The end justifies the definition: the manifold outlooks on the digital divide and their practical usefulness for policy-making

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Abstract:

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 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.

Keywords: digital divide, measurement methodology, ICT, policy, development, budget.

1. 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.

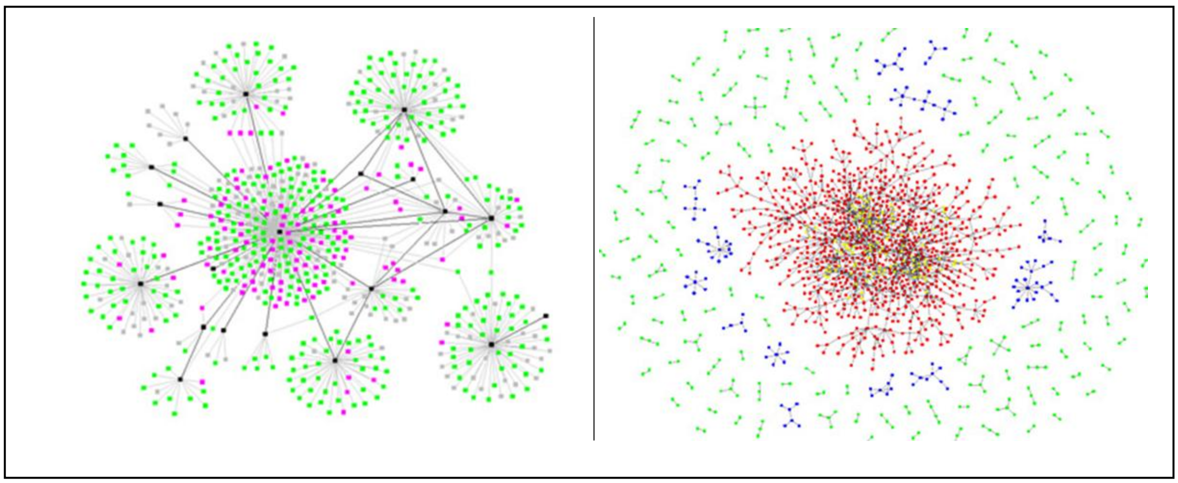
In conclusion, from an analytical perspective, the literature has identified a large variety of justifiable definitions of the digital divide. From a practical perspective, a large variety of diverse policy makers aim to exploit ICT to achieve very different ends. There is no evidence to suggest that 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.

2. 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).[1] 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 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. Fig. 1-2 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).

Fig. 1: Social network of the spread of diseases. Fig. 2: Social network of emergent online community.



Source: Krebs, 2003, 2005.

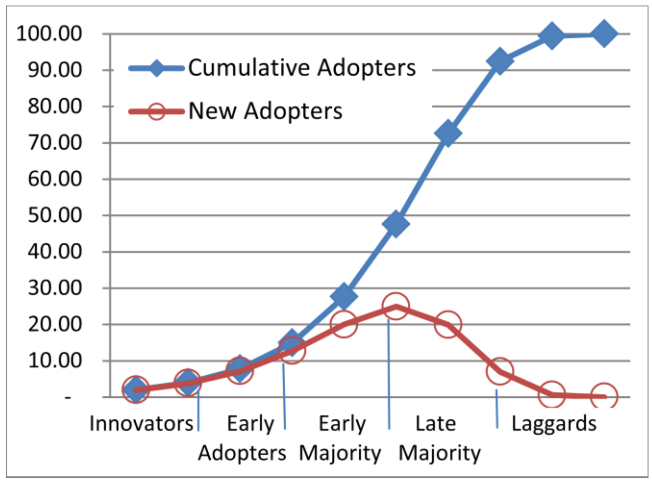
With the framework of a social network in mind, it is straightforward to model the basic logic of the characteristic S-shaped diffusion curve that gives rise to the digital divide. Fig. 3 assumes a social group of 100 people, whereas some technological innovation was adopted by 2 initial innovators. 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 Fig. 3). The

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

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 Fig. 4 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 Fig. 3, 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 Fig. 4 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).

