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# DIGITAL POVERTY: CONCEPT AND MEASUREMENT, WITH AN APPLICATION TO PERU

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## ABSTRACT

This paper discusses the notions of demand, poverty, information needs, and information and communication technologies (ICTs) to offer a concept of digital poverty, which may be useful to estimate the digital poverty level in Latin America and the Caribbean. The paper is composed of two sections. The first section contains a conceptual discussion of digital poverty, its types and possible levels, and the underlying economic foundations. ICTs are defined based on their use and the conditions for such use. Digital poverty is therefore defined as a lack of ICTs and might be a feature of any population segment, whether or not economically poor. The second section of this paper is an empirical attempt to validate the classification, using data from a household survey (ENAHO) carried out in Peru. The limitations in measuring digital poverty at the household level instead of at the individual level are acknowledged. Lastly, the conclusions reached, possible implications for public policy, and the avenues open for further research are presented.



## RESUMEN

En este documento, discutimos las nociones de demanda, pobreza, necesidades de información y tecnologías de información y comunicación (TICs) para ofrecer el concepto de pobreza digital, que puede ser de utilidad para estimar niveles de pobreza digital en América Latina y el Caribe. El trabajo tiene dos secciones. La primera contiene la discusión conceptual sobre pobreza digital, sus tipos y posibles niveles y los fundamentos económicos subyacentes. Se define las TICs en cuanto al uso y condiciones para dicho uso. La pobreza digital es definida así como una carencia en TICs y puede ser característica de cualquier segmento de la población, sea o no pobre económico. En la segunda parte, el concepto y las clasificaciones resultantes son probados utilizando los datos de la encuesta de hogares (ENAHO) en el Perú, reconociendo los límites de una medición por hogar en lugar de por individuos, como propone el marco conceptual. Las conclusiones y las líneas de investigación que este trabajo inicia, cierran el texto.

## INTRODUCTION

This paper is the first step of a more comprehensive work, which intends to analyze the demand for *information and communication technologies* (ICTs) to better design policies aiming at increasing coverage and fostering productive use of ICTs among the more marginalized people of Latin America and the Caribbean. It is developed as part of a broader effort undertaken by the Regional Dialog Network on Information Society (Diálogo Regional sobre Sociedad de la Información, DIRSI), which brings together researchers from the region, with the coordination of the Institute for Connectivity in the Americas.

Several topics must be defined and discussed when posing the issue of increased and better use of ICTs for the region's poor.[1] One issue is the availability of ICT goods and services. This aspect is called the supply side of the problem and requires looking at physical connectivity aspects as well as availability of radios, TV sets, and computers.

The use and purchase of ICT goods and services is another important issue. This is the demand side of the problem and requires an examination of actual usage, affordability and individual capabilities. This is the approach I take in this paper, and it should begin with the definition of the product, or service, demanded; thus, a definition of ICTs is pertinent to this analysis.

Considering the issue from the ICT demand perspective, we must study in depth one of the key factors of market demand: family (or individual) income level and its distribution within the population. The approach allows us to extend the discussion of the relationship between poverty and ICTs towards a concept that has not been sufficiently discussed: "digital poverty"—i.e., the lack of goods and services based on ICTs.

This lack of goods and services can at the same time be analyzed from two different perspectives. One is ICT demand from the marginalized sectors, or low-income/economically poor people's lack of ICTs. This is the most common point of view (Nyaki, 2002) and leads us to study the role of ICTs in overcoming economic poverty and including the traditionally marginalized sectors.

However, from another perspective, it is relevant to analyze how much the demand for the service is characterized by a set of joint or sequential consumption

variables, which help define digital poverty, as I refer to it in this paper. This approach forces us to pay attention to all individuals in the population, who for different reasons neither use nor demand ICTs.

The concept of "digital poverty" is not frequently mentioned in discussions of the issue.[2] "Digital divide" is the most used concept, generally understood as measuring the inequalities in ICT access and use of ICTs at household or country levels.[3] Contrary to the divide concept, the digital poverty concept tries to find the minimum ICT use and consumption levels as well as income levels of the population necessary to demand ICT products. Since the concept of digital poverty encompasses both functionality and connectivity, it also goes beyond the concept of "digital illiteracy."[4]

The practical consequences of the two approaches are clear. By establishing a minimum basket of goods and minimal functionalities allowed by the technologies and services, the digital poverty concept helps to specify clear goals, which can be easily adapted to particular countries. The gap concept, on the contrary, is elusive since relative differences will always exist, due to both cultural and income differences among countries coupled with technological improvements in telecommunication services.

This paper is organized in two parts. The first part lays out our understanding of digital poverty and consists of a conceptual discussion of the issues underlined in this introduction. The second part attempts an application of the conceptual framework proposed. We used the National Survey of Living Standards in Peru (ENAHO), which allowed us to focus on one ICT aspect: connectivity. This application showed interesting results, despite database limitations. The paper ends with conclusions and research areas for further study.

## PART ONE: DEFINITION OF DIGITAL POVERTY

Defining digital poverty, or any kind of poverty for that matter, requires defining a threshold, in this case along a continuum of potential consumption of ICT goods and services. With this understanding, it is interesting to begin explaining the conceptual framework with a discussion of the economic concept of demand.

## Economic Concept of Demand[5]

Demand, as understood by economists, is defined as the amount of a good/service people are willing to buy at a certain price. Demand is therefore a concept affected by buying power—without it, a person may have needs but not demand. Buying power is, in turn, affected by the consumer's income. With insufficient income, demand can be null or reduced, even if the need is urgent.

Demand or buying power for a good/service arises from the consumer's preferences for specific goods or services. Thus, two issues become relevant in the analysis: defining a good and studying how the consumer orders his/her preferences for such good in relation to other available goods.

The definition of a good plays a vital role when establishing consumer preferences. Defining a good means knowing what it is, knowing its use, and knowing the disadvantages (or costs) associated with its consumption, which means understanding the full benefits of its consumption. Defining a good is equivalent to defining a group of attributes or features of such good that fulfill a consumer need. Demand arises then from previous knowledge and a subjective evaluation of the advantages (benefits) and disadvantages (costs).

Those who do not know the service or who do not have buying power will not have demand. Hence, advertising is extremely important when introducing new products. One can enter a vicious circle: the most excluded within marginalized sectors, with no access to information, will never have demand, because they will never know the benefits of the service.

The theory of consumer demand leads us to pose several questions regarding our research, among which I would like to mention only three. A first question refers to the definition of ICTs: what they are, what type of good/service they are, the set of attributes that can be associated with them, the possibility of identifying a hierarchical order within this set. An additional question will explore the income level needed for ICT demand. Finally, the concept of digital poverty is discussed, in relation to lack of ICTs.

## ICTs as Goods or Services in Demand

In order to talk about digital poverty, the understanding of ICT services, or lack thereof, must first be laid out. The definition used in this paper brings together a variety of attributes associated with ICT[6] use and consumption:

- Connectivity. A means of communication is necessary. This includes end-user equipment and fixed or wireless networks. Connectivity needs will be met by having access to and using radio receivers, television devices, fixed or mobile telephone services, and/or computers.
- Communication. It may be one-way or two-way communication. This defines the type of connectivity and the use of the information involved. For instance, traditional television gives information but does not allow for information exchange, unless another means is used.[7]
- Information. At the same time, information is divided into creation, storage, diffusion, exchange and consumption. It is important to note that information has both private and public components. As a public good, information—once available—generates benefits that are not exclusive, i.e., that are not diminished when shared, which is why we tend to make available less information than would be efficient.

In this paper, ICT demand will be understood as the demand for these attributes, which may be fulfilled through the consumption of goods and services with such attributes, or through the consumption of a subcategory of such products. ICT demand makes explicit the demand for the information and communication ICTs offer. Therefore, the technologies simply mediate the human need for information and communication.

## Economic Poverty

To be complete, it is important to discuss the concept of poverty and the ways to measure it. In this section, we briefly review this important concept.[8]

The concept of poverty has a counterpart in the concept of welfare or well-being. Thus, somebody who lacks well-being is considered poor.[9] There could be several aspects from which to examine, or assert, well-being, as the quality of human life can be affected by different variables. Therefore, one could talk about income poverty, or human

development poverty, or poverty in abilities. While income, or economic, poverty includes the monetary aspect, as the inability to buy goods and services to attain well-being, human development poverty focuses on the dimensions that affect the personal ability to attain well-being, such as health, education, etc.

Since it is easier to measure and relate to other economic variables, most studies put the emphasis on economic poverty. This, in turn, can be subdivided into two categories: extreme poverty and poverty. People, or households, are classified as extremely poor when their income is lower than the expense needed to buy a basket of basic food staples, providing the minimum caloric intake. Similarly, households are classified as poor when the expense needed to buy the basic food basket plus basic transportation, utilities, and other home goods and services is higher than the household income. Recently, the World Bank (2003), as part of the work explaining and setting the Millennium Development Goals, has defined two economic thresholds which can be used in international comparisons. Extremely poor people are defined as those that live under $1 per day; and poor people as those who live under $2 per day.

Economic poverty can also be measured by looking at unfulfilled basic needs. This approach sets a threshold of basic goods and services; if these are not attained, human life is not considered fulfilled. This means looking at whether the members of the household are literate, whether the household has access to running water and electricity, the size of the house and type of materials used, etc. The levels of poverty are set by the number of unfulfilled basic needs: one need unfulfilled means that the person is poor; while extreme poverty is defined when two or more basic needs are unfulfilled.

## Digital Poverty

When introducing the concept of digital poverty, we are concerned not with any particular information or communication, but with data that can be stored, made available, used, and consumed by digital media. Hence, we are introducing a specific dimension: the use of computer or, more generally, digital communication technologies that broaden the equipment's functionality (e.g., the cameras, phonebooks, music players, etc., that are now part of mobile phones) in order to facilitate information and communication.

In this approach, digitally poor individuals lack the information and communication enabled by digital technologies due to a lack of knowledge on how they are used, or a lack of income (a demand consideration). Technologies are the means but, at the same time, their availability is the most visible component of the demand that can be estimated.[10]

Therefore, digitally poor individuals are not only low-income or people with unfulfilled basic needs with no ICT access or use; digitally poor individuals may also include people who could not be called poor when their economic conditions are evaluated. Thus, there are several types of digitally poor people:

- Low-income or economically poor individuals, who do not have the minimum abilities required to use ICTs, and to whom services are not offered. There is a double restriction for ICT use: supply and ability restrictions.
- Low-income or economically poor individuals with no service available, although they have the minimum abilities required to use ICTs. There is only a supply restriction for ICT use.
- Economically poor individuals who do not have demand for ICTs, although they have the minimum abilities required to use ICTs. It is precisely their lack of income that shuts them out from ICT demand. There is a demand restriction for ICT use.
- Individuals who are not economically poor but have no demand because they lack the minimum abilities required. This type of poverty appears more clearly as a generational gap.

Taking into account this approach, marginalized sectors with low income are not the only digitally poor individuals. Digitally poor individuals may be those who do not use ICTs due to lack of services or lack of use abilities. We will use four variables to define digitally poor individuals:

1. Age. The hypothesis states that the older the person is, the more likely he/she will be a digitally poor person. It is a way of measuring human capital.
2. Education. The hypothesis states that the higher a person's educational level is, the less likely he/she will be a digitally poor person. It is the most common way of measuring human capital.

3. Available Infrastructure. Radio, open television, fixed and mobile telephone services, cable television, computers, and Internet access are taken into account.
4. Accomplished Functionality. Functionality refers to the uses given to technology: from the mere reception of information to the full interaction involved in electronic forms of government or commercial purchases, as well as the creation of content.

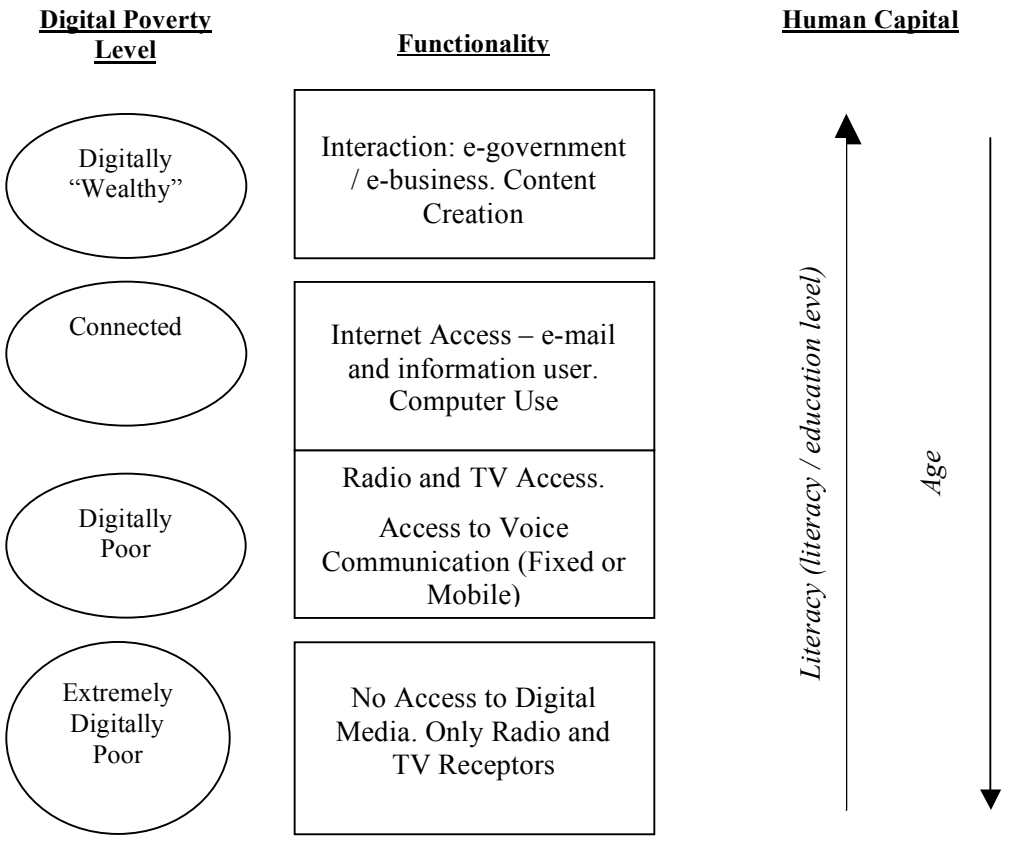
Using these four variables, it is possible for us to establish four possible categories of digital poverty:

1) The extremely digitally poor person will typically be someone who uses technology for the reception of information. This may be due to lack of knowledge of its use or lack of communication services. However, even when services are available, the person's age and learning ability may hinder his/her knowledge to fully use the equipment.
2) Digitally poor people have communication media available, so they can receive information and can communicate. However, digital media use is limited due to a lack of supply or human capital, low level of education, a high degree of illiteracy, or older age.
3) Connected people. They have Internet access and their use is passive. This means that Internet access and use substitute for traditional types of information consumption or communicating in general, instead of changing the way people interact with information providers.
4) Digitally wealthy people. They have Internet access and their use is active, since the individuals in this group have the knowledge needed to make transactions or to take advantage of the government's electronic applications, or other forms implying interaction or active use of ICTs.

The taxonomy cannot be rigid if it intends to be useful. Two variables allow for a more flexible taxonomy: age and economic poverty. On the one hand, economically poor young people living in areas with no connection (supply problem) can not possibly belong to level 4, although they may be perfectly capable of actively using ICTs. On the other hand, it is difficult for elders who are not poor to be classified at level 4, for the usual difficulties in the learning process by older people.

This discussion is summarized in Figure 1, which lists some considerations taken into account when classifying digital poverty levels, using the arrows located at the right to show the variables of human capital. These show greater digital wealth with higher educational levels and lower digital wealth with older age.

**Figure 1: Digital Poverty Level**




When compared to the methodologies used to measure economic poverty, briefly reviewed in the previous section, the approach used for measuring digital poverty is more similar to the unfulfilled basic needs approach than to the consumption deficit one. An individual who does not fulfill communication and information needs through digital means will be considered an extremely digitally poor person.

Our approach requires researching ICT use, in order to determine not only the connectivity component, which is the most studied, but also actual use. In other words, if ICT demand is understood as a demand for connectivity attributes, information consumption, and information and communication availability, the measurement of digital poverty should estimate the dimensions of each attribute for every individual, and determine the person's fulfillment, or lack thereof, in each aspect.

This approach is useful in several respects. It begins with a definition of minimum ICT goods and services, so that policies can be better oriented as to the minimum supply that should be attained through public policies. Using gap analysis, policies are aiming at a moving target, since gaps may never close. Another useful aspect of the approach is the importance given to people's capabilities and ICT functionalities. Policies that rely mostly on the ICT supply are questioned, since they may prove ineffective in taking people out of digital poverty. And, by emphasizing ICT use (or the functionality attribute), specific policies can be designed so as to broaden effective consumption of ICTs.

## PART TWO: APPLICATION TO PERU

In order to illustrate the possible applications of this conceptual framework, I used the Peruvian National Survey of Living Standards (ENAHO)[11] of 2003. There are two major constraints in this exercise. Firstly, it should be noted that ENAHO gathers socioeconomic household information, while the conceptual framework proposed applies to individuals. Secondly, ENAHO will only allow us to analyze *access* to ICTs, while the conceptual framework hinges upon *uses* of ICTs, or functionalities accomplished for those individuals. Therefore, the outcomes of this exercise are merely illustrative of the type of analysis enabled by the conceptual framework, as we can only observe the ICT connectivity attribute, but not the reception/diffusion attributes of information and/or communication.

With that point clear, I used ENAHO for two purposes: Firstly, to apply the conceptual framework to learn the distribution of Peruvian households along the digital poverty classification proposed in this paper. Secondly, to test simple hypotheses as to

what can explain the connectivity dimension of digital poverty and the different levels of digital poverty among Peruvian households, following the conceptual framework presented.

## Levels of Digital Poverty among Peruvian Households

Let us examine the results obtained, selecting 16,894 households, that is, households with complete answers regarding having and accessing ICTs.[12] This universe will be known as a "selected sample." I first classify the households according to their poverty level, measured by expenditure deficit. Classification outcomes are shown in Table 1. About 48% of the households qualify as poor households, and 18% of the households in the nation are considered extremely poor, that is failing to earn enough income to buy a basic food basket. Also in Table 1, we can observe that the classification of our selected sample closely matches that of the whole sample, although one can find less extremely poor households in the selected sample.

**Table 1**

**Poverty in Peruvian Households**

| Poverty Level | Selected Sample | | Total Sample of ENAHO | |
|---|---|---|---|---|
| | No. Obs. | (%) | No. Obs. | (%) |
| **Extremely Poor** | 2 972 | 17.59 | 3 424 | 18.1 |
| **Not Extremely Poor** | 4 824 | 28.55 | 5 158 | 27.27 |
| **Not Poor** | 9 098 | 53.85 | 10 330 | 54.62 |
| **Total** | 16 894 | 100 | 18 912 | 100 |

Source: ENAHO 2003 (INEI 2003).

I then classified the households according to their digital poverty level by looking at the connectivity attribute discussed in the previous section. The extremely digitally poor households are those that do not have access to voice communication or Internet in telecenters,[13] and own only radio and/or TV sets. Clearly, in this situation digital means are not used to obtain information or effect communication. Digitally poor people do not

use the Internet but they do have access to voice communications.[14] The connected have Internet access only in telecenters, and the "digitally wealthy" are those who own a personal computer and have Internet access in the household.

Before going on with the classification results, a note is in order regarding telecenters in developing countries.[15] Telecenters are the way that Internet access has expanded in less developed countries (LDC). These are usually small businesses where several computers are located; access is obtained by paying an hourly fee, usually a very low one.[16] The expansion of telecenters depends on the availability of high-speed connectivity and telecommunications infrastructure in general. When telecenters are available, people do not need to own a computer to access the Internet, thus easing access because computers are extremely expensive in LDCs.

When applying the classification framework, I found that the strict application of the criteria could make us lose sight of an important group of households.[17] In particular, the conceptual framework proposes a classification with increasing connectivity and ICT use, but Peruvian households show more Internet access in telecenters than residential phone use.[18] Therefore, if the connected group had included only those who have a telephone at home and access the Internet only in telecenters, I would have missed more than 10% of the households participating in the survey. Taking this into account, I defined a pair of subgroups within those households classified as "connected," taking into account whether or not they have any kind of residential telephone services. The "connected households 1" are those that do not have telephones and that access the Internet only in telecenters.[19] The "connected households 2" are those who have any kind of telephone, fixed or mobile, and who have Internet access only in telecenters. The criteria for the selection of the groups are shown in Table 2.

**Table 2**

**Household Classification Criteria According to Digital Poverty Level**

| | Owns Radio and TV set | Owns Telephone | Uses Internet in Telecenters | Has Computer and Internet in Household |
|---|---|---|---|---|
| Extremely Digitally Poor | P | X | X | X |
| Digitally Poor | P | P | X | X |
| Connected Household | | | | X |
| Connected Household 1 | P | X | P | X |
| Connected Household 2 | P | P | P | X |
| Digitally Wealthy Household | P | P | P | P |

Once this adjustment was made, I could proceed with the classification. Table 3, which shows the results of the grouping by both digital and economic poverty levels, provides relevant information from our analysis. The first fact that attracts attention is the importance of households classified as extremely digitally poor, since over 68% of the households are basically receptors of information by means of radio and TV.

The second important note is the small number of households with Internet access at home: less than 1% of the sample, which represents the national level. This figure is even less than the proportion of households classified as "extremely wealthy" in socio economic groupings.[20] As opposed to ownership of TV or radio sets, absolutely widespread among the population, computer ownership is very limited and may be taken as a signal of wealth.

Thirdly, it is important to notice that only one out of four households has Internet access either at home or through telecenters.[21] Although Peru is usually given as an example of the expansion of telecenters, they have yet to serve as an effective tool for attaining universal internet connectivity.

Fourthly, even if there is a strong connection between economic and digital poverty, there is no exact correspondence. Among the extremely digitally poor households, over 40 percent are not economically poor; and among those who do not

have Internet access by any means (digitally poor people) there is a predominance of not poor households (83%). Confirming our initial intuition, digital poverty is not a phenomenon restricted to economically poor people.[22]

Finally, the characteristics of "connected households 1," those with no telephone but with Internet access in telecenters, attract attention, as the proportion of economic poor households is greater (33.45%) in that group than among the digitally poor households (16.07%). This may suggest that in LDCs with low telephone penetration,[23] a direct jump into the Internet as the main telecommunication service may be observed. This fact may have important public policy consequences.

**Table 3**

**Digital and Economic Poverty Level of Peruvian Households**

| Digital Poverty | No. of Obs. