambiguity regarding the units of kilobit in storage (one kilo being traditionally equal to 1024 bits) and communication technologies (one kilo being traditionally equal to 1000 bits), the latter can be measured in kibibit per second [Kibps] and mebibit per second [Mibps], which correspond to 1024 bits and 1024^2 bits per second, respectively.

measurement (Hennessy and Patterson, 2007). For pragmatic reasons, we refer to the historic data produced by Nordhaus (2006), which are mainly based on MacCallum (2003). The resulting index is called CPS (computations per second) and is oriented by the instructions per second a computer executes. In agreement with industry standards, it is calibrated on the computer Digital Equipment Corporation VAX 11/780 from the year 1978 and correlated to the millions of instructions per second that a computer can execute (MIPS) (see Appendix). The VAX 11/780 is considered to perform exactly 1 MIPS, which, as a rough guide, is 150 million times as powerful as manual computations[65].

It is important to remember that the number of bits does not consider the meaning or value of the information content. As the father of information theory, Claude Shannon (1948), points out: "Frequently the messages have meaning […but…] these semantic aspects of communication are irrelevant to the engineering problem" (p. 379). From an engineering perspective, a bit only gives a measure of how much uncertainty can potentially be reduced with regard to a known possibility space (such as the selection of a letter from an alphabet to construct words or the selection of a color to fill an image). It does not reveal anything about the 'meaning' or 'value' of the information in the message (in the sense that some words might be more important to the receiver than others). Currently, there is no universally accepted scientific measure to classify the 'meaningful value' of information. This is not tragic for our purposes, as we estimate the installed information processing capacity to transmit and store information, independently of a specific purpose. Going one step further, some might want to trust in the common assumption that individual users are rational and self-interested actors, and would assume

[65] Nordhaus (2006) defines that manual computation would imply that "you can add two five-digit numbers in 7 seconds and multiply two five-digit numbers in 80 seconds" (p. 11).

that they would utilize the provided technologies for ends that are useful and meaningful to their specific ends. This additional step, however, is independent from our basic exercise to estimate the available installed capacity in bits and bytes. Our estimations do not differentiate among the meanings of information contents (by the way, the same also holds for estimations that are based on equipment headcounts).

Having defined the measurement units, the two required statistics are the quantity of ICT equipment and their respective performance. The first statistic is mainly extracted from ITU's World ICT indicators Database (2007), which is the world's most complete historical administrative registry for ICT. It receives its inputs from national telecommunications and industry authorities. We estimated missing years and complemented these data with information from mainly private sector sources, including the assessments of the distribution of the various generations of the particular technologies, such as the distinction between the share of existing mobile standards (such as analogue, GSM, GPRS, CDMA2000, etc), the different television standards, and the distribution of various existing hard disks according to their diameter, among others (see Appendix). The historical performance of the various technologies has been gathered by industry and academic sources, such as detailed in the Appendix.

The fact that we use national statistics as a basis for our calculations conceals the fact that the digital information infrastructure is global in nature. If a user from one country uses a hard disk in another country over an Internet connection, this international outsourcing of informational capacity cannot be covered by our estimations. This lack of coverage is not too damaging in the case of our specific example that estimates the installed information processing capacity of the consumer segment. The amount of

international infrastructure sharing, such as cloud and grid computing, is minimum in the consumer segment. This would change, however, when applying the presented logic to the broader economy, including businesses, universities and research center. Super-computing facilities are often shared on the international level.

For reasons of simplicity and missing statistics, estimations focus on the installed capacity, not on its real usage. In other words, it is assumed that the installed technology would be running 24 hours for 365 days a year. As another general rule we decided that estimations adopt an "optimistic bias" in favor of developing countries. This means that in case of missing statistical information, it was assumed that the newly introduced equipment performs at the technological frontier. This surely leads to an overestimation of the installed capacity in all countries, as consumers might purchase older technology from earlier years. Assuming that the technology consumed in developed countries is generally closer to the technological frontier, this bias overestimates the installed capacity in developing countries and is therefore "optimistic" from a development perspective.

The result is summarized in Table. It is to be understood as an optimistic estimation of the worldwide installed capacity to communicate, transmit[60], store and compute information through digital systems. It shows that the personal capacity to compute and store information has clearly experienced the largest progress. This is in agreement with what we have already observed in Table, and is rather surprising[62], as the advancement of telecommunications is often celebrated as the epitome of the network revolution. The plain numbers of Table question this generally accepted notion. This conceptual concentration on communications – instead of computation or storage – is not only prevalent in academic writing, but also in the area of policy making. In most countries,

for example, the telecommunications authority is in charge of shaping the road toward the Information Society, and private and public authorities of computer engineering often do not even participate in policy agenda setting (for Latin America and the Caribbean see for example Guerra, et.al., 2008). The United Nations World Summit on the Information Society (2003-2005; e.g. Klein, 2004), as another example, has been organized by the International Telecommunications Union, and its audience and the discussed topics have been largely determined by this bias. Looking at Table, one can no longer say that technological progress in communication technologies is the defining characteristic of the Information Society. The table instead suggests that the storage of information in vast memories and its meaningful computation are the principal characteristics of the Information Society.

An interesting insight can be garnered by comparing the capacity of the different subsystems. For example, the table allows for the following thought experiment: if communication channels were running at full capacity and if every kind of communicated information was original and saved as soon as it was received, then every user could have filled the available per-capita storage capacity in roughly two weeks in 2006[66]. It shows, however, that under the same assumptions[67] in 1990, the available storage capacity would have been filled up completely in less than one and a half hours[68]. This shows how the

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[66] (299 951 493 kbits/inhabitant storage) divided by (224 kibps/inhabitant communication) = 1 339 069 seconds, which is 15.5 days.

[67] In reality, not all information is, of course, original, and neither is all received information saved on a hard disk right away. Therefore, the period between required erasures of memory are actually expected to be much longer.

[68] (56 438 kbits/inhabitant storage) divided by (12 kibps/inhabitant communication) = 4 703 seconds, which is 1.31 hours.

estimated global capacity to store information has increased much more remarkably than the global capacity to communicate.

Table 12 Worldwide installed capacity to compute, communicate and store digital information

	1980	1990	2000	2006	Compound annual growth rate between 1980 and 2006
Communication (telephony and Internet) **Kibps/inhabitant**	9	12	34	224	13.2%
Transmission (radio and TV) **Kibps/inhabitant**	2 653	4 403	7 230	8 143	4.4%
Computation (computers and mobile devices) **MCps/inhabitant**	0.0020	0.0958	63.15	957.74	65.4%
Storage (hard disks) **Kbits/inhabitant**	9 475	56 438	14 501 988	299 951 493	49.0%

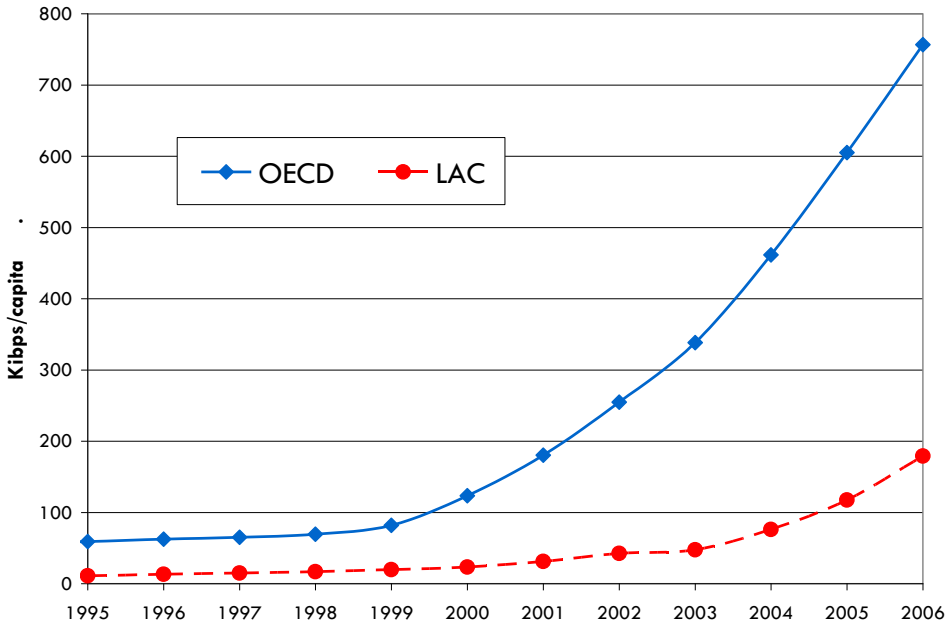
Source: own elaboration, based on various sources, see specifications in Appendix.

The digital divide as a moving target

The result of comparing the countries of the OECD with the countries of Latin America and the Caribbean is shown in Figures. Figure represents the digital divide of the capacity to communicate and exchange information through ICT, considering fixed lines and mobile telephony, as well as Internet (including broadband). It shows that in 1996 the average inhabitant of the OECD counted with a capacity of 49 kibps (equal to 49*1024 bits per second, see Appendix) more than its counterpart from LAC (62 kibps versus 13 kibps). Ten years later, this gap widened to 577 kibps (756 kibps as OECD average versus 179 kibps as LAC average). It is important to point out that this

development also represents a slight reduction of the digital divide in relative terms, given that the ratio between OECD/LAC lowered from 4.7 to 4.3 (reduction to 91% of original). However, this relative reduction is significantly smaller than the ratios presented in Table (which show ratio reductions between 16-57%). Furthermore, in contrast to the signs of saturation of the advanced OECD countries in ICT equipment diffusion (see Table), Figure does not show any significant signs of saturation. The amount of information that is communicated by the average member of the developed region of OECD continues to grow explosively.

Figure 13 Capacity to communicate through fixed line, mobile telephony and Internet

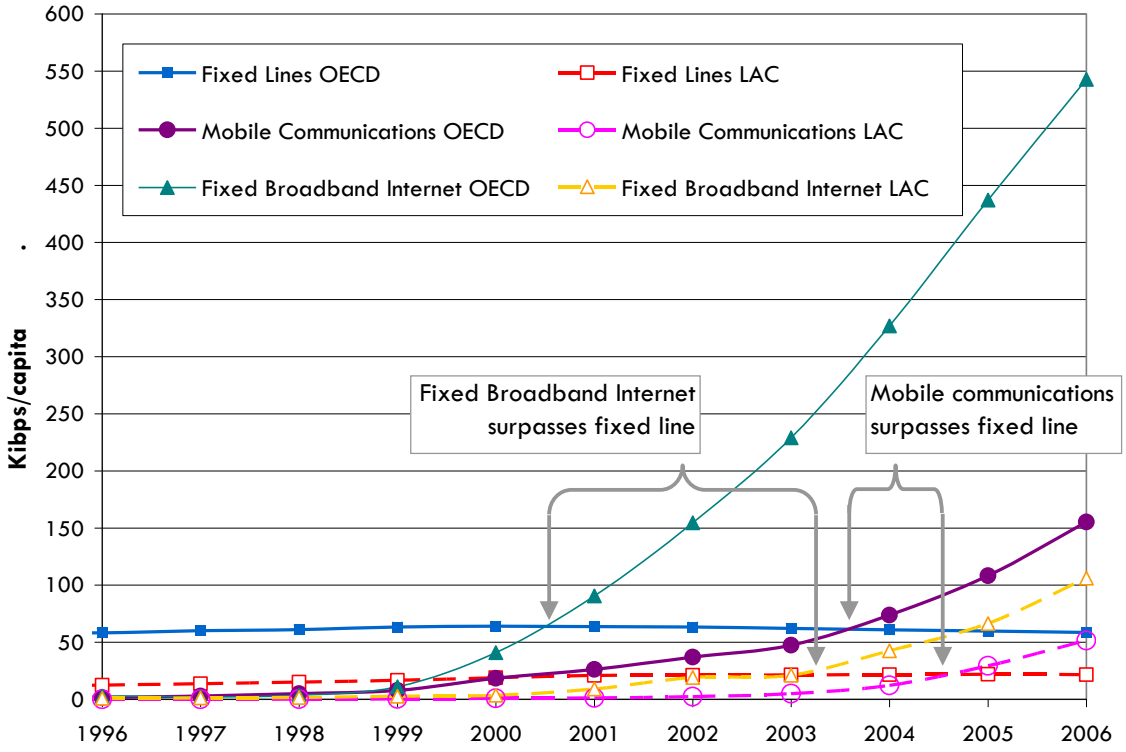


Source: own elaboration, based on various sources, see specifications in Appendix.

Figure takes a closer look at the reasons for this result. The bulk of installed communication capacity of a country is explained by fixed broadband Internet connections, especially DSL, cable modem and fixed-wireless, such as WiFi (representing 73% of the installed communication capacity in OECD and 61% in LAC in 2006). The capacity of the broadband Internet has surpassed the installed fixed line capacity (including fixed-line telephony or alternatively dial-up Internet) in the OECD in 2000 and in LAC in 2003. An interesting insight points to the importance of mobile telephony. In terms of equipment diffusion, the number of mobile phones equaled the number of fixed lines in 2001 in the OECD and in 2002 in LAC (ITU, 2007). However, this does not directly lead to a conclusion about the installed communication capacity through fixed or mobile networks. One needs to consider that 2G mobile communications (such as GSM and cdmaOne) provide a bandwidth of roughly 14 kibps, which only allows very limited data services, such as SMS messaging. A fixed line opens up a communication channel of up to 125 kibps, which can for example be used for dial-up Internet. Therefore, in terms of communication capacity, a 2G mobile phone channel is only a partial substitute for a fixed line in terms of data transmission rates. On the other hand, 2.5G or 3G mobile communications allow up to 350 kibps (such as WCDMA). As a result, the bulked communication capacity of mobile technology only surpassed fixed line communication with the introduction of advanced mobile data services, such as EDGE and CDMA2000. The breakeven point between fixed line and mobile communication was delayed for two years in both regions (2003 in OECD and 2004 in LAC). On the one hand, these cost-effective solutions also lead to the fact that mobile communication is increasingly becoming important in developing countries: in 2006,

mobile channels represented 28% of the communication capacity in LAC and only 19% in the OECD (partly due to lack of fixed lines in developing countries). On the other hand, while the number of mobile phones has started to slow down in the OECD during recent years (with 86.6% of the population having a mobile phone in 2006), the amount of information communicated through mobile networks in the OECD does not show any sign of deceleration. The introduction of multimedia 3G and 4G communication continues to push the capacity to communicate on the go, even though the number of devices might not grow as fast anymore. These findings demonstrate that the analysis of communication capacity can lead to different results and insights than the analysis of the quantity of equipment.

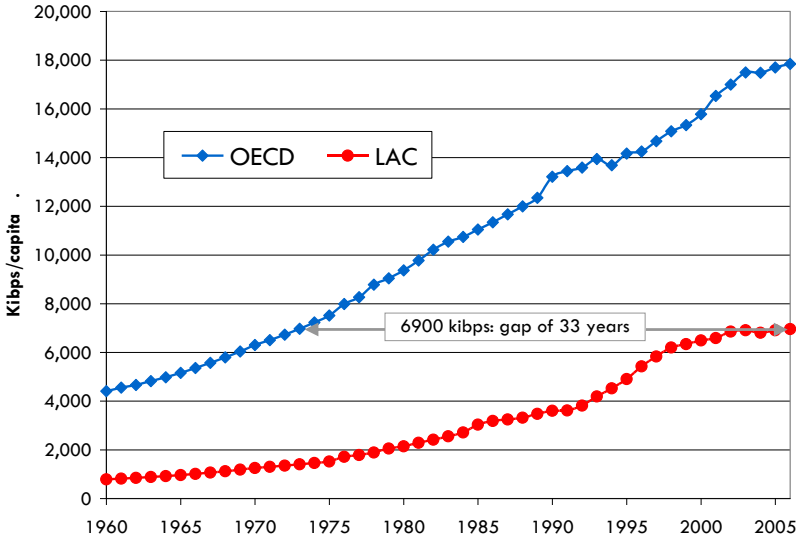
Figure 14 Capacity to communicate according to technology



Source: own elaboration, based on various sources, see specifications in Appendix.

Figure shows the capacity to transmit and disseminate information through one-way broadcasting channels, such as TV and radio. In 1996, the OECD had 8800 kibps more than LAC (14 200 kibps versus 5 400 kibps). In 2006, this gap widened to 10900 kibps (every OECD inhabitant on average had 17 800 kibps, versus 6900 kibps for every LAC inhabitant). The massive diffusion of satellite and cable-TV in developed countries is contributing to this widening of the gap. Actually, the data reveal that in 2006 around 62% of the OECD's broadcast capacity was installed in high-quality cable and satellite technology, while in LAC 71% was still transmitted through unreliable analogue terrestrial TV systems. While the data show a relatively stable OECD/LAC ratio in relative terms (around 2.6 throughout the decade), the absolute numbers disclose that the 6900 kibps/capita broadcast capacity of LAC in 2006 corresponds to the installed OECD capacity of the year 1973. In other words, in terms of installed broadcast capacity per-capita, LAC is 33 years behind the OECD. It can be expected that the introduction of digital TV will very soon introduce a new dynamic in both regions.

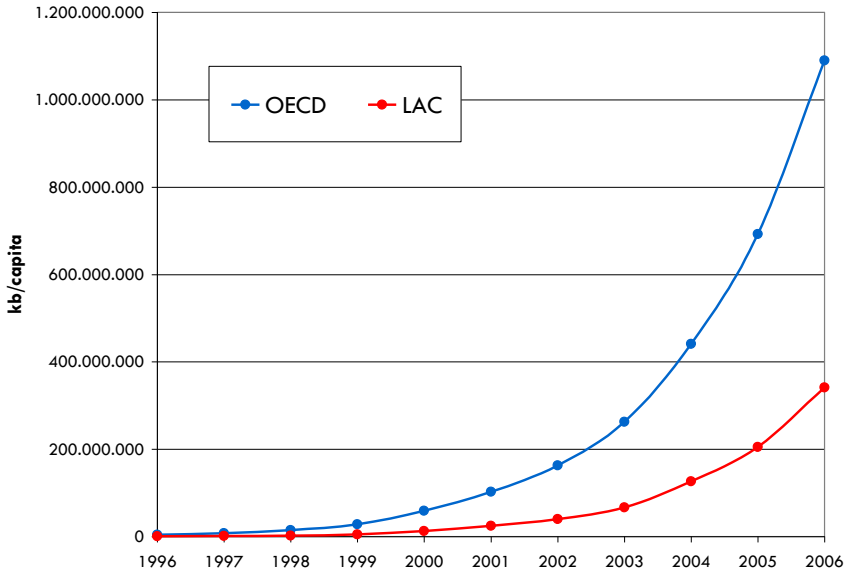
Figure 15 Capacity to transmit information through radio and TV (terrestrial, satellite, cable)



Source: own elaboration, based on various sources, see specifications in Appendix.

A similar situation accounts for the storage of information in computer hard disk drives (Figure). In 1996, an inhabitant of the OECD had on average 3 780 000 kilobits more storage capacity in hard drives of PCs and laptops than its LAC counterparts (4 552 000 vs. 772 000). Ten years later, the advantage of the OECD increased to almost 750 000 000 kilobits per capita (1 090 000 000 vs. 341 160 000).

Figure 16 Capacity to store information in hard disks of PCs and laptops



Source: own elaboration, based on various sources, see specifications in Appendix.

We have repeated this – and other – exercises with different methodological assumptions. For example, in agreement with Jorgenson and Vu (2005) we have estimated an economic utility lifetime of seven years for a computer and its hard disk (this estimate is based on economic depreciation rates) (see Appendix). Changing this assumption to five or three years (which might be close to the actual usage period of usage, not its complete economic depreciation), the results do not significantly affect the ratio between both regions[69]. It does, however, affect absolute storage capacity in both

[69] The gap increases roughly 200-fold regardless of the seven years assumption ([750000000]/[3780000]=198); five years assumption ([878000000]/[4345500]=202) or three years assumption of computer life-time ([1091000000]/[5560000]=196). We can conclude that changing the lifetime of hard disk drives does not significantly affect the final results in terms of the ratio between the differences of the storage capacity in OECD and Latin America, as those methodological changes affect both regions in a similar manner.

regions. In the case of reducing lifetime, the installed equipment is updated to the technological frontier more frequently, increasing the final storage capacity in 15-17 or 45-47 per cent with the five and three years assumptions, respectively. Methodological considerations surely can make a difference in the absolute numbers, but our tests and re-tests have shown that they do not change the general tendency and therefore the validity of the arguments that are presented here.

Figure shows the capacity to compute information. For computers (PCs and notebooks) we apply the same performance indicators to both regions. We include computers (including Mac and PC), laptops and mobile phones (which have started to possess considerable computing power). Regarding mobile phones, we use the available statistics of 2G, 2.5G and 3G communication services to estimate the computational power of mobile devices. As a result, we can see that in 1996 the OECD counted with 19 million computations per second per capita more than LAC, while in 2006 this gap widened to 2 520 MCPS/capita[70]. It is interesting to observe the increasing importance of computing capacity of mobile phones, which rely on a small processor. We estimate that the individual processing power of a computer or notebook in 2006 is 22 times larger than the computational power of a multi-service mobile phone (see Appendix). As a result, in 2006, mobile devices represent 3.5% of the installed computational power in the OECD and in LAC 2.3%. It is expected that the rapid diffusion of multimedia phones

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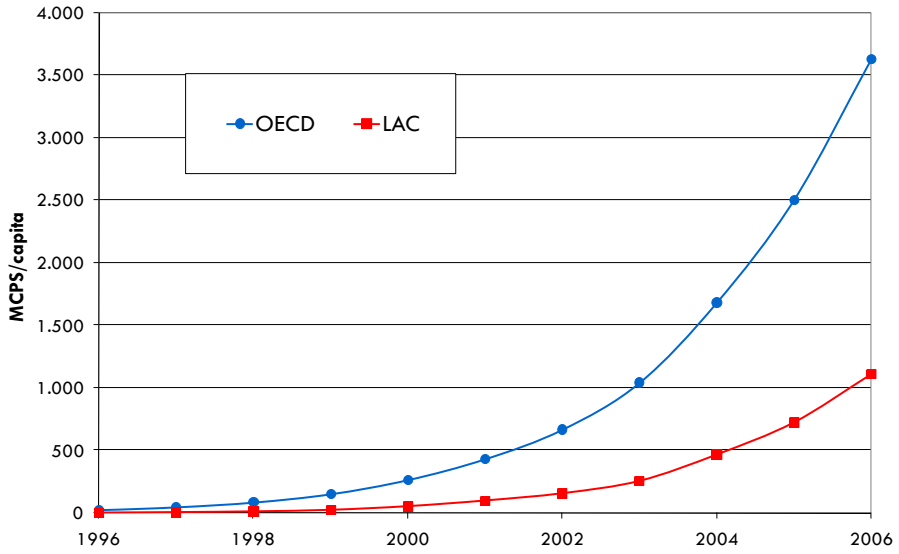
[70] Retesting these results with varying utility lifetime of computers, we observe something similar as already observed with storage. The total installed computing capacity increases in both regions between 10-20 when changing lifetime from seven to five years, and 20-40% with three years. Notwithstanding, the ratio between both region does not change too much: with the seven years supposition the gap increases over 130-fold [2520]/[19]=132.6, with five years [2920]/[22]=132.7 and with three years, it reduces to 115-fold [3456]/[30]=115.2.

will decisively increase the computational importance of mobile devices in the short-term future.

Figure 17 Capacity to compute information with PCs, notebooks, and mobile phones



Source: own elaboration, based on various sources, see specifications in Appendix.

Summing up, measuring the digital divide in terms of information processing capacity leads to different conclusions than comparing diffusion of ICT equipment. Contrary to the superficial conclusion of a rapidly closing digital divide in terms of plain access to the technology, the change in perspective presented here shows that the digital divide is a moving target. Increasing saturation of ICT equipments diffusion in developed markets does not imply a stagnation of increases in information processing capacity, due to the incessant creative destruction of technological innovation. The number of devices a

person can possess might be limited, but this does not give us insight into how much information a person can process with them.

Limitations and corresponding research challenges

This article proposes to measure digital development in terms of information processing capacity, not in terms of the mere number of installed equipment. The headcount of devices has long served as a rough proxy for the development of the Information Society. While it is a fact of socio-economic research that measurement efforts have to work with proxies most of the time, we need to take care that the usage of proxies does not disguise the nature of the analyzed phenomena, which can result in misleading policy conclusions. The simple exercise presented here shows that a refinement of indicators can tell a quite different story about the same observed phenomena. There is a difference in measuring the quantity of equipment in a society, we might call the result "ICT-equipment-societies", and measuring the amount of information that a society processes: "Information Societies".

With presented exercise as a starting point, we can see that a number of areas open up for research. The first set of issues focus on the limitations of the presented exercise and on potential refinements.

Access and real usage: In our estimations, we have assumed that ICT run 24 hours for 365 days a year. An important refinement would be to estimate the "actual usage" of these technologies in hours, not simply the installed and potentially usable capacity. Available statistics are the limiting factor, but can be found in local or national samples, such as time-budget studies.

Analogue ICT: In accordance with the conventional definition of the digital divide, we only consider digital ICT as access tools. In the Information Society, however, analogue technologies, such as books, newspapers, radio and analogue TV, VHS and music cassettes, among others, also play an important role. Presentation of all of these technologies in approximated bit rates would allow for the first time to quantitatively compare the capacity of "analogue" and "digital" solutions. Is most of the world's information already in digital format? If yes, when did it happen? What is the current ratio? Right now, nobody knows the answer to these questions. Nevertheless, this translation from analogue to digital is not straightforward. Analogue technologies do not work with bits and any translation would require a set of reasonable assumptions.

Aggregate measures disguise their underlying distribution: One of the main benefits of the approach presented in this article is that it reduces an array of traditional indicators to only three indicators, expressed in bits, bits per second and computations per second. In the presented exercise we have not focused on the nature of the distribution that leads to these aggregate values. For example, four 14 kbps 2G mobile phones reach the same amount of kbps as one 56 kbps modem connection (4*14 = 56). However, in the former case, lower capacity is distributed among four tools (and most probably four distinct users), and in the latter case it is concentrated in one tool. This leads to questions of equality: Is there a trade-off between having few with much resources (capacity) and having many with little? The total amount of bits per inhabitant does not tell us anything about its concentration. The inclusion of this aspect could lead to interesting insights into the effects of the concentration of information processing capacities. The installed information processing capacity of one particular Information Society might be built on

high-quality broadband connections for a few, while another Information Society with the same aggregate information processing capacity (*ceteris paribus*), might be constructed on the basis of low-quality mobile phones for everybody. What difference does it make? This leads to the analysis of the domestic digital divide. As already mentioned in the introduction, even though the presented example focuses on the international scenario, its underlying logic can easily be applied to the domestic setting.

ICT Functionality: A similar logic that looks for patterns disguised by aggregate statistics applies to the consideration of other determinants of functionality. Mobile solutions are different from fixed solutions, and storage devices come with all kinds of different storage latencies and throughputs (reading and writing speeds). A multi-dimensional definition of ICT functionality would certainly make any analysis more complex, but could enable deeper insights.

Type of content: The present analysis does not differentiate between the type of content, such as voice, text, images, videos, etc. The main restriction to this refinement is the availability of statistics about the nature of digital content. Consideration of the type of content would not only allow for an analysis of its relevance, but also estimation of the ultimate information entropy of installed systems (in Shannon's sense), since compression algorithms heavily depend on the type of content.

The second set of issues is conceptual and policy oriented in nature.

Moving target: If the Information Society is defined by its capacity to work with information, the digital access divide becomes an extremely rapidly moving target. From this perspective, it becomes clear that increasing pace of technological change will make it impossible to "close" the digital access divide in a uniform sense. Some will always

have more access than others and the approach presented in this paper points out to these qualitative differences. While qualitative difference will remain, the divide could be bridged nevertheless. This implies that every member of an Information Society could have sufficient resources to continuously maintain minimum connectivity to the public on the basis of equal entitlement. This is a constant challenge, and much depends on how the terms “sufficient” and “minimum” are defined.

Sustainable policies: Given that the digital access divide is a constantly moving target that widens informational abyss inside and between societies with every digital innovation, and given the importance of digital ICT for today’s socio-economic organization, appropriate policies will not cease to be part of the policy agenda. During the past decades, the private sector has led the deployment of infrastructure, in most cases under vigilant observation by regulators, such as the FCC, the European Commission and other national authorities in countries all over the world. The regulation of ICT infrastructure has become a complex subject by itself and even the fiercest market competition is often closely regulated. This task will continue as technological progress continues. The data presented in this article shows no sign of an innovation downturn. Users continue to strive for more and more information processing power all over the world. One of the resulting research questions is how to design policies that consider the fast innovation cycles, but are independently of a specific – and rapidly outdated – technological solution.

Is there an end? Even though there might be a limit to the number of devices a person can possess, is not evident that there is a limit to the number of bits an individual or a society can process. The human brain seems to have an upper limit for conscious

information processing, but when is it reached? And even when it is reached, the theory of biological evolution suggests that human intelligence is a flexible and expandable variable. While our grandparents could hardly imagine the amount of information we consume today on a daily basis, there seems to be no reason why our grandchildren would not shake their heads in amazement when looking back at our informational snail-systems.

From a methodological perspective, the conclusion is that it is necessary to go beyond simplistic approximations of ICT equipment penetration rates. This will also deepen our comprehension of the Information Society. This article presented an alternative perspective that will perhaps contribute to the elaboration of new approaches for this challenging undertaking.

The world's Technological Capacity to Store, Communicate and Compute Information[71,72]

We estimate the world's technological capacity to store, communicate, and compute information, tracking 60 analog and digital technologies during the period from 1986 to 2007. In 2007, humankind was able to store 295 x 10^{18} optimally compressed bytes, communicated almost 2 x 10^{21} bytes, and carry out 6.4 x 10^{18} instructions per second on general-purpose computers. Our sample of application-specific embedded computing power grew at a compound annual growth rate of 83 % over two decades and general-purpose computing capacity at 58 % annually. The world's capacity for bidirectional telecommunication grew at 28 % per year, closely followed by the increase in globally stored information (23 %). Humankind's capacity for unidirectional information diffusion through broadcasting channels has experienced comparatively modest annual growth (6 %). Telecommunication has been dominated by digital technologies since 1990 (99.9 % in digital format in 2007) and the majority of our technological memory has been in digital format since the early 2000s (94% digital in 2007).

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[71] This article has been published as Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. Science, 332(6025), 60 –65. doi:10.1126/science.1200970

[72] We would like to thank the Information Society Program of United Nations ECLAC (in Chile) for its support, Tom Coughlin, John McCallum, Don Franz, Miguel Gonzalez, Cristian Vasquez, Len Adleman, Manuel Castells and the statisticians from UPU (Universal Post Union) and ITU (International Telecommunications Union), as well as numerous colleagues who motivated us by doubting the feasibility of this undertaking.

Leading social scientists have recognized that we are living through an age in which "the generation of wealth, the exercise of power, and the creation of cultural codes came to depend on the technological capacity of societies and individuals, with information technologies as the core of this capacity" (Castells, 1998; 367). Despite this insight, most evaluations of society's technological capacity to handle information are based on either qualitative assessments or indirect approximations, such as the stock of installed devices or the economic value of related products and services.

Previous work

Some pioneering studies have taken a more direct approach to quantify the amount of information that society processes with its information and communication technologies (ICT). Following pioneering work in Japan (Ito, 1981), Pool (1983) estimated the growth trends of the "amount of words" transmitted by 17 major communications media in the United States from 1960 to 1977. This study was the first to show empirically the declining relevance of print media with respect to electronic media. In 1997, Lesk (1997) asked "how much information is there in the world?" and presented a brief outline on how to go about estimating the global information storage capacity. A group of researchers at the University of California, at Berkeley, took up the measurement challenge between 2000 and 2003 (Lyman and Varian, 2003). Their focus on "uniquely created" information resulted in the conclusion that "most of the total volume of new information flows is derived from the volume of voice telephone traffic, most of which is unique content" (97 %); as broadcasted television and most information storage mainly consists of duplicate information, these omnipresent categories

contributed relatively little. A storage company hired a private sector research firm (International Data Corporation, IDC) to estimate the global hardware capacity of digital ICT for the years 2007-2008 (Gantz, 2008). For digital storage, IDC estimates that in 2007 "all the empty or usable space on hard drives, tapes, CDs, DVDs, and memory (volatile and nonvolatile) in the market equaled 264 exabytes" (Gantz, 2008; 3). During 2008, an industry and university collaboration explicitly focused on information consumption (Bohn and Short, 2009), measured in hardware capacity, words, and hours. The results are highly reliant on media time-budget studies, which estimate how many hours people interact with a media device. The result obtained with this methodology was that computer games, TV and movies represent 99.2 % of the total amount of data "consumed".

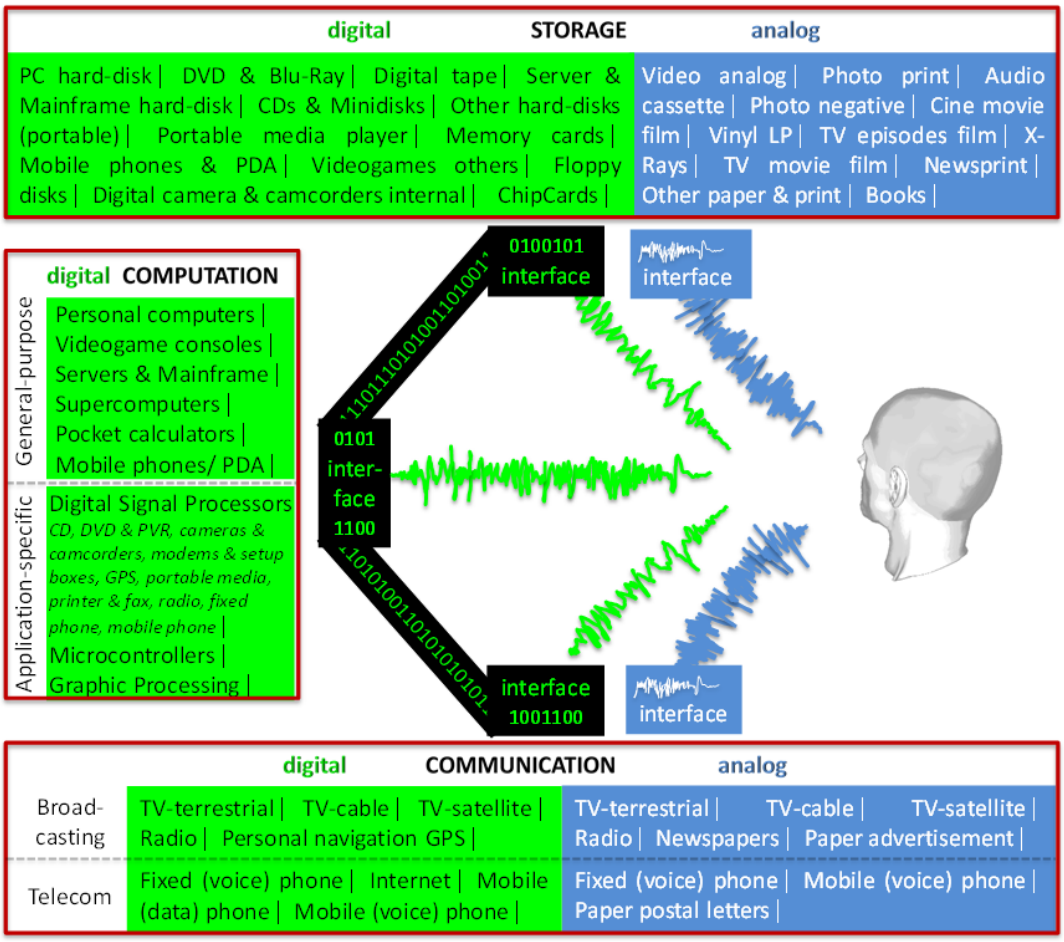
Scope of our exercise

To reconcile these different results, we focus on the world's technological capacity to handle information. We do not account for uniqueness of information, since it is very difficult to differentiate between truly new and merely recombined, duplicate information. Instead we assume that all information has some relevance for some individual. Aside from the traditional focus on the transmission through space (communication) and time (storage), we also consider the computation of information. We define storage as the *maintenance of information over a considerable amount of time* for explicit later retrieval and estimate the installed (available) capacity. We do not consider volatile storage in the respective inventory (such as RAM), since the ultimate end of volatile memory is computation, not storage per se. Communication is defined as

the amount of information that is *effectively received or sent by the user, while being transmitted over a considerable distance* (outside the local area). This includes those transmissions whose main purpose consists in the overcoming of distances, not the local sharing of information (such as the distribution of copies at a meeting, or communication through private local area networks). We take inventory of the effective communication capacity (the actual amount of bits transmitted). We define computation as the *meaningful transformation of information* and estimate the installed (available) capacity.

More precisely, as shown in Figure, we distinguish between: (a) storage of information in bits; (b1) unidirectional diffusion through broadcasting in bits per second; (b2) bidirectional telecommunication in bits per second; (c1) computation of information by general purpose computers in instructions per second (or MIPS); and (c2) we estimate the computational capacity of a selected sample of application-specific devices (MIPS). While previous studies tracked some two or three dozen categories of ICT over three consecutive years at most, our study encompasses worldwide estimates for 60 categories (21 analog and 39 digital) and spans over two decades (1986-2007).

Figure 18: The three basic information operations and its most prominent technologies.



We obtain the technological capacity by basically multiplying the number of installed technological devices with their respective performances. All estimates are yearly averages, but we adjust for the fact that the installed technological stock of a given year is the result of an accumulation process of previous years, whereas each year's technologies contribute with different performance rates. We used 1,120 sources and explain our assumptions in detail in Supporting Online Material (López and Hilbert, 2012). The statistics we rely on include databases from international organizations,

historical inventories from individuals for commercial or academic purposes, publicly available statistics from private research firms, as well as a myriad of sales and product specifications from equipment producers. We filled in occasional blanks with either linear or exponential interpolations, depending on the nature of the process in question. Frequently we compared diverse sources for the same phenomena and strove for reasonable middle grounds in case of contradictions. In cases where specific country data were not available, we aimed for a globally balanced outlook by creating at least two international profiles, one for the "developed" member countries of the Organisation for Economic Co-operation and Development (OECD), and another one for the rest of the world.

Information, not hardware with redundant data

While the estimation of the global hardware capacity for information storage and communication is of interest for the ICT industry, we are more interested in the amount of information that is handled by this hardware. Therefore, we convert the data contained in storage and communication hardware capacity into informational bits by normalizing on compression rates. This addresses the fact that information sources have different degrees of redundancy. The redundancy (or predictability) of the source is primarily determined by the content in question, such as text, images, audio or video (Shannon, 1948; Cover and Thomas, 2006). Considering the kind of content, we measure information as if all redundancy were removed with the most efficient compression algorithms available in 2007 (we call this level of compression "optimally compressed"). Shannon (1948) showed that the uttermost compression of information approximates the

entropy of the source, which unambiguously quantifies the amount of information contained in the message. In an information theoretic sense, information is defined as the opposite of uncertainty. Shannon defined one bit as the amount of information that reduces uncertainty by half (regarding a given probability space, such as letters from an alphabet or pixels from a color scale). This definition is independent of the specific task or content. For example, after normalization on optimally compressed bits we can say things like "a 6 square-cm newspaper image is worth a 1000 words", because both require the same average number of binary yes/no decisions to resolve the same amount of uncertainty.

Normalization on compression rates is essential for comparing the informational performance of analog and digital technologies. It is also indispensable for obtaining meaningful time series of digital technologies, since more efficient compression algorithms enable us to handle more information with the same amount of hardware. For example, we estimate that a hard disk with a hardware performance of 1 MB for video storage was holding the equivalent of 1 optimally compressed MB in 2007 ("optimally compressed" with MPEG-4), but only 0.45 optimally compressed MB in 2000 (compressed with MPEG-1), 0.33 in 1993 (compressed with cinepack) and merely 0.017 optimally compressed MB in 1986 (supposing that no compression algorithms were used). Given that statistics on the most commonly used compression algorithms are scarce, we limit our estimations of information storage and communication to the years 1986, 1993, 2000 and 2007 (see López and Hilbert, 2012).

Conventionally bits are abbreviated with a small "b" (such as in kilobits per second: kbps) and bytes (equal to 8 bits) with a capital "B" (such as in Megabyte: MB). Standard

decimal prefixes are used: kilo (10^3), mega (10^6), giga (10^9), tera (10^{12}), peta (10^{15}), exa (10^{18}), zetta (10^{21}).

Storage

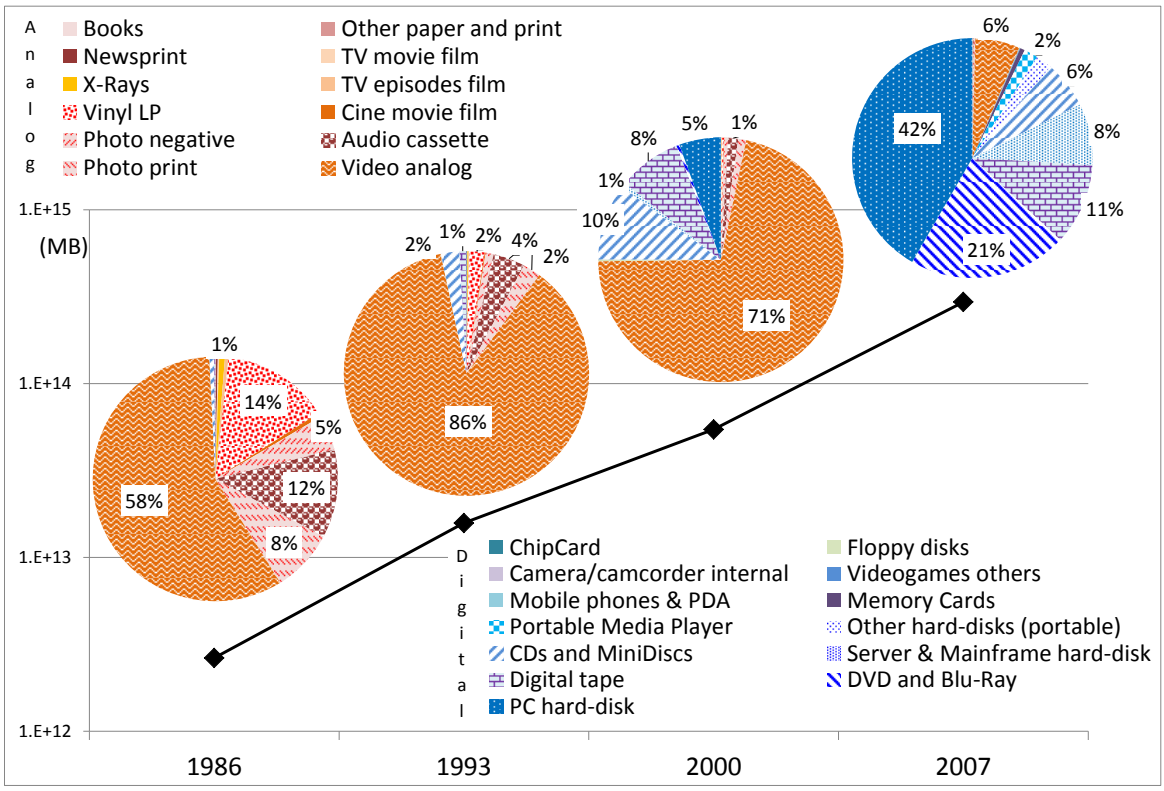
We estimate how much information could possibly have been stored by the 12 most widely used families of analog storage technologies and the 13 most prominent families of digital memory, from paper-based advertisement to the memory chips installed on a credit card (Figure). The total amount of information grew from 2.6 optimally compressed exabytes in 1986, to 15.8 in 1993, over 54.5 in 2000, to 295 optimally compressed exabytes in 2007. This is equivalent to less than one 730 MB CD-ROM per person in 1986 (539 MB per person), roughly 4 CD-ROM per person of 1993, 12 in the year 2000 and almost 61 CD-ROM per person in 2007. Piling up the imagined 404 billion CD-ROM from 2007 would create a stack from the earth to the moon and a quarter of this distance beyond (with 1.2 mm thickness per CD).

Our estimate is significantly larger than the previously cited hardware estimate from IDC for the same year (Gantz, 2008) (IDC estimates 264 exabytes of digital hardware, not normalized for compression, while we count 276 optimally compressed exabytes on digital devices, which occupy 363 exabytes of digital hardware). While our study is more comprehensive, we are not in a position to fully analyze all differences, since IDC's methodological assumptions and statistics are based on inaccessible and proprietary company sources.

Before the digital revolution, the amount of stored information was dominated by the bits stored in analog videotapes, such as VHS cassettes (Figure). In 1986, vinyl Long-

Play records still made up a significant part (14 %), as did analog audio cassettes (12 %) and photography (5 % and 8 %). It was not until the year 2000 that digital storage made a significant contribution to our technological memory, contributing 25 % of the total in 2000. Hard disks make up the lion share of storage in 2007 (summing up to 52 %), while optical storage contributes more than a quarter (28 %) and digital tape some 11 %. Paper-based storage solutions capture a decreasing share of the total (0.33 % in 1986 and 0.007 % in 2007), even though their capacity was steadily increasing in absolute terms (from 8.7 to 19.4 optimally compressed petabytes).

Figure 19 World's technological installed capacity to store information, in optimally compressed Megabytes (MB) per year, for 1986, 1993, 2000 and 2007, semi-log plot.



Communication

We divide the world's technological communication capacity into two broad groups: one includes technological systems that provide only unidirectional downstream capacity to diffuse information (referred to as broadcasting), and one provides bidirectional upstream and downstream channels (telecommunication). The ongoing technological convergence between broadcasting and telecommunication is blurring this distinction, as exemplified by the case of digital TV, which we count as broadcasting, even though it incorporates a small, but existent upstream channel (e.g. video-on-demand).

The inventories of Figures account for only those bits that are actually communicated. In the case of telecommunication, the sum of the effective usages of all users is quite similar to the total installed capacity (any difference represents an over- or future investment). This is because most backbone networks are shared and only used sporadically by an individual user. If all users demanded their promised bandwidth simultaneously, the network would collapse. This is not the case for individual broadcast subscribers, who could continuously receive incoming information. In order to meaningfully compare the carrying capacities of each, we apply effective consumption rates to the installed capacity of broadcasting (calling it the effective capacity). This reduces the installed capacity by a stable factor (by 9 in 1986; 9.1 in 1993; 8.7 in 2000; and 8.4 in 2007), implying an average individual broadcast consumption of roughly 2 hours and 45 minutes per 24 hours. It does not significantly change the relative distribution of the diverse technologies (Figure \).

Figure displays the capacity of 6 analog and 5 digital broadcast technologies, including newspapers and personal navigation devices (GPS). In 1986, the world's technological receivers picked up around 432 exabytes of optimally compressed information, 715 in 1993, 1.2 optimally compressed zettabytes in 2000 and 1.9 in 2007. Cable and satellite TV steadily gained importance but analog over-the-air terrestrial television still dominates the evolutionary trajectory. Digital satellite television leads the pack into the digital age, receiving 50 % of all digital broadcast signals in 2007. Only a quarter of all broadcasting information was in digital format in 2007. The share of radio declined gradually from 7.2 % in 1986 to 2.2 % in 2007.

Figure 20 World's technological effective capacity to broadcast information, in optimally compressed Megabytes (MB) per year, for 1986, 1993, 2000 and 2007, semi-log

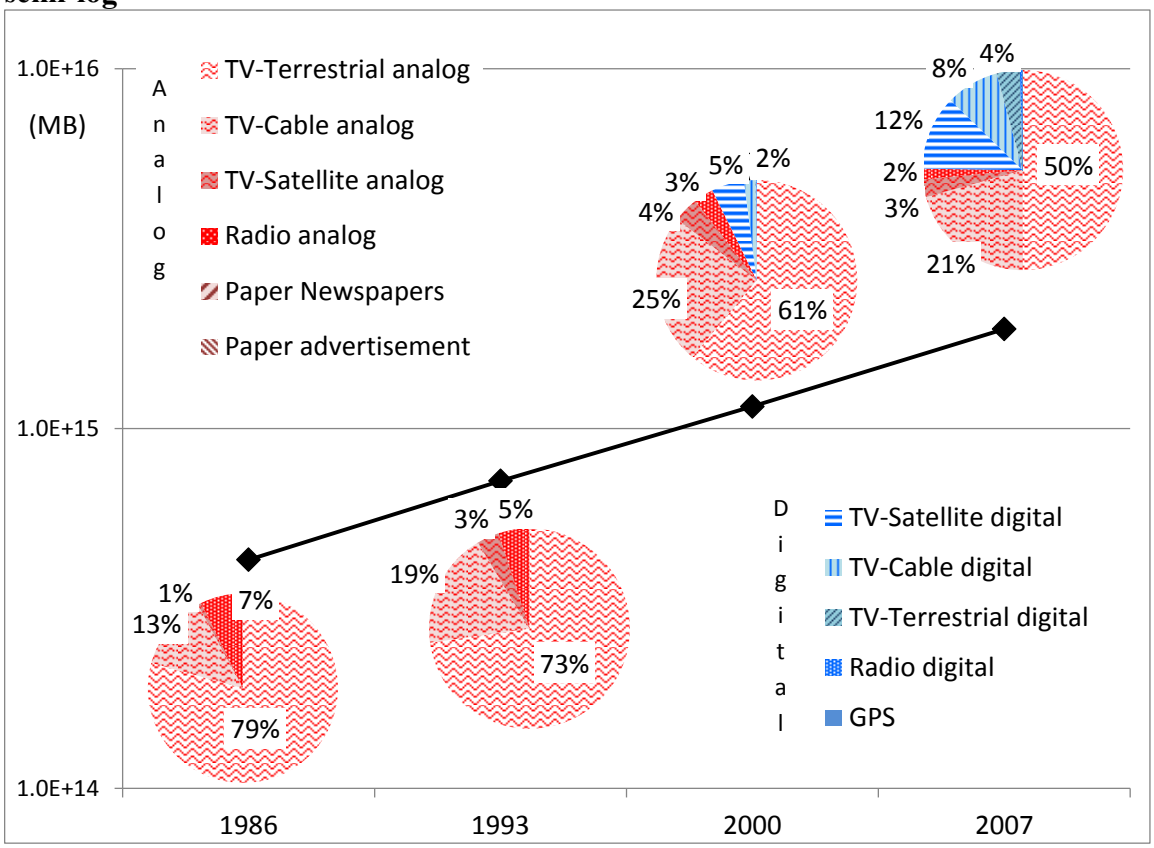
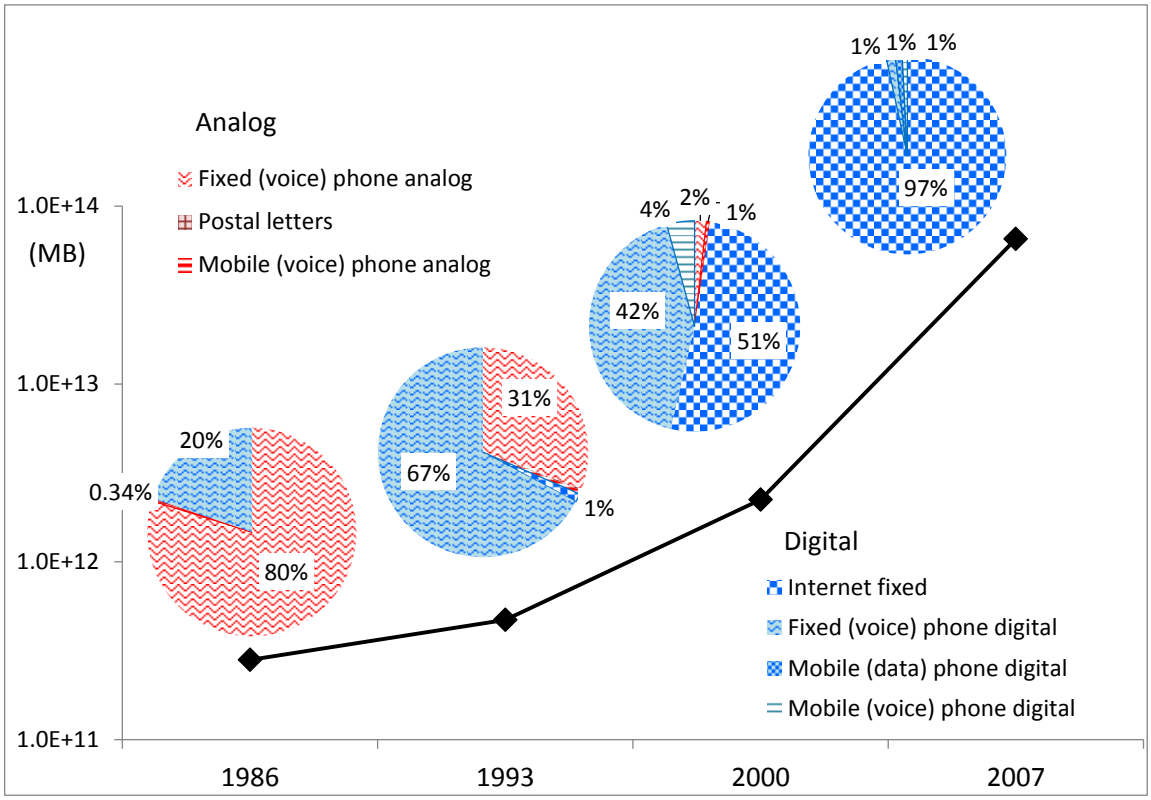


Figure presents effective capacity of the 3 most common bidirectional analog telecommunication technologies and their 4 most prominent digital heirs. The 281 petabytes of optimally compressed information from 1986 were overwhelmingly dominated by fixed line telephony, while postal letters contributed with a mere 0.34 %. 1993 was characterized by the digitization of the fixed phone network (471 optimally compressed petabytes). We estimate the year 1990 to be the turning point from analog to digital supremacy. The Internet revolution began shortly after the year 2000. In only 7 years, the introduction of broadband Internet effectively multiplied the world's telecommunication capacity by a factor of 29, from 2.2 optimally compressed exabytes in

2000, to 65 in 2007. The most widespread telecommunication technology was the mobile phone, with 3.4 billion devices in 2007 (versus 1.2 billion fixed line phones and 0.6 billion Internet subscriptions). Nevertheless, the fixed-line phone is still the solution of choice for voice communication (1.5 % of the total), while the mobile phone network is increasingly dominated by data traffic in 2007 (1.1 % for mobile data versus 0.8 % for mobile voice).

Figure 21 World's technological effective capacity to telecommunicate information, in optimally compressed Megabytes (MB) per year, for 1986, 1993, 2000 and 2007, semi-logarithmic plot



Compared with broadcasting, telecommunications still makes a quite modest, but rapidly growing part of the global communications landscape (3.3 % of their sum in 2007, up from 0.07 % in 1986). While there are only 8 % more broadcast devices in the world than

telecommunication equipment (6.66 billion vs. 6.15 billion in 2007), the average broadcasting device communicates 27 times more information per day than the average telecommunications gadget. This result might be unexpected at first sight, especially considering the omnipresence of the Internet, but can be understood when considering that an average Internet subscription effectively uses its full bandwidth for only around 9 minutes per day (during an average 1 hour and 36 minutes daily session).

Computation

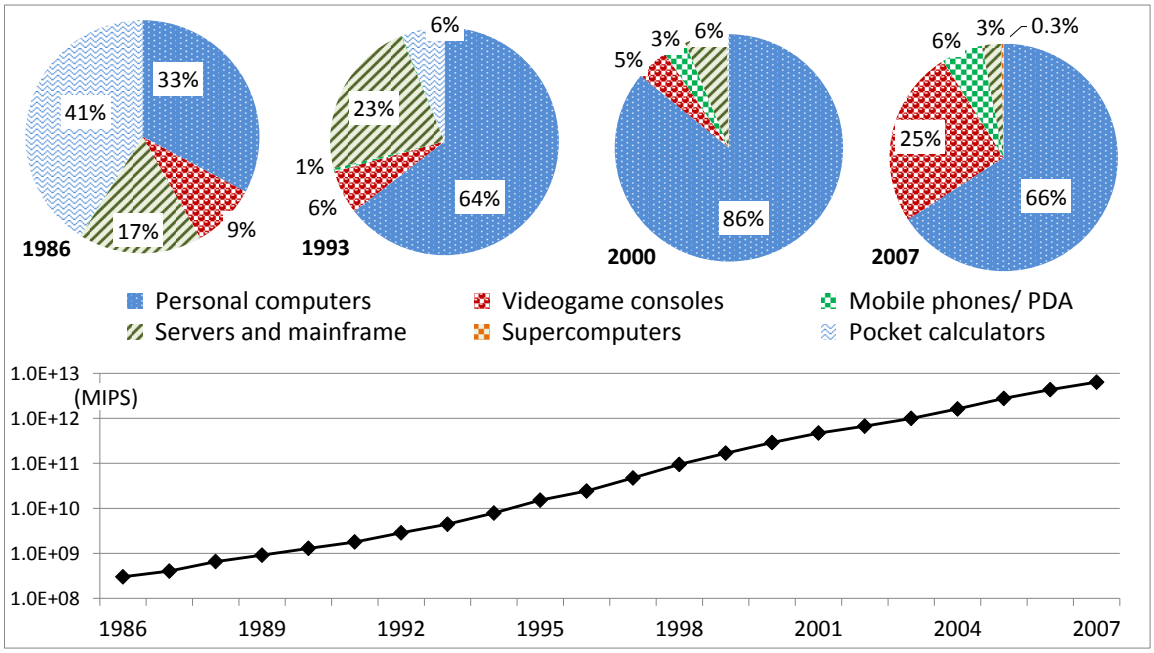
From a theoretical standpoint, a "computation" is nothing else than the repeated transmission of information through space (communication) and time (storage), guided by some algorithmic procedure (Turing, 1937). The problem is that the applied algorithmic procedure influences the overall performance of a computer, both in terms of hardware design and in terms of the contributions of software. As a result, the theoretical, methodological, and statistical bases for our estimates for computation are less solid than the ones for storage and communication. In contrast to Shannon's bit (1948), there is no generally accepted theory that provides us with an ultimate performance measure for computers. There are several ways to measure computational hardware performance, such as FLOPS and SPECs. Our hardware performance variable of choice is MIPS (*Million* or *Mega Instructions Per Second*), which was imposed upon us by the reality of available statistics. Regarding the contributions of software, it would theoretically be possible to normalize the resulting hardware capacity for algorithmic efficiency (such as measured by O-notation). This would recognize the constant progress of algorithms, which continuously make more efficient use of existing hardware. However, the

weighted contribution of each algorithm would require statistics on respective execution intensities of diverse algorithms on different computational devices. We are not aware of such statistics. As a result of these limitations, our estimates refer to the installed hardware capacity of computers.

We distinguish between two broad groups of computers. The first group includes all computers whose functionality is directly guided by their human users. We call this group "general-purpose computers" and include 6 technological families (Figure). The second group carries out automated computations that are incidental to the primary task, such as in electronic appliances or visual interfaces. While the user may have a range of predefined choices regarding their functionality, the user cannot change the automated logic of these embedded systems. We call this group "application-specific computers".

While general-purpose computers are also equipped with application-specific parts (mobile phones come with digital signal processors, and PCs contain microcontroller units, etc.), we only include the capacity of humanly guidable microprocessors in the respective inventory. The calculator laid the cornerstone for modern microprocessors and was still the dominant way to compute information in 1986 (41 % of 300 general-purpose tera-IPS). The landscape changed quickly during the early 1990s, as personal computers and servers and mainframe computers pushed the evolutionary trajectory to 4.4 peta-IPS. The personal computer extended its dominance during the year 2000 (289 peta-IPS), to be rivaled by videogame consoles and increasingly relevant mobile phones by 2007 (6.4 exa-IPS). Videogame consoles contributed 25 % of the total in 2007. Nowadays, clusters of videogame consoles are occasionally used as supercomputer substitutes for scientific purposes and other data intensive computational tasks.

Figure 22 World's technological installed capacity to compute information on general-purpose computers, in millions instructions per second (MIPS), distribution for 1986, 1993, 2000 and 2007, semi-logarithmic plot

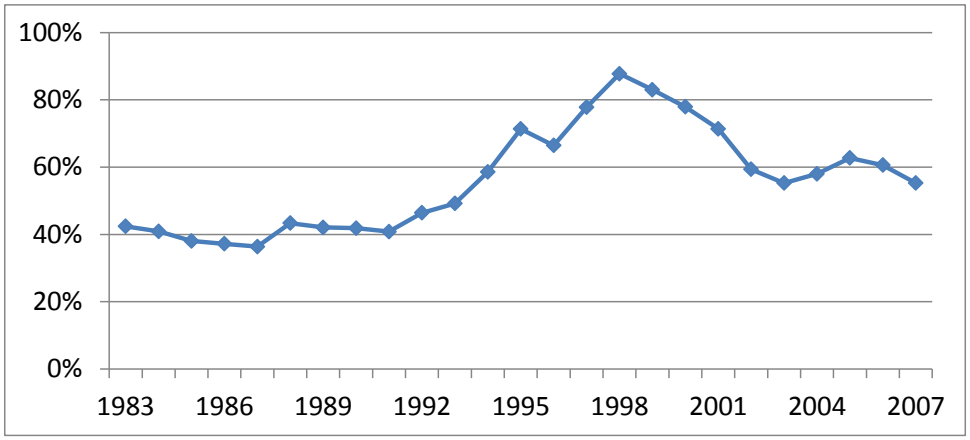


The relatively small role of supercomputers (less than 0.5 % throughout) and professional servers and mainframes might come as a surprise. It can partially be explained by the fact that the inventory of Figure presents the installed capacity, independent of effective usage rates. We also carried out some estimations based on the effective gross usage of the computers, which considers the time users interact with computers (not the net computational time). As a result we get between 5.8 % and 9.1 % of the installed capacity. The share of servers and mainframes grows to 89 % in 1986 and 11 % in 2007, and supercomputers contribute 4 % to the effective capacity in 2007.

The data also allows us to look at respective growth rates. Until the early 1990s, the annual growth rate was quite stable, at roughly 40 % (Figure). The 1990s show

outstanding growth, reaching a peak of 88 % in 1998. Since then, the technological progress has slowed. In recent times, every new year allows humankind to carry out roughly 60 % of the computations that could have possibly been executed by all existing general-purpose computers before that year.

Figure 23 Annual growth of installed general-purpose computational capacity as percentage of all previous computations since 1977 (yeart / Σ[1977, yeart-1]).



Our inventory of application-specific computations is the least complete one. The entire group of application-specific computers is very large and diverse (for example, dice cups and roulette wheels are application-specific analog random number generators) and it is often not straightforward to translate their performance into MIPS. The main goal of our inventory of this group was to show that the computational hardware capacity of application-specific computers is larger than the computational capacity of general-purpose computers. To achieve this we focused on a sample that includes three prominent groups: digital signal processors (DSP), which translate between analog and digital signals (including CD, DVD and PVR devices, cameras and camcorders, modems and

setup boxes, GPS, portable media, printer and fax, radio, fixed and mobile phones); microcontrollers (MCU) (which regulate electronics and appliances); and graphic processing units (GPU) (an increasingly powerful microprocessor for visual displays). While microcontrollers dominated our sample of application-specific computing support in 1986 (90 % of the 433 application-specific tera-IPS from our sample), graphic processing units clearly made up the lion share in 2007 (97 % of 189 exa-IPS).

Comparisons and growth rates

The world's technological capacity to compute information has by far experienced the highest growth (Table). The per capita capacity of our sample of application-specific machine mediators grew with a compound annual growth rate of 83 % between 1986 and 2007 and humanly guided general-purpose computers with 58 % per year. The world's technological capacity to telecommunicate only grew half as fast (CAGR of 28 %). This might seem a little surprising, as the advancement of telecommunications, and especially the Internet, is often celebrated as the epitome of the digital revolution. The results from Table challenge this idea and move human kinds' ability to compute information into the spotlight. The storage of information in vast technological memories has experienced a growth rate almost similar to telecommunication (CAGR of 23 % per capita over two decades). The lower growth rate results from the relatively high base level provided by prevalent analog storage devices. The main characteristic of the storage trajectory is the digitalization of previously analog information (from 0.8 % digital in 1986, to 94 % in 2007). The global capacity to broadcast information has experienced the least progress, at 6 % CAGR per capita. Broadcasting is also the only information operation that is still

dominated by analog ICT. As a result, the capacity to store information has grown at a much faster rate than the combined growth rate of tele- and broadcast communication. In 1986 it would have been possible to fill the global storage capacity with help of all effectively used communication technologies in roughly 2.2 days (539/241.16). In 1993 it would have taken almost 8 days, in the year 2000 roughly 2.5 weeks, and in 2007 almost 8 weeks.

The presented compound annual growth rates represent the temporal average of periods with differential intensities of technological change. While general-purpose computation had its peak growth around the turn of the millennia (Figure), storage capacity had slowed down around the year 2000, just to restart accelerated growth in recent years (CAGR of 27 % for 1986-1993, 18 % for 1993-2000 and 26 % for 2000-2007; Table). The introduction of broadband has led to a continuous acceleration of the telecommunication landscape (CAGR of 6 % for 1986-1993, 23 % for 1993-2000 and 60 % for 2000-2007; Table), and broadcasting is subject to a relatively stable rate of change (CAGRs of 5.7 %, 5.6 % and 6.1 % for 1986-1993, 1993-2000 and 2000-2007; Table).

Table 13Evolution of the world's capacity to store, communicate and compute information, absolute per capita, compound annual growth rate (CAGR), and percentage in digital format.

		1986	1993	2000	2007	CARG 86-07
Storage	MB optimal compression per capita (installed capacity)	539	2,866	8,988	44,716	23%
	% digital	0.8%	3%	25%	94%	
Broadcast	MB optimal compression per capita per day (effective capacity)	241	356	520	784	6%
	% digital	0.0%	0.0%	7.3%	25%	
Telecom	MB optimal compression per capita per day (effective capacity)	0.16	0.23	1.01	27	28%
	% digital	19.8%	68.5%	97.7%	99.9%	
General-purpose computation	MIPS per capita (installed capacity)	0.06	0.8	48	968	58%
Sample of application-specific computation	MIPS per capita (installed capacity)	0.09	3.3	239	28,620	83%

The growth rates also allow us to formulate some kinds of Moore's laws for the technological information processing capacity of humankind. Machines' application-specific capacity to compute information per capita has roughly doubled every 14 months over the past decades in our sample, while the per capita capacity of the world's general-purpose computers has doubled every 18 months. The global telecommunication capacity per capita doubled every 2 years and 10 months, while the world's storage capacity per capita required roughly 3 years and 4 months to increase twofold. Per capita broadcast information has doubled roughly every 12.3 years. Of course, such averages disguise the varying nature of technological innovation avenues.

Perspectives

To put our findings in perspective, the 6.4*10^18 instructions per second that human kind can carry out on its general-purpose computers in 2007 are in the same

ballpark area as the maximum number of nerve impulses executed by one human brain per second (10^17).[73] The 2.4*10^21 bits stored by humanity in all of its technological devices in 2007 is approaching order of magnitude of the roughly 10^23 bits stored in all the DNA molecules of a human adult[74], but it is still minuscule compared to the 10^90 bits stored in the observable universe (Lloyd, 2002). However, in contrast to natural information processing, the world's technological information processing capacities are quickly growing at clearly exponential rates.

[73] Assuming 100 billion neurons * 1,000 connections per neuron * max 1,000 nerve impulses per second

[74] Considering a quaternary DNA alphabet, in which each base pair can store 4 bits * 3 billion DNA base pairs per human cell * 60 trillion cells per adult human

Chapter Four: Policy Actions for the Transition

This last Chapter draws from the lessons learned about the particularities of the transition from the previous Chapters and analyzes how they were integrated into an international policy making process in Latin America. The article analyzes the experience of a foresight Delphi study that I had previously designed and carried out with policy-makers in Latin America. The Delphi aimed at creating a future policy-agenda in Latin America, and led to several interesting lessons about policy-making in the field of digital development.

Foresight Tools for Participative Policy-Making in Inter-Governmental Processes in Developing Countries: Lessons Learned from the eLAC Policy Priorities Delphi[75]

The paper shows how international foresight exercises, through online and offline tools, can make policy-making in developing countries more participatory, fostering transparency and accountability of public decision-making. A five-round Delphi exercise (with 1,454 contributions), based on the priorities of the 2005-2007 Latin American and Caribbean Action Plan for the Information Society (eLAC2007), was implemented. This exercise aimed at identifying future priorities that offered input into the inter-governmental negotiation of a 2008-2010 Action Plan (eLAC2010). It is believed to be the most extensive online participatory policy-making foresight exercise in the history of intergovernmental processes in the developing world to date. In addition to the specific policy guidance provided, the major lessons learned include (1) the potential of Policy Delphi methods to introduce transparency and accountability into public decision-making, especially in developing countries; (2) the utility of foresight exercises to foster multi-agency networking in the development community; (3) the usefulness of embedding foresight exercises into established mechanisms of representative democracy and international multilateralism, such as the United Nations; (4) the potential of online tools to facilitate participation in resource-scarce developing countries; and (5) the

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resource-efficiency stemming from the scale of international foresight exercises, and therefore its adequacy for resource-scarce regions. Two different types of practical implications have been observed. One is the governments' acknowledgement of the value of collective intelligence from civil society, academic and private sector participants of the Delphi and the ensuing appreciation of participative policy-making. The other is the demonstration of the role that can be played by the United Nations (and potentially by other inter-governmental agencies) in international participatory policy-making in the digital age, especially if they modernize the way they assist member countries in developing public policy agendas.

Over the last decades, much has been written about the structural changes in societies and economies associated with the advent of modern Information and Communication Technologies (ICT). Change continues at a rapid pace. We are continuing to see the emergence of technologies like the Internet and mobile phones with applicability to practically all kinds of human endeavours, some of them displaying unprecedented speed of diffusion (with the Internet having reached almost every fifth inhabitant of the world, and mobile telephony almost every second, in less than two decades). The digital paradigm is characterised by fast innovation cycles and accelerating technological progress. These factors have led to a high level of uncertainty concerning the options for, and implications of, this technological change. At a global level, the problem of the digital divide and prospects of digital opportunities for development have been underlined at the highest possible political levels, during the two phases of the United Nations' World Summit on the Information Society[76] (WSIS) in Geneva in 2003 and Tunis in 2005. This globally approved policy agenda spans a variety of subjects and sets goals to be worked on by the international community between 2005 and 2015.

Latin American and Caribbean (LAC) countries have responded to this global challenge by identifying the most urgent and important short-term policy goals for the region. The result was a selection of thirty areas of interest and seventy concrete goals to be implemented during 2005-2007, through a plan dubbed eLAC2007[77]. This Regional

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[76] See: http://www.itu.int/wsis. Heads of State and government discussed the implications of the digital revolution and approved two ambitious agendas (Geneva Plan of Action, 2003; and the Tunis Agenda for the Information Society, 2005). It is part of a global political undertaking known as the Millennium Development Goals (see http://www.un.org/millenniumgoals/), which recognizes the role of ICT in enhancing development and focuses on partnerships with the private sector to "ensure that the benefits of new technologies, especially information and communication technologies ... are available to all".

[77] For further details on the eLAC process see: http://www.eclac.org/SocInfo/eLAC

Action Plan for the Information Society was approved at the *Regional Preparatory Ministerial Conference of Latin America and the Caribbean for the second phase of the World Summit on the Information Society*, in Rio de Janeiro from 8-10 June 2005[78], and was seen as a first partial step towards the goals for 2015. The plan's purpose is to mediate between the ambitious goals of the global agenda, and the local demands of individual countries of the region, by identifying common regional priorities. The plan's nature is a short-term. Accelerating technological progress, proliferating applications, and the related uncertainty in this field of development, have forced policy-makers to opt for a short-term approach of no more than two or three years, allowing for continuous revision and adjustment to constantly changing challenges[79]. The logic applied here calls for a series of consecutive short-term Action Plans in order to implement the long-term vision until 2015.

During the execution of eLAC2007, significant advancements have been observed in the development of Information Societies in Latin America and the Caribbean (OSILAC, 2007), while at the same time an increased level of policy activity could be evidenced. As a result, countries and international organizations evaluated the plan as a success (ECALC Resolution, 2006) and decided to start the discussion about future priorities concerning the effective usage of ICT to tackle pending challenges in the LAC development agenda. The promises of effective ICT usage are multifaceted. These

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[78] See the Conference portal: http://www.riocmsi.gov.br

[79] The uncertainty associated with technological progress implies that even if there was an "optimum path towards an information society", in the sense of an ideal recipe for policy-making, the rapid pace of ICT development makes it unlikely that any such ideal could be grasped -the world would have moved on before it could be established. This leads to the necessity of adaptive short-term policy-planning – which needs to be informed by a view of long-term technology development possibilities..

promises include economic growth and productivity, social inclusion, the modernization of public administration, education and health sectors, security and disaster management, cultural development, and many potentials. The Information Society Programme of the United Nations' Economic Commission for Latin America and the Caribbean (UN-ECLAC), acted as the technical secretariat for the Regional Action Plan eLAC2007. In response to the task of elaborating a new regional agenda for the year 2010, the Programme elaborated the "eLAC Policy Priorities Delphi". The exercise aimed to identify public policy priorities and strategic policy alternatives regarding the use of ICT for development in the LAC region, for the period between 2008 and 2010. It did so by systematically collecting, and analyzing information so as to provide results that can help to improve the quality of policy choices made in a public policy agenda. The Delphi policy process was conducted between April 2006 and February 2008, with the report of the Delphi exercise being used as an input for the new 2008-2010 Regional Action Plan eLAC2010. (A short description of the inter-governmentally approved eLAC2010 Action Plan can be found in the left-hand columns of the Annex to this paper, which also provides a general overview of the different topics and thematic areas on the agenda an Action Plan for the development of Information Societies).

Below we review this participatory exercise and highlight the lessons learned. It starts with a summary of particularities to consider when working on regional-level agenda-building on such a dynamic and cross-cutting topic as ICT in developing regions. It then presents the Delphi policy process, before drawing conclusions as to the conduct of foresight and participatory policy-making exercises, in developing countries and more generally.

Regional agenda-building for digital development in developing countries

A public policy agenda may be defined as "the list of subjects or problems to which governmental officials, and people outside of government circles who are closely associated with those officials, are paying some serious attention at any given time." [Kingdon, 1995; 3]. The agenda-setting process then, involves determining which approaches to understanding and tackling these "subjects or problems" are liable to be most effective ones. Policymakers require good advice as to these approaches, and for the strategic formulation of goals and of plans to achieve these goals. This may result in a shortlist of proposals. "Having a viable alternative available for adoption facilitates the placement of a subject high on a governmental agenda and dramatically increases the high placement of a subject on a governmental agenda" [Kingdon, 1995; 144]. The ensuing question for policy-making in the field of ICT in Latin America and the Caribbean is therefore *who* is in the best position to formulate this "good advice" and the required "shortlist of policy proposals" on a regional level? This section discusses how the consideration of this question resulted in the decision to opt for a Policy Priority Delphi as the method of choice to determine the 2008-2010 Regional Information Society Action Plan.

At the two extremes, the choice is to opt either for a technocratic or a more democratic and participative way of securing such advice. A technocratic approach will involve relying on a group of experts who are members of a highly skilled and legitimized elite group ("technocrats" such as public government officials and those

knowledgeable and well-connected people known in the U.K. as "the great and the good"). More participative approaches, in contrast, will aim to draw on a wider range of inputs as to the nature of problems and possible solutions. This dichotomy suggests that adequate knowledge to determine policy options may be found either within a small and centralized subgroup of society, or dispersed more widely as decentralized intelligence among an unlimited number of people. This duality has been at the heart of the governance question ever since institutional mechanisms were established to govern the fate of societies through political organization, including Athens's Polis, monarchic forms of governance, or different kinds of democratic governance in the contemporary world.

From the point of view of the prevailing political system and legitimization of public decision making, representative democracy is the current choice of governance throughout the LAC region. In practice, this represents an intermediate solution between rather "technocratic" and more "democratic/participatory" approaches to deciding who formulates "good policy advice". Elected and legitimized by popular vote, politicians and the public officials who serve them have the task of arriving at policy options that can rise to the challenges confronting their countries. In the words of James Madison, one of the founding fathers of representative democracy (Madison, 1787; 6): "the delegation of the government ... to a smaller number of citizens elected by the rest ... [aims] ... to refine and enlarge the public views by passing them through the medium of a chosen body of citizens whose wisdom may best discern the true interest of their country". This logic of governance seems to have produced acceptable results throughout recent centuries. The task of elaborating a regional public policy agenda for ICT development in a developing

region, however, can challenge important aspects of Madison's logic. Various particularities associated with ICT and international development suggest that it is beneficial to expand the circle of participation and to enrich the established mechanisms of representative democracy with the opinions of a decentralized group.

First of all, ICT is a pervasive technology with multisectoral impacts and implications. Common core technologies associated with digital information processing are extremely widely adopted. But the pace of adoption, the development of applications, the configuration of systems, and the modes of usage can evolve in dissimilar ways across different branches of the economy and society (e.g. firms, hospitals, schools, municipalities), and across organizations of different types (e.g. larger and smaller firms), and in different locations (e.g. metropolitan and more remote areas). The notion of creating Information Societies implies that the transformation affects every aspect of society. The cross-cutting nature of the transformations affects the development of infrastructure and science and technology, as well as the educational and health sectors, the economy and entrepreneurship, community and local life, cultural heritage, legislation, the management of disasters and national security, public administration, among many others. Knowledge concerning these patterns of digital development is thus distributed in a decentralized manner throughout society. Very few people having much overview of the overall contours of this development, let alone possessing insight into the variety of localized experiences and initiatives. But this also implies that the centralization of activities with any specific actor is liable to run into difficulties. The scope and diversity of the challenges make it improbable that a small group, in the public sector or elsewhere,

can have developed a complete basis of information in all of these fields. This implies the need for a decentralized structure in the development of a public policy ICT agenda.

Second, uncertainty is very high in a field of such dizzying technological progress. ICT performance systems display exponential trajectories ever since they came into existence. The past 35 years of ICT development have been extremely fast and diverse, starting with the black and white Xerox text-processors developed by the Palo Alto Research Centre, passing by the PC and the first graphical PC operating systems, over the Internet and mobile phones, to wireless multimedia broadband computers through which millions of virtual avatars spend considerable amounts of time in massively three-dimensional multiplayer online environments.

The velocity of innovation, and the constantly changing supply-side and user-side environments make it extremely difficult for the public sector to gather all the necessary data to found its decisions on a solid information base – and to continue to do so on an ongoing basis. This uncertainty with regard to technological progress is especially severe for developing regions such as Latin America and the Caribbean, given that the great majority of technological Research and Development is exogenous to the region. This means that regional decision-makers are not even involved in the definition of choices that shape the final technological choices. In turn this means that the expertise to provide intelligence on future opportunities needs to be acquired from a wider audience, which might have better insights, such as the academic and private sector.

Third, efforts to create an international public policy agenda come up against the demographic and socio-economic heterogeneity of LAC countries. The region is host to countries with a population of more than 100 million (Brazil, Mexico) - and to others

with less than 50,000 (Saint Kitts and Nevis). In 2008, telephone penetration is over 100% is some countries (Argentina, Bahamas, Barbados, Jamaica, Trinidad and Tobago) - but less than 40% in others (Bolivia, Cuba, Haiti, Nicaragua, Peru). There are LAC countries in which half of the population is already connected to the Internet (Barbados, Jamaica) - and others in which Internet penetration is less than 5% (Cuba, Honduras, Nicaragua, Paraguay). This heterogeneity means that experiences will be very diverse. The implication, then, is that a diverse group of people need to be involved in the search for "good advice" relevant for the region as a whole.

These three sets of considerations informed the planning and design of the eLAC Policy Priorities Delphi. This aimed to elicit decentralized intelligence that would be useful for preparing adequate policy choices. In accordance with Turoff's definition, a Policy Delphi is "a tool for the analysis of Policy issues and not a mechanism for making decisions" (Turoff, 1975). In this sense, the goal is to inform the traditionally closed circle of decision-makers in public offices, aiming to enable them to access knowledge dispersed throughout society through open-ended consultations with the larger stakeholder community concerned with ICT for development. A similar widening of perspectives to inform decisions around Science and Technology has underpinned the Technology Foresight programmes that many countries instituted over the part 10-15 years.

But widening participation is not unproblematic. Should consultation be open to everybody – after all, uninformed people may opt for unrealistic policy choices? What about the danger that powerful private sector actors will use these new channels of participation to manipulate policy choices in their favour? Both possibilities have to be

taken seriously. The first echoes the longstanding concerns expressed by critics of direct democratic systems, fearing that decisions will be made on the basis of fickle sentiment rather than deliberation and analysis. The second danger is especially relevant in the field of ICT, with the world's two richest individuals in 2007 being from ICT industries -- one of them having business priorities almost exclusively focused on Latin America's connectivity[80].

Opening up the consultation to everybody carries the risk of uninformed decisions. Students of public opinion frequently caution that ordinary citizens generally lack well-developed attitudes or opinions on most public issues. Max Weber (1918) famously argued that the mass public – across all social classes —thinks only as far as the day after tomorrow, and is always susceptible to emotional and irrational influences. Notwithstanding, handpicking experts carries the risk of including a limited selection of technocrats.[81] For practical reasons, the eLAC Policy Priorities Delphi opted for a mix between the criteria of self-selection and handpicking. Rounds one, two and four of the exercise were carried out virtually, receiving 1274 contributions from an open-ended group that was filtered by the criterion of self-selection – are you prepared to dedicate the time to fill out the online questionnaire? (see Figure). Since it took between thirty and forty-five minutes to complete each online questionnaire, and given the specificity of the nature of the topic, the willingness to devote sufficient time to it was a decisive criterion.

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[80] Carlos Slim Helú is a Mexican business man who controls Teléfonos de México (Telmex), Telcel and América Móvil. He was identified as the richest man on earth by Forbes Magazine in 2007, followed by Bill Gates, co-founder and chairman of Microsoft.

[81] Even in the pioneering European Foresight exercises of the mid-1990s, a common experience was that of discovering that the implications of the technological developments that were being considered required knowledge that went well beyond that possessed by those recruited to participate in Panels – knowledge of such diverse issues as entrepreneurship and the problems of small firms, consumer behaviour and public opinion, impacts of tax and pension schemes, ethical issues around new technologies, and much else.

Rounds three and five of the exercise were carried out by face-to-face consultations, via personal interviews of selected experts or face-to-face workshops with handpicked invitees. 180 contributions were achieved by this process of handpicking regional opinion leaders.

The threat of opinion manipulation by lobby groups is extremely difficult to control. Promoting the consultation with a very heterogeneous group of participants, spanning diverse industries and communities, is one way to reduce the potential influence of a particular lobby group. However, this cannot assure the absence of vested interests. Efforts to make the selection of Delphi participants more transparent, democratic, and representative would have been extremely resource-intensive. This would have been disproportionate for the intended purpose – since the eLAC Policy Priority Delphi is not a final decision making tool itself. Rather, it serves as informal input for the established system of representative democracy. Democratically elected representatives evaluate the usefulness and validity of the Delphi results. The Policy Delphi is not intended to undermine the legitimacy of representative democracy, but to enrich it with the opinions of a broader group enlisted into direct participation.

Similarly, the eLAC Policy Priorities Delphi supports multilateral policymaking. It feeds into established governmental processes carried forward in the form of the Ministerial Conferences held in Rio de Janeiro (June, 2005) and El Salvador (February 2008), under the auspices of the United Nations. This multilateral organization is the only inclusive intergovernmental body in today's world, and thus plays an important role in formulating and diffusing ICT policy.

In summary, this Delphi plays a role in constructing the policy agenda: with an approach that is (1) based on open-ended consultations that exploits the decentralized intelligence of the group "from the bottom up" (through the direct contributions to the Policy Delphi from a specific group of stakeholders, such as civil society, private sector foundations and academia), while (2) assuring the legitimacy of the process "from top-down" (through democratically legitimized bodies and their selected technocrats, such as national governments and their intergovernmental institutions, such as the United Nations system).

The eLAC Policy Priority Delphi

The eLAC Policy Priorities Delphi was carried out between April 2006 and September 2007 with the financial assistance of the European Commission's @LIS project[82]. Its design was inspired by the European Union's policy priority foresight experiences[83]. The natural starting point was the existing 2005-2007 Regional Plan of Action, eLAC2007.

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[82] @LIS - Alliance for the Information Society – is a Programme of the European Commission aiming to reinforce the partnership between the European Union and Latin America in the field of the Information Society. Its objectives are to establish dialogue and cooperation on policy and regulatory frameworks in key areas and to boost interconnections between research networks and communities in both regions reducing the digital divide and integrating Latin America into a Global Information Society. After the successful execution of the 2003-2007 total budget of €77.5m (€63.5m financed by the EC and the rest by the partners of the programme) @LIS is going into its second phase for the 2008-2014 period. See http://www.dft.gov.uk/pgr/scienceresearch/futures/secsceniss/wrdsenariotoolv2

[83] The European Union has a strong track record of information society foresight exercises [20], in order to provide regular insight and updated intelligence for the eEurope2002-eEurope2005-i2010 agendas. Some recent ones include the Delphi-based EUFORIA scenarios [21], the survey-based STAR scenarios, the projection-based SEAMATE scenarios, the workshop-based ISTAG scenarios, the panel-based FLOWS scenarios and the [22] foresight exercise.

The first Delphi round basically presented the thirty priority areas of this inter-governmentally consented Action Plan for revision and comments in the light of upcoming challenges. Four additional rounds of consultation followed, leading to a revised priority agenda for the period 2008-2010. The entire process was presented in a comprehensive report (eLAC Delphi Report, 2007). In February 2008 it served as the main input for the inter-governmental negotiations that led up to the approval of the 2008-2010 Action Plan eLAC2010, during the Latin American and Caribbean Ministerial Conference on the Information Society in El Salvador.[84]

Overall, the Delphi process received 1,454 contributions from public, private and academic sectors and civil society throughout *five* consecutive rounds (see Figure 1). The distribution of contributions for each round can be seen in the Figure. Following the general design of a Policy Delphi, it used the results of previous rounds as feedback during subsequent rounds, in order to enable judgments to be reconsidered in the light of opinions collected in those rounds and thus identify areas of emerging consensus and potential differences of interests. The five rounds of the eLAC Policy Priorities Delphi were implemented through three online questionnaires (receiving 1,274 contributions) and two face-to-face consultations (180 contributions). The first two rounds were carried out online and aimed at the reconsideration of the priority areas of the (outgoing) Action Plan eLAC2007. The final three rounds were carried out through a mix of personal interviews and online questionnaires and aimed at the elaboration of practical policy options to work on the newly identified priority areas.

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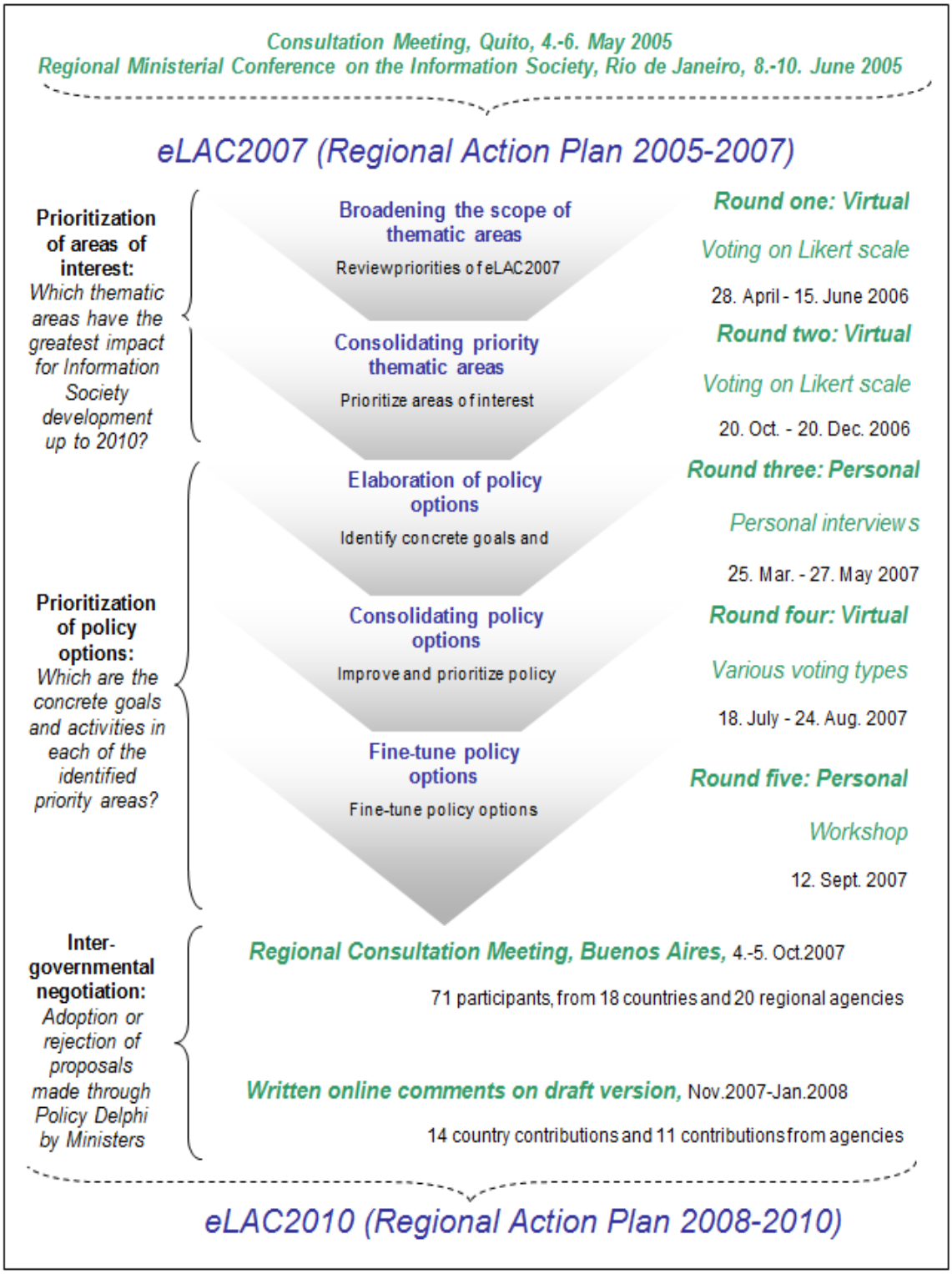
[84] See the Conference portal: http://www.eLAC2007.org.sv

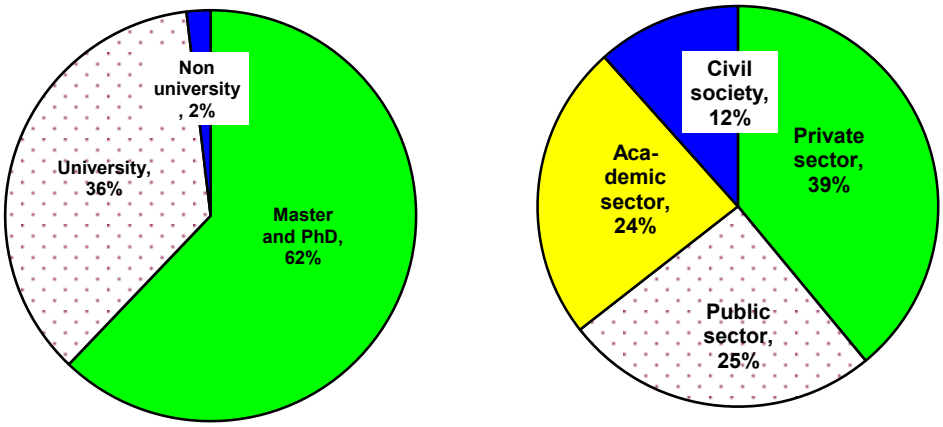
Figure 24 eLAC Policy Priority Delphi from eLAC2007 to eLAC2010



As the eLAC community had not established a network of active stakeholders before embarking on this exercise, the design involved an open-ended opinion poll. The invitations to participate in the three online questionnaires were sent to about 7,000 contacts from the region gathered by the ECLAC Information Society Programme, with a request for further dissemination of the invitation. Thirteen regional institutions from the public and private sector and civil society, joined in this multi-stakeholder effort - disseminating the questionnaires over their e-mail networks, posting them on their Websites, and including them in their newsletters and bulletin boards. As already noted, participants were self-selected from this pool of contactees. This process attracted a relatively educated group, in which the majority of the participants were individuals with a master's degree or doctorate (62%) (Figure 2). Figure 2 also demonstrates that, at least in broad terms, the range of participants was highly representative geographically.

The distribution of participants in terms of regional and professional affiliation, gender and education level proved to be very similar over the three online rounds of the exercise; it may provide a rough idea of the structure of the general ICT-for-development community in developing countries. The high degree of participation of private sector informants (39%) shows the proactive interest of the industry. But it is also notable that the online method admitted traditionally underrepresented voices, such as from the Caribbean or Central America.

Figure 25 Distribution of 1,274 online contributions (Delphi Round one, two and four) according to education, professional affiliation, gender and geographic representation of participants



Gender	
Women	34%
Men	66%

Subregion	Participation	Real population
South America	69%	67%
Meso-America	23%	26%
Caribbean	8%	7%

Note: The virtual consultation was carried out during Delphi rounds one, two and four (see Figure 1). Duplicates have not been removed from the presented count of contributions, given the limited possibility to do so (due to the anonymity of the open-ended group of participants and the fact that formal registration was not sought, since this might be a barrier to participation).

In agreement with common Policy Delphi practice, anonymity was assured during the virtual rounds, resulting in a focus of individual opinions, and not in organizational statements (these have been collected during the two face-to-face rounds). Anonymity enables participants to avoid potential repercussions and embarrassment, including the difficulty of publicly contradicting colleagues or superiors. The participants were invited to provide an e-mail address, without the need for self-identification, in order to be able to invite them to receive feedback and participate in consecutive rounds (for percentages of returning participants, see note in Figure 1). Of the 1,274 contributions in the three

online rounds, 720 Email addresses have been obtained, thus laying the foundations for a more solid eLAC multi-stakeholder community. It was decided not to use a mechanism that would have allowed for anonymous tracking of participants (such as the option to register with an anonymous username and password). The analytical drawback of this choice is the inability to identify with certainty how many of the participants returned in each round. Nevertheless, it was consciously decided against this alternative given the implied risk of reducing the number of participants. Delphi exercises are not very common in LAC and initially it was not even clear if a critical mass of participants could be reached at all. The extra effort of registration and eventual doubts about the reasons behind a need for registration (i.e. for a political susceptibility exercise like the eLAC Policy Priority Delphi) might have lowered the participant turn out. The obtained Email addresses provide some insight on returning participants. While it is important to remember that the same person does not necessarily provide the same Email address in each round, we estimate that between 10-15% of the second round had already participated in the first round and between 25-35% of the last online questionnaire (fourth round) had already participated in the second round. This leaves a rather small group of people that participated consistently in all online rounds (less than 10% of the 501 contributors of the second round), but overall increasing amount of returning participants is interpreted as a positive sign towards the establishment of a committed stakeholder community (and a related participative culture) for these kinds of practices in LAC.

The two rounds of personal face-to-face consultations have also been carried out, through a selection of 180 regional opinion leaders, mainly government representatives, officers of international organizations, and researchers and experts from academia, the

private sector and civil society. The names and affiliations of the participants of the face-to-face rounds are listed in the final eLAC Policy Priority Delphi report and attest the representativeness of this international multi-sector exercise.

Most Delphi studies ask for forecasts of *when* various developments are liable to occur, or *how far* such developments will have progressed by a particular point in time. The present study first used a **Policy Delphi** approach, focusing on the extent to which various trends and actions might contribute to overall goals. Subsequently, a **Goals Delphi** was used which examined what targets should be associated with particular goals, or how far particular goals were prioritized. For example, the 2005-2007 Action Plan eLAC2007 covered thirty thematic areas, related to issues like public ICT access centres, computers in schools, connectivity of hospitals, ICT alphabetization and training of the work force, digital management of disasters, regional backbone infrastructure, telework, required legislative frameworks, e-government, among others (see the Annex for brief characterization of the eLAC issues). The questions to be answered by the first two rounds of the Policy Delphi focused the relevance of these, and other thematic areas, for the period 2008-2010. Thematic areas were prioritized and ranked. Rounds three to five focused on the formulation or reformulation of concrete goals to move forward in the identified thematic areas. The consultations aimed at the determination of the aspired level of connectivity, the intensity of training programs, the kind of work that would need to be done on various legislative challenges, and the creation of regional working groups to deepen comprehension about specific issues, among other policy goals.

A major characteristic of a Policy Delphi is that participants are presented with various voting dimensions. Traditionally, the preferred voting dimensions include

dimensions are desirability and feasibility, as are consistency with existing values and anticipation of future constraints. The subjects addressed are complicated ones, but – like more conventional Delphis - Policy Delphi questionnaires are necessarily limited in terms of their scope and depth. The eLAC Policy Priority Delphi had the ambition to mobilize the largest number of stakeholders possible, fulfilling an advocacy and network role, which led to the decision to simplify voting dimensions by summarizing several of the possible evaluation criteria in the question into one major variable. In this sense, the eLAC Policy Priorities Delphi asked the participants to themselves synthesise the possible evaluation criteria in the question into one major variable for each issue addressed. They were asked to assess the impact of each thematic area for "the development of Latin American and Caribbean Information Societies for the year 2010".

Another characteristic of a Policy Delphi is that it aims at determining the areas of disagreement among groups of participants. The delineation of differing views aims at providing an opportunity for the recipient audience members to prepare their respective cases adequately (in our case the Ministerial Conference that will finally approve the eLAC2010 Action Plan). The questionnaires of the first two survey rounds asked participants to differentiate between economic, social and political impacts for development and to evaluate each one of them on a Likert scale from "negative impact" to "positive impact". This information then allows analyzing the degree of consensus and disagreement between various groups, such as subregions (South America, Meso-America, Caribbean) and participating sectors (Public Sector, Private Sector, Civil Society, Academia).

The choice of these questions allows to gather enough information to satisfy the defined goals of a Policy Delphi, without demanding too much of the participants' time. It is important to point out that throughout all Delphi rounds, participants have always been invited to write and hand in open comments and ideas. The attained summary insights were complemented in rounds three and five of the Delphi by means of face-to-face consultations and personal interviews. These provided the opportunity to dig a little deeper into the different opinions, and to explore the underlying arguments and patterns of reasoning associated with different topics, and with specific priorities and policy actions.

The five consecutive Delphi rounds

The thematic areas addressed in the **first Delphi round** (during April and June 2006) were based on the thirty priority areas for development of the information society in LAC countries that the countries of the region had identified in their 2005-2007 Regional Action Plan (eLAC2007). 155 participants took part, using the virtual eLAC platform[85] to rank these thirty areas (see Annex) by social, economic and political impact for development up to the year 2010, on a Likert scale from one ("negative impact") to five ("positive impact"). Since the dynamics of the ICT revolution are ongoing, they were also invited to suggest new fields of interest to be considered. The analysis of the first round shows that participants esteem the greatest impacts for social development from thematic areas related to access to ICT (connectivity and equipment diffusion), the largest

[85] The platform was set up at: http://www.eLAC2007.info and the underling software was provided by Groupmind Solutions, based on the tool GroupMind Express.

impacts for economiv development from areas related to capabilities (training and education), and the greatest impacts for political development from policy areas related to the coordination of activities across sectors.

In the **second Delphi round**, during October and December 2006, a revised ladder of 47 priority issues was displayed, in order to construct a fresh impact ranking, including the thematic areas of eLAC2007 (ranked according to the first round results), as well as suggestions for new thematic areas, such as "e-democracy", "electronic management for agriculture and fishing", "content for mobile phones", "ICT connectivity for tourist centres", among others[86]. This time, 501 contributors from twenty-two LAC countries answered the online questionnaire. Connectivity for schools and local governments, ICT training for enterprises and the workforce, e-government and national Information Society strategies and agendas were identified as the top priorities throughout the region.

In order to get a general idea of the magnitude of the differences in opinion among subregions (South America, Meso-America[87], Caribbean) and participating sectors (Public Sector, Private Sector, Civil Society, Academia), a simple polarization index was adopted from (Schneider, 1972). In his article, Schneider proposes to compute the absolute value of differences of the average vote for each one-to-one combination of subgroup pairs. Following this method, the average difference among each pair of groups was computed for the votes on the 30 thematic areas of the first round, and the 47 thematic areas of the second round. The results can be seen in Figure 3.

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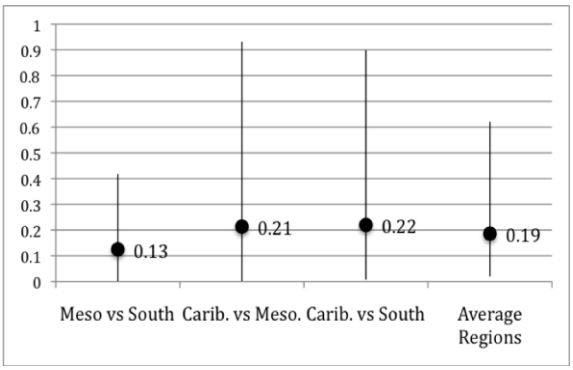
[86] For the ranking that resulted from the first round, see http://www.cepal.org/socinfo/noticias/paginas/8/26998/RANKINGS_english.xls . For the ranking that resulted from the second round, including all 47 thematic areas, see: http://www.cepal.org/socinfo/noticias/paginas/8/26998/Ranking%20by%20area%20of%20impact.pdf

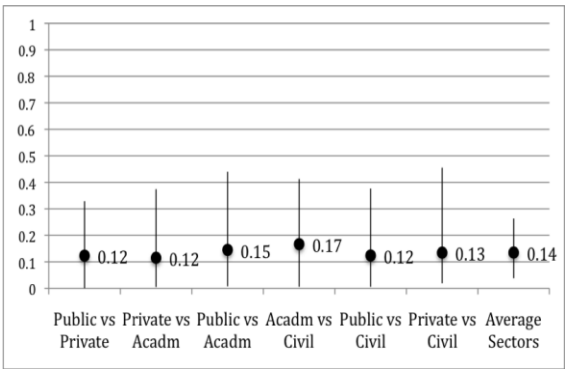
[87] For the purpose of this study, Meso-America is defined as Central-America plus Mexico.

Figure 26 Polarization Index for Subregions and Sectors of professional affiliation of participants

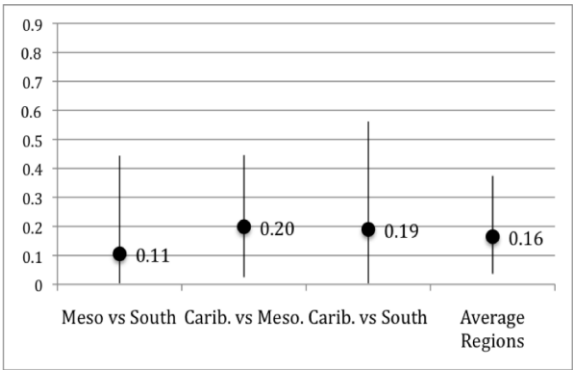
First Round Subregions



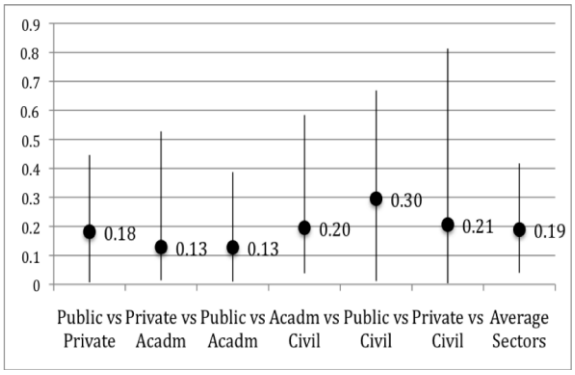
First Round Sectors



Second Round Subregions



Second Round Sectors



The first conclusion from Figure 3 is that despite the notorious heterogeneity in the region, the results shows a striking coincidence of interests and a surprisingly large and stable consensus (on average the differences are less than 0.2 on a Likert scale from one to five). This has been a positive surprise and shows the feasibility and readiness of the LAC region to create and foster a regional vision and policy agenda. While it is the declared goal of a Policy Delphi to identify areas of disagreement, the politically

sensitive environment of the eLAC Policy Priority Delphi motivated the project team to highlight and foster this important evidence of a concerted regional outlook on a common challenge. The risk of political escalation is always latent in inter-governmental processes and LAC governments do not have any obligation to approve a Regional Action Plan. Care needed to be taken in order to foster a climate of cooperation and compromise, which then enables the creation and commitment to an innovative policy tool such as eLAC.

However, the graphs allow the identification of several trends in disagreements. As expected, among subregions the difference in opinion of the Caribbean sticks out. In both rounds, it becomes clear that the small island States of the Caribbean have somewhat different priorities than South- and Meso-America. Regarding the disagreement among the various groups of professional affiliation of participants, the first round shows a pretty harmonious picture, while in the second round civil society takes up its traditional advocacy role and seems to increase opinion polarization by returning to their habitual role of opposition of the public and private sectors. It is also interesting to note that in the first round, the consensus among professional sectors was larger than the consensus among regions, while in the second round, more disagreement could be fond among sectors than among subregions. We will refer to specific cases of this polarization index (P.I., as the average of the Subregion and Sector values of the second round) throughout the rest of the article.

Given the need for prioritization that underpins the existing eLAC2007, the top thirty priority areas (as identified in the second survey round) were selected for the rest of

the Delphi. Twenty-three of these areas of interest coincided with eLAC2007, while seven new issues had entered the list of regional ICT priorities.

In terms of topics that were dropped, it is somewhat surprising that the participants did not consider that thematic areas such as "free software and open source software" (ranked 33 out of 47) and "Internet Governance" (ranked 37) would have a large impact on LAC development up to the year 2010. Both issues took up a large share of the discussion that took place during the World Summit on the Information Society (WSIS, 2003-2005) - it seems that the broader ICT-for-development community assigns a different importance to these controversial issues than their political representatives. While the polarization index shows a large degree on disagreement on the Internet Governance issue (0.30 as the average of Subregion and Sector P.I. of second round), the low evaluation of the impact of free and open source software seems not as controversial (P.I. of 0.16). Another thematic area which did not make it into the top thirty priorities was the "local supply of hardware-related goods and services" (ranked 42) – this is only a concern of larger countries, such as Brazil, in which the thematic area reached rank 31[88], and generally there was a fairly strong consensus on this issue (P.I. of 0.09).

Among the newly identified areas of interest are: "electronic democracy" (rank 10), the "inclusion of the gender perspective" (rank 16), "distance medicine" (rank 25), "intellectual property and copyright" (rank 26) and "Voice-over-Internet-Protocol" (rank 29). This reorganization of priority areas at the time of the second Delphi round suggested some reprioritization of main concerns since the outgoing Action Plan

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[88] For the individual country ranks see: Argentina (http://www.cepal.org/socinfo/noticias/paginas/2/27002/Argentina.pdf), aNNd similar pages for Brazil (.../Brasil.pdf), Chile (.../Chile.pdf), Colombia (.../Colombia.pdf), Mexico (.../Mexico.pdf), Peru (.../Per%FA.pdf) and Venezuela (.../Venezuela.pdf)

eLAC2007 had been approved. Later, this paper will consider how far the final version of the inter-governmentally approved new Action Plan eLAC2010 adopted these newly identified priorities.

The **third Delphi round** consisted of personal interviews with 116 experts from the public and private sectors, academia, and civil society, from nineteen countries. The interviews were intended to result in the formulation of concrete goals and activities to implement the 30 priority areas that had been identified in the second survey round. The input that was received by the project team during the interviews was immense, partially consisting of very unique and creative ideas, and partly recurring to well-known policy options.

In order to facilitate work on the thirty priority areas of a new Regional Action Plan, the project team needed to filter this input. It followed two simple rules to select 100 goals from the material:

- Policy options and goals need to be quantifiable and measurable (results-oriented); and/or
- Policy options and goals need to rely on existing international mechanisms, in the sense that specific action-oriented international agencies or institutions have to be identified that actively work on this challenge in the region (action-oriented).

The two rules aim at avoiding "utopian wishful thinking" at contributing to the practicality of the plan's implementation (and its monitoring and follow-up). They helped to narrow down the scope of goals considerably, leaving the project team with 100 potential goals have that could facilitate advancements in the thirty identified priority areas. Twenty-four of the 100 concrete goals were mainly results-oriented and therefore

quantifiable, while the remaining seventy-six goals were mainly action-oriented and more qualitative in nature. The project team was responsible to assure a harmonized and understandable formulation of the selected 100 goals and for the respective translation in English, Spanish and Portuguese.

The goals were submitted to the regional stakeholder community for ranking during July and August 2007. In this **fourth round** of the exercise, 618 contributions were received with a view to fine-tuning the contents of the goals. For the quantifiable results-oriented goals, the participants were asked to identify a target number, expressed in absolute and relative terms. For example: "Train [*select from the following four choices: 100% / 75% / 50% / 25%*] of teachers in the use of ICT or [*select from the following five choices: increase by ⅓ / increase by one half / increase by ⅔ / double / triple*] the share of so-trained teachers." The identified target numbers are expressed as regional averages for Latin America and the Caribbean as a whole. For the qualitative action-oriented goals, participants were asked to evaluate each activity's importance to the regional development agenda up to 2010, on a Likert scale from one (not important at all) to five (very important), and to identify agencies that are active in the field and could potentially help to implement them.

The **fifth and final round** of the Delphi exercise was a face-to-face consultation with the main public- and private-sector agencies and international NGOs. This inter-institutional meeting took place on 12 September 2007 at ECLAC headquarters in Santiago, Chile. Sixty-four experts from fifty institutions helped to refine the priority agenda for 2010. Twenty of these institutions were intergovernmental organizations from the region, eighteen were public sector institutions, ten were private sector foundations

and entities, nine were civil society institutions and NGOs, and seven were academic networks and institutions active in the region. The final proposal for a new Regional Action Plan contained sixty-three concrete goals in six Chapters - in comparison with eLAC2007, which included seventy goals in five Chapters (see Figure 1 for a schematization of the five rounds and Annex for a comparison between eLAC2007 and eLAC2010).

Evaluation of the effectiveness of the Delphi: the acceptance by the inter-governmental process

The complete report, with its final proposals, was presented at the regional consultations that took place in Buenos Aires on 4 and 5 October 2007. These consultations served as input for the inter-governmental negotiations leading up to the Ministerial Conference on the Information Society in Latin America and the Caribbean, which was held in San Salvador on 6-8 February 2008. This inter-governmental Conference approved the new Action Plan eLAC2010 – this is the substantive part of the so-called "San Salvador Commitment"[89]. Based on the sixty-three goals of the Delphi proposal, eLAC2010 contains eighty-three concrete goals following the same six Chapter format proposed by the eLAC Policy Priority Delphi result. The following sections will explore the changes, additions and droppings of the goals that were identified in the Policy Delphi, as compared with the officially approved Action Plan. This will then allow us to form an opinion about the effectiveness of the exercise, and therefore its success or failure.

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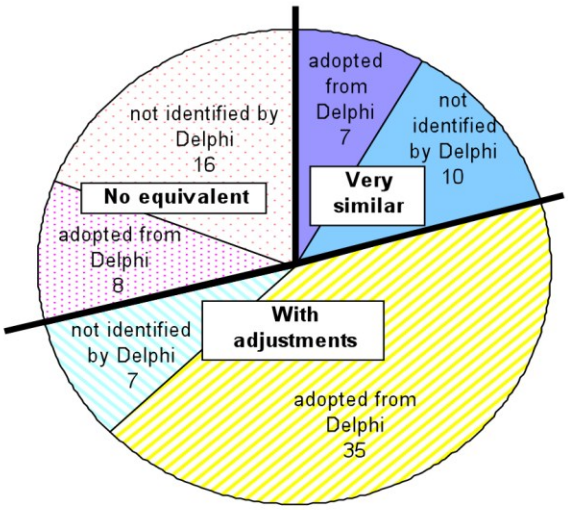
[89] For a complete version of the San Salvador Commitment see: http://www.eLAC2007.org.sv

The evolution of goals depicted in Figure 4 suggests that an interval of three years can be a reasonable period to review a policy agenda in fields related to rapid technological change. Only 20% of the goals in eLAC2010 are very similar to goals in eLAC2007 (almost literally adopted, including minor changes without substantive importance). Half of the goals have been adjusted to a changing environment. Around 30% of the goals of eLAC2010 are completely new on the agenda, with no equivalent in the old Action Plan (see Annex). The figure also reveals that 60% of the goals of the 2008-2010 ICT policy agenda (fifty out of the eighty-three goals) were already found in the proposal of the Policy Delphi results and were maintained by the policy makers throughout the inter-governmental negotiations until their final appearance in the officially approved version of eLAC2010[90].

Figure 27 Goals of eLAC2010 in comparison with goals of eLAC2007



[90] This is in spite of their being no direct recognition, in the final political document approved by the Regional Ministerial Conference, of the input and contributions made by the regional stakeholder community towards the elaboration of the goals through the Policy Delphi.

Figure 5 takes a closer look at the relation between the eLAC Policy Priorities Delphi results and the final political agenda eLAC2010 agreed on an inter-governmental basis. It shows that thirty-eight of the eighty-three goals of eLAC2010 have been adopted by the inter-governmental Conference almost literally from the Delphi results (46%). Notably, the quantitative, measurable goals stand out among these. It seems that governmental policy-makers respected the expertise and knowledge of the wider community of Delphi participants in setting realistic quantitative benchmarks for connectivity and other targets. Only thirteen goals (13%) proposed by the Policy Delphi exercise were actually rejected by the governments (in the sense of their not appearing in eLAC2010). Governmental representatives also brought their own current (and sometimes very specific) concerns to the table and introduced sixteen new goals, such as the creation of a regional education content market, promotion of IPv6, geo-referenced information systems, technological waste and garbage, among others (see sixth column in Annex). Even though most of the newly introduced goals (nine) did not count with a concrete policy formulation in the final Delphi proposal, they are in agreement with the thematic areas identified by the second Delphi round. Then again, the governmental representatives resuscitated seventeen goals from the old eLAC2007 agenda (which makes up 20% of the new eLAC2010). It seems that decision-makers were comfortable with the language and formulations previously agreed around these earlier -debated goals, and/or they did not want to tamper and meddle with the established political consensus. The resuscitation of these goals makes the eLAC2010 agenda much closer to its predecessor eLAC2007. The Delphi proposal was considerably more radical in its

suggestions for change. But political processes seem to favour the safeguarding of an established and balanced consensus, as opposed to endorsing major change – at least on this occasion.

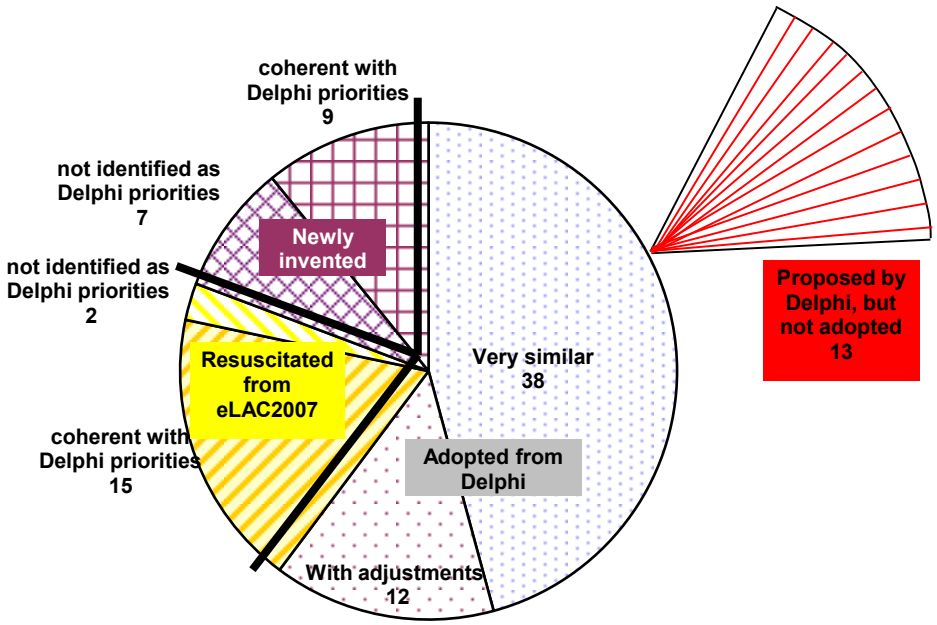
Two conclusions can be drawn from Figure 5. First, as a result of the political desire to resuscitate old goals from eLAC2007 and at the same time to introduce new goals, eLAC2010 is longer than its predecessor (eighty-three instead of seventy goals). This follows the political logic of maintaining and adding to the original formulations, without being willing to reduce, simplify and prioritize.

Second, a considerable number of goals that appear in eLAC2010 are in agreement with the broad thematic areas that were identified in the second Delphi round, but that do not appear as a concrete goal suggestion in the final Delphi proposal. (This applies to nine of the goals that have been "newly invented" by policy makers, and fifteen of the goals resuscitated from eLAC2007). This suggests that final rounds of the Delphi (rounds three to five) had difficulty in translating the identified thematic areas into the desired policy goals. For example, the second Delphi round identified the thematic area of "Regional infrastructure and interconnection of networks among countries" as one of the top priority areas (rank 11). But the policy goals elaborated during rounds three to five of the Delphi did not foresee the necessity of promoting IPv6 (Internet Protocol version6)[91] as part of this challenge. Similarly, the thematic area of "Legislative Frameworks" was prioritized during the second Delphi round (rank 21). But successive consultations during Delphi rounds three to five did not result in the formulation of separate policy

[91] Internet Protocol version 6 (IPv6) is designated as the successor of IPv4, the current version of the Internet Protocol, for general use on the Internet. The main change brought by IPv6 is a much larger address space that allows greater flexibility in assigning addresses.

goals for “digital signature”, “electronic payment”, or “electronic contracting”, which have been introduced by policy makers during the inter-governmental negotiations during the Ministerial Conference in February 2008. In short, while the Delphi was able to anticipate the majority of the broad interests of policy makers, it was not, then, able to anticipate how these thematic areas would translate into concrete policy actions. There appear to be limits to the scope of elaborating qualitative policy goal formulations in a collective manner, at least when resources limited. The 180 personal interviews might not have been sufficient (in number or range) and the methodology to collectively formulate policy goals through digital media (such as intended during the fourth Delphi round), might not have been sufficiently sophisticated to assure that the broad thematic areas of interest would be translated into all relevant policy goals.

Figure 28 Goals of eLAC2010 in comparison to goals proposed by Policy Delphi results



Let us consider the nine goals that governments included in the eLAC2010 Action Plan, though they had not been among the priorities identified by the Policy Delphi – and also take a look at the thirteen policy options rejected by the public officials. This will give us further insight on the dynamic between the Policy Delphi and its main beneficiaries, the Ministerial Conference.

Among the nine goals that have been adopted by the Ministers against the opinion of the Delphi participants, the politically relevant goals of "Internet Governance" (goal 72 of eLAC2010, with a very high disagreement of 0.30 P.I. average among subregions and sectors in the second Delphi round), "software development" (goal 74 of eLAC2010, middle P.I. of 0.16) and "hardware and industry development" (goals 50 and 53, eLAC2010, high consensus with P.I. of 0.09) stand out. During recent years both of these thematic areas have received much political visibility and attracted above-average

political attention in the region. To justify the inclusion of these goals despite the Delphi proposal, governmental officials argued that the wider ICT-for-development community might not fully recognize the importance of Internet Governance for development of sustainable Information Societies, and likewise the strategic importance of ICT production capacities[92]. Though the wider stakeholder group of Delphi participants considers that these issues do not have a major impact on regional development in the years to come, governmental representatives insisted on these issues for development in the digital age.

With regard to the thirteen policy goals proposed by the eLAC Policy Priorities Delphi that the Ministerial Conference rejected, no straightforward explanation was given at the time, nor is it easy to find a common thread. But some points are notable:

- Some of the newly suggested priorities have been rejected by the inter-governmental group. A policy action to foster "distance and telemedicine" (goal 25 of the final Delphi proposal, and a slightly elevated P.I. of 0.23) was rejected, as were the regulatory debates about "Voice-over-Internet-Protocol" (goal 18 of the final Delphi proposal, with a rather low P.I. of 0.13) and "intellectual property" (goal 49 of the final Delphi proposal, with a middle P.I. of 0.20). The latter two are critical issues of public concern, but are also delicate issues on the international policy agenda, involving strong industry interests. Even though the Polarization Index shows that there was no

[92] During the negotiations, one governmental official used a metaphor to justify the inclusion of these goals. According to some Latin American narratives, the indigenous inhabitants of the region had not been able to recognize the ships of Christopher Columbus and other colonizers during their week-long anchoring in front of the coasts of the Americas. They had never seen such a thing as a ship on the open ocean, and their cognitive processes could not classify the phenomenon - leading to the well-known bloody result of the unforeseen surprise visit. Internet Governance and the strategic importance of software (especially open source) might be compared to such unknown and cognitively incomprehensible phenomena and –according to the government official— it should not be a surprise that the larger public would not recognize their importance.

extraordinary disagreement among the Delphi community on these issues, decision makers were not able to find common ground. It might be that the positive spirit of consensus-building did not leave room to bring these discussions to an agreeable result for the 2008-2010 policy debate.

- Five of the thirteen rejected goals concerned democratic and transparent governance. One of these concerned the modernization of the justice system, including the introduction of digital tools for transparency and judicial efficiency (goal 33 of the final Delphi proposal, with an elevated P.I. of 0.25 among subregions and sectors); two referred to the strengthening of democratic practices, including the usage of ICT in parliaments and the approval of freedom of information legislation (goals 36 and 60 of the final Delphi proposal, with an elevated P.I. of 0.24); and two goals concerned privacy issues and the protection of personal data (goals 35 and 61 of the final Delphi proposal, also with an elevated P.I. of 0.25). The Polarization Index shows clearly how controversial these issues are. However, it is surprising that in a Regional Action Plan for Information Society development, crucial topics associated with the strengthening of democratic institutions and practices, the transparency of the judicial system, and the protection of privacy rights, did not join the eighty-three priority issues. It is a cause for concern that the LAC developing countries do not consider these issues in their current policy agenda.

Conclusions and lessons learned

In retrospect, it is possible to identify a number of issues that could have been done differently, and might have improved the effectiveness of the exercise. One of the mayor

challenges was the formulation of concrete policy options to implement the identified thematic priority areas. The received online comments turned out not to be very useful to find the adequate wording of concrete policy actions, and more personal interviews or workshops during the face-to-face meetings in round three and five would have required more resources. It might have been a cost-effective intermediate solution to establish a multi-sector editorial board to assist and supervise the project team's work on synthesising online comments and the results of face-to-face interviews. If resources are available, this group could also serve as a focus group of regional opinion leaders. Sequential workshops could provide regular input and guidance throughout the exercise. A very positive externality of this approach is the creation of a group of regional agents of change. Future exercises should consider the creation of such board to accompany the process.

Several design options have been influenced by trade-offs between the "theoretically desirable" and what was thought to be "politically practicable". One such choice of design related to the right balance between the logic of a Policy Delphi to generate opposing views and the need for a political consensus to go ahead with the inter-governmental negotiation of a common LAC Action Plan. Given that the eLAC process has matured decisively and has entered its second generation already, it might be possible and beneficial for future exercises to deepen analysis and to focus with more detail on the disagreements of participants. In the same line of reasoning it would surely be of analytical interest to employ some kind of mechanism or software to register online users anonymously (such as with a username and password). This would allow tracking the evolution of disagreements over several rounds and the stability of the emerging consent or dissent. Contrary to all initial concerns, the LAC stakeholder community reacted very positively to the chance of

participation, which seems to suggest that the addition of some minor user hurdles that enrich later analysis (such as registration or additional background questions) might not necessarily lower participant turn out.

Besides lessons learned on design issues, the exercise discussed here also led to several insights about the nature and potential of foresight exercises in developing countries. The eLAC Policy Priorities Delphi brought a considerable amount of transparency and accountability, by introducing public debate into the traditionally obscure and somewhat arbitrary nature of inter-governmental agreements. Decision-makers found themselves asked to justify publicly why they rejected and preferred certain thematic priorities - though they did not always respond to this request. In this sense, the use of foresight tools to enhance participative policy-making in inter-governmental processes is not a quick fix or magic bullet for the longstanding challenges of more democratic and transparent approaches to policy-making. It is a gradual innovation, which respects established customs and procedures of inter-governmental decision-making. While the overwhelming bulk of the results of the Policy Delphi results were accepted by the inter-governmental power structures, the open-ended Delphi community did not replace traditional decision-making mechanisms - nor could it remedy all of their defects. The eLAC Policy Delphi supported public decision making by providing a more open and transparent mechanism, but governments remained free to follow what they see as their given mandates and to act as they see fit.

The Policy Delphi did highlight points of mismatch between governmental opinions and the result of the open-ended multi-stakeholder consultations. For example, the newly approved Regional Action Plan for the Information Society in Latin America and the

Caribbean, eLAC2010, does not mention the issues (identified as crucial by the Delphi participants) related to the strengthening of democratic institutions and practices, the transparency and efficiency of the judicial system and the protection of privacy. This is a significant mismatch, whose wider implications deserve more consideration than we can give them now. This "democratic deficit" would have been much less visible if there had been no Policy Delphi exercise to urge the inclusion of these issues in the public policy agenda. The fact that the inter-governmental Ministerial Conference rejected five democracy-related policy actions that have been proposed by the multi-stakeholder group provides rather tangible evidence of political perspectives. Such tangible evidence would be less apparent were all arguments and decisions taking place in the opaque channels of inter-governmental negotiations – the common situation in such political decision-making. Thus, Policy Delphi exercises can help to augment transparency and accountability in public decision-making by simply reveal mismatches of opinion between political leaders and stakeholders. This is of special importance in developing countries, where institutional structures are frequently immature. In this sense, the exercise can serve as a demonstration of a cost-effective way to foster transparent and accountable public decision-making - and not only in developing countries.

Furthermore, the potential of participatory mechanisms was not just a theoretical matter, but has already shown practical results. The open-ended consultations during the five consecutive Delphi rounds strengthened a network of stakeholders and institutions that are involved in complementary tasks related to the areas of interest of the Regional Action Plan. As a result, the Annex of the eLAC2010 Action Plan lists eighty-eight regional agencies that are active in the various challenges outlined by the regional

strategy. This Annex can be seen as a first “who-is-who” and “who-does-what” in the LAC ICT-for-development community. This incipient multi-agency networking is surely one of the most valuable results of the exercise. Such approaches are likely to be especially important in cross-cutting and multi-thematic areas as ICT-for-development. In this sense - as is so often the case in Delphi exercises and in Foresight more generally - the process itself turned out to be just as important, or maybe even more important, for advancement on the ground, than the final product presented in the report.

One reason for the acceptance and success of the exercise lies in its positioning and presentation. The Policy Delphi was not seen to be questioning the legitimacy of representative democracy and established multilateralism. Rather, the process aimed at enriching its functionality, at supporting established inter-governmental practices in the framework of the United Nations system (in form of its Regional Commission UN-ECLAC). This is the basic ambition of participatory policy-making in a representative democracy, where the aim is more for incremental change than for a radical break with traditional notions of democracy. Nevertheless, it does recognize that there are techniques and technological opportunities to gradually modernize the relationship between State and societal actors, and it has been shown that traditional policy makers are receptive to such innovations.

These changes involve a growing prominence of such notions as stakeholder and of shared responsibility. Civil society, private and academic sectors and governments are viewed as different parts of society that affect and are affected by the public policy making process, and can contribute their knowledge and take responsibility in a collective way through public foresight consultations. The process relies on the

involvement of publicly legitimized technocrats, but recognizes that they cannot possibly possess all the information required to make sound policy choices in such a dynamic and generic topic as ICT-for-development. It therefore mobilizes the collective intelligence of an open-ended stakeholder group, while respecting the established legitimization of democratically elected governments, following the basic definition of a Policy Delphi as a "decision-analysis tool", and not a decision making tool.

Additionally, the eLAC Policy Priorities Delphi is not only about ICT-for-development, but it also exploits the ICTs` involved, drawing on the benefits of digital communication. This helps to overcome geographical barriers and provides a 24/7 availability of the online platform. Cheap channels for participation are essential in Latin America and the Caribbean, given the region's large size and scarce resources. For example, while a four and a half hours flight between Stockholm and Lisbon represents one of the largest barriers to a face-to-face meeting in Europe (3,000 km), a flight from Mexico City to Buenos Aires easily takes over eleven hours (7,500 km). Thus, every personal meeting with regional scope in Latin America and the Caribbean requires at least one day of travel each way for all participants to be able to come, whereas, in Europe, most participants in European Union or OECD meetings can go to a meeting and return the same day. Combined with the cost of travel and the much more limited resources in developing countries – not to mention environmental and personal burdens associated with long-distance travel - virtual channels prove to have great potential to facilitate participatory policy-making. There is bound to be much more use of such methods in coming years.

Last but not least, the most important lesson learned might be the contribution of international collaboration in this exercise. The elaboration of a Public Policy Action Plan in the fast-changing field of innovation and technological change is an ongoing challenge that can be confronted internationally. Technological progress is a moving target, but many developing countries do not have sufficient resources to maintain continuous foresight exercises. In this case, the support from Europe (in form of the funds from the European Commission's @LIS project and the conceptual collaboration between UN-ECLAC and the much more experienced team at the University of Manchester, UK), and the South-South deliberations within Latin America and the Caribbean, has shown that international cooperation provides an adequate platform and sufficient scale for developing countries to adjust their policy actions to permanent technological change. Foresight exercises are resource intensive and if developing countries want to prepare better for the future, international collaboration at the regional level seems like the most feasible level to start with an institutionalization of such exercises in the developing world.

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