Fig. 3: Hypothetical example of homogeneous mixing. Fig. 4: Prototypical S-shaped diffusion curve.

	Cumulative Adopters		Rate of adoption		Non-adopters		New Adopters
	2.00	x	0.01	x	98.00	=	1.96
=>	3.96	x	0.01	x	96.04	=	3.80
=>	7.76	x	0.01	x	92.24	=	7.16
=>	14.92	x	0.01	x	85.08	=	12.70
=>	27.62	x	0.01	x	72.38	=	19.99
=>	47.61	x	0.01	x	52.39	=	**24.94**
=>	72.55	x	0.01	x	27.45	=	19.91
=>	92.47	x	0.01	x	7.53	=	6.97
=>	99.43	x	0.01	x	0.57	=	0.56
=>	100.00	x	0.01	x	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 Figs. 3-4), but is influenced by the particular structure of the social network and by the characteristics of its nodes (such as shown in Figs. 1-2). Some networks are more centralized than others, and others are characterized by clusters and cliques (Fig. 1). Besides, innovators can often be found at the periphery of social networks, which means that they have few ties (Fig. 2). 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).[2]

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, 1973; Porat, 1977; Forester, 1985; Miles, 1988; Freeman & Louçã, 2002; Guerrieri & Padoan, 2007; Mansell, 2009; Castells, 2009).

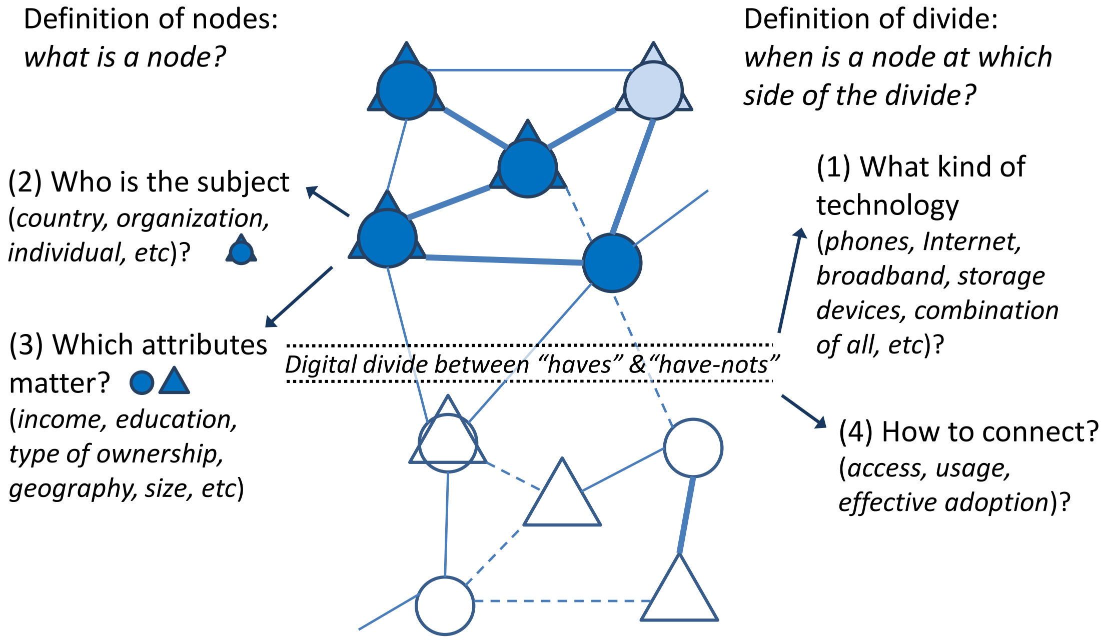
3. How to define the digital divide analytically?

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. Fig. 5 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”.

Fig. 5 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?

[2] 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).

Fig. 5: 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 Fig. 5. 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.

3.1. *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 (Fig. 5). This allows to observe how the innovation spreads through the network (much like a disease follows a pattern of contagion) (see Figs. 1-2). 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. Fig. 6 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[3] 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.

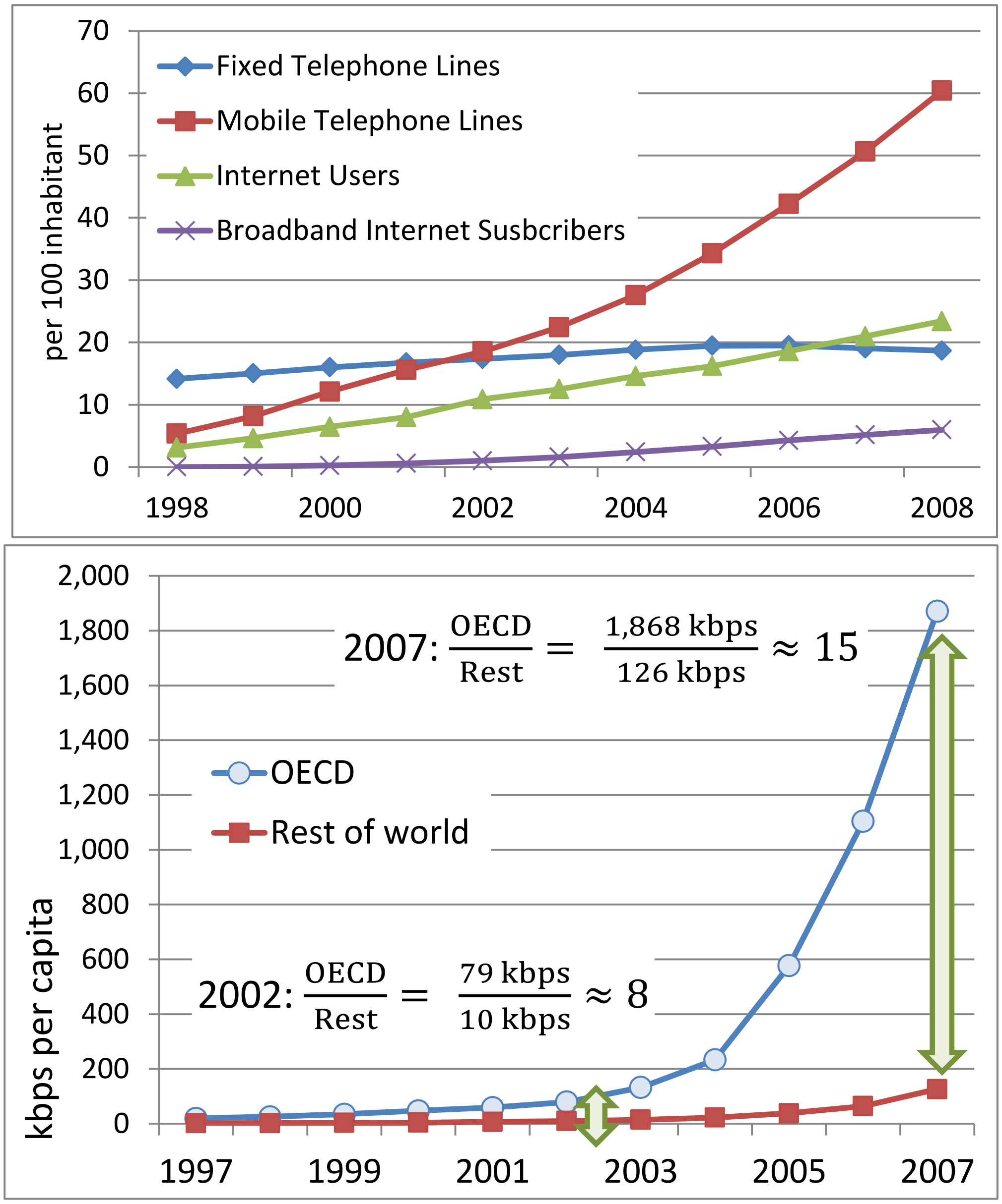
Another, maybe more justifiable way of considering a combination of different technologies into a single indicator is to measure them in terms of their performance, measured in [MB], [MIPS] or [kbps] (Hilbert, López & Vasquez, 2010; Hilbert & López, 2011a). This implies not only to count the number of devices, but to multiply them with their informational performance (Hilbert & López, 2011c). The resulting sum provides insight into the technological capacity to process information. Fig. 7 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). Fig. 7 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

[3] 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.

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 Fig. 5).

Fig. 6: Diffusion of most common ICT with individuals. Fig. 7: 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 Fig. 5, 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

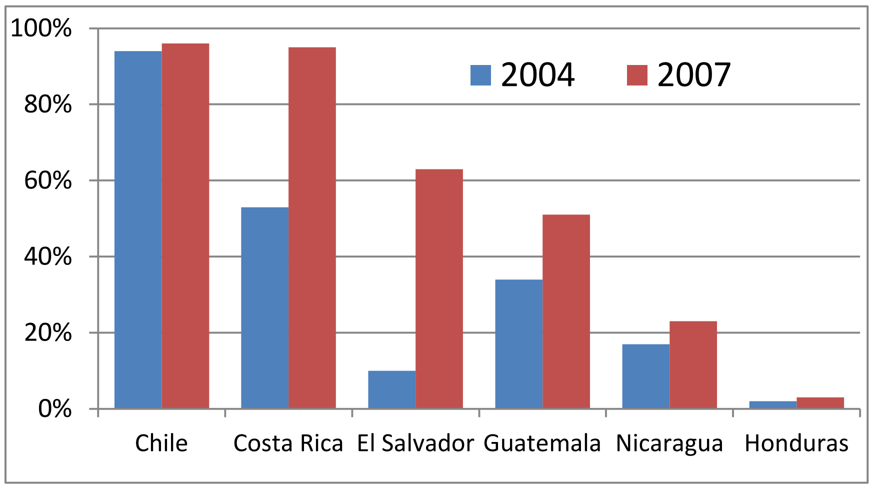
As seen, different definitions of the technology in question can lead to different conclusions about the digital divide. Depending on the chosen technology, the divide can at the same time be closing and widening. The same differences in definition also affect the question of who is in charge to confront 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.

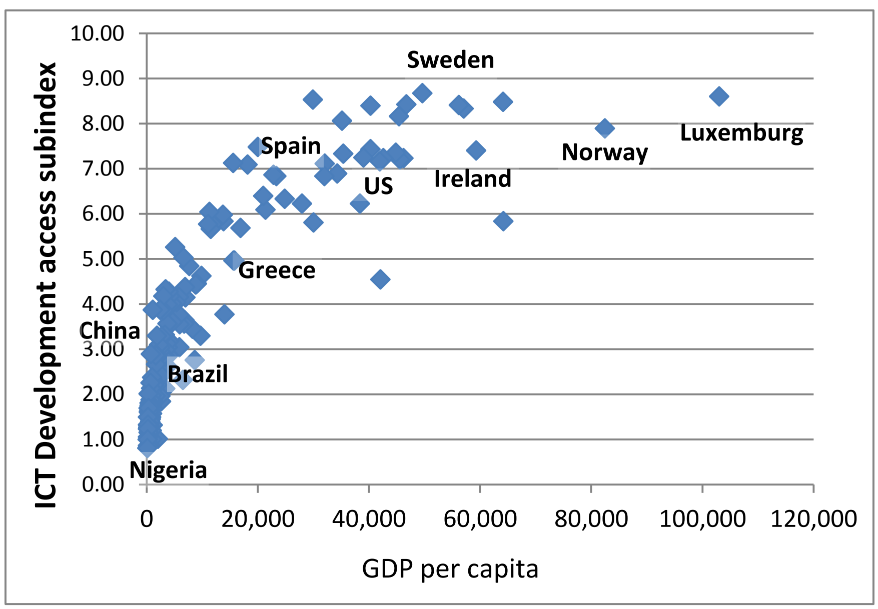
3.2. Choice of subject

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. Fig. 6-7 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, Fig. 8 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.

Fig. 9 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).

Fig. 8: Availability of Email in local governments. Fig. 9: Country's access (ICT Development access subindex) and income for 2007 (n=147).





Source: (8) OSILAC, 2007. (9) ITU, 2009. Note (9): 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)[4]; several regional action plans, such as in Europe[5] and Latin America[6]; national policy strategies (e.g. ECLAC, DIRSI, & UNDP, 2008; Guerra & Jordan, 2010), and local strategies[7]. 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.

3.3. Attributes of nodes and ties

Fig. 9 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. Fig. 5 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. Fig. 5 suggests that

[4] 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.
[5] 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
[6] 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
[7] For example, Iberomunicipios (http://www.iberomunicipios.org) is a network of hundreds of municipalities and local e-government initiatives throughout Latin America and Europe.

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.

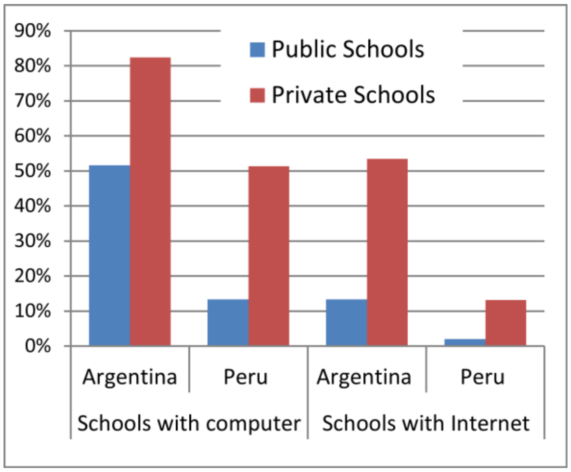
Fig. 10 shows the digital divide between public and private schools in Argentina and Peru. Here the nodes are schools, the chosen technologies are computers and the Internet, and the additional attribute is related to the type of ownership of the educational establishment. In reality, each node has an 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. Fig. 10 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.

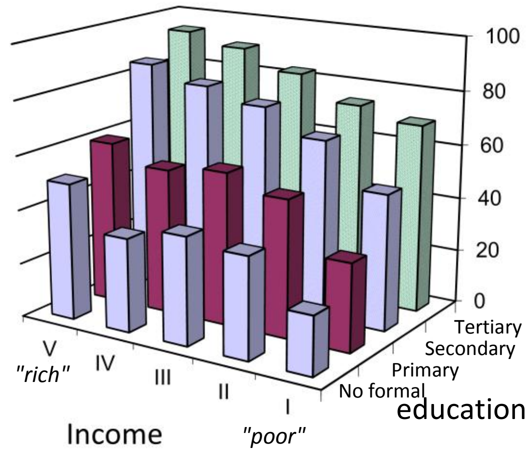
Fig. 11 shows the diffusion of mobile telephony in Brazil according to two different attributes: income and education of individuals. It can be seen that both attributes have independent effects: at the same level of income, access grows with increasing education, and independent of education, access 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.

Fig. 12 presents a multivariate discriminative analysis of ten attributes of individuals, testing for household Internet access.[8] 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 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.

[8] 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).

Fig. 10: Computer and Internet access in schools (2004/5). Fig. 11: Mobile penetration in Brazil (2005). Fig. 12: 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[9] (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 Fig. 5, 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.[10] 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 Fig. 12: 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 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). Fig. 12 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

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[9] 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).

[10] 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.

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.

3.4. 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.[11]

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 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 Fig. 6-7). Fig. 13 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 (Fig. 13). 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.

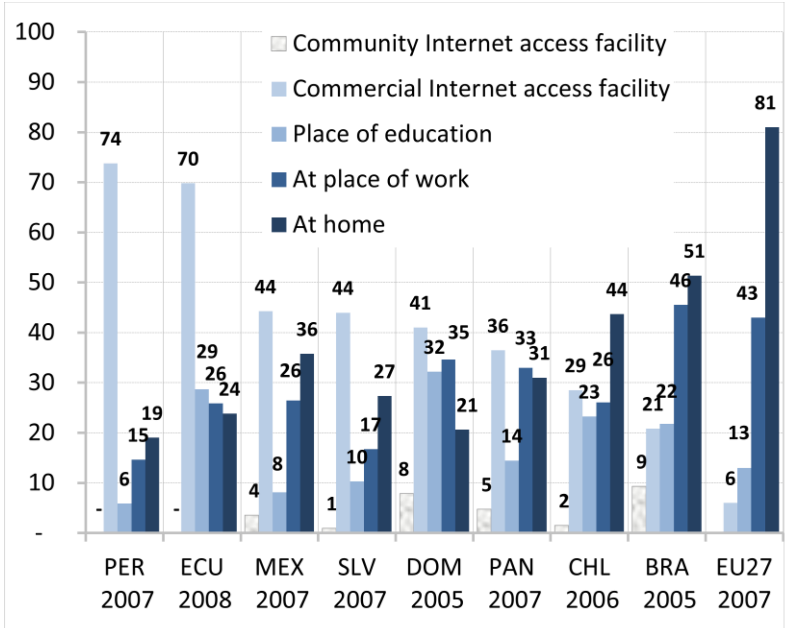
The step from access to usage refers to Rogers' stages (iv) and (v) and is also not free from ambiguities. Fig. 14 compares the usage pattern of some Latin American countries

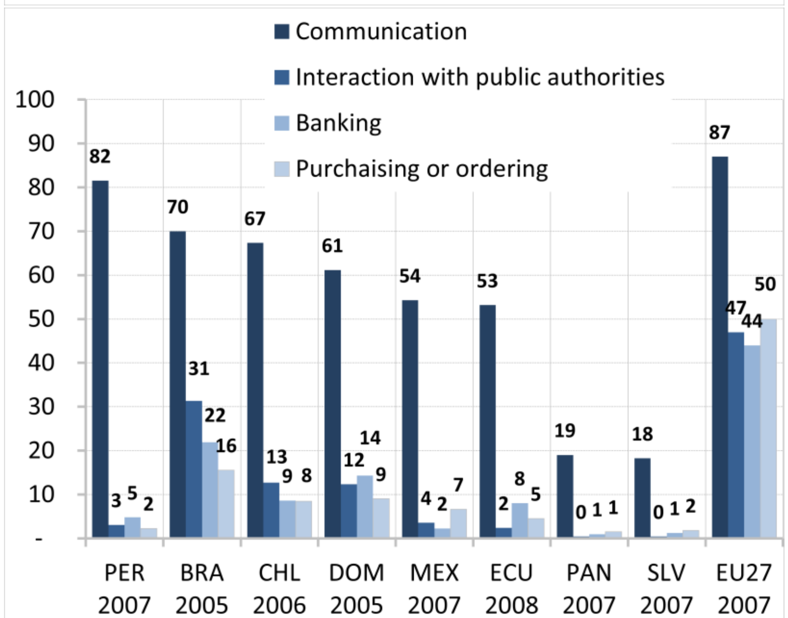
[11] This then often results in feedback that goes back to shape the very nature of the technology (for example by users demanding a particular kind of technology from manufacturing companies; von Hippel, 2005).

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).

Fig. 13: ICT access at different locations. Fig. 14: 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).[4] 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.

3.5. *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 (Fig. 5). 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 Figs. 6-7). 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 Figs. 8-9). 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 Figs. 10-12). 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 Fig. 14). In short: the end determines the definition of choice.

4. 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.

4.1. 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.[12]

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 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.

4.2. 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

[12] 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.

Chilean Digital Agenda.[13] 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 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.[14] 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 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.

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[13] 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.

[14] 163/4.86 = 33.6; or with a broader definition of ICT spending, including salaries: 205/4.86 = 42.

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.

4.3. 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.[15] 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-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.

4.4. In search for evidence of impact of a common outlook

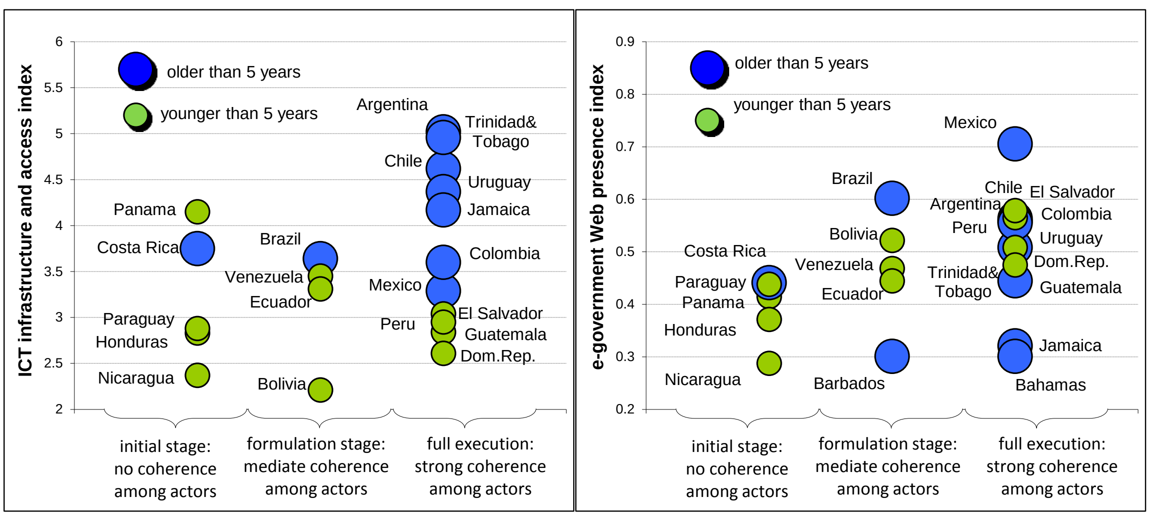
These examples point to the usefulness for one common and coherent strategy to confront the multiple challenges of digital development. With this in mind, many countries have started attempts to unify and streamline the different visions by bringing ICT policy under one common and coherent umbrella with 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;

[15] 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.

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, Figs. 15-16 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. Fig. 15 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.

Fig. 15: ICT policy coherence versus ICT infrastructure and access index, 2007. Fig. 16: ICT policy coherence versus online presence of e-government index, 2007.



Sources: (15) 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. (16) 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.[16] Figs. 15-16 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 Fig. 15). Infrastructure deployment is a very concrete 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 Fig. 16. Something similar accounts for Bolivia. The country has long struggled with the development of vibrant ICT infrastructure (ITU, 2001) (see Fig. 15), but has successfully set up relatively well-working e-government online content (ADSIB, 2010) (see Fig. 16). 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 Figs. 15-16 supports this intuitive idea. However, this effect seems to be merely secondary to the provision of concrete and tailor-made solutions for particular challenges.

[16] Note that Figs. 15-16 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.

5. 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.[17] 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.

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

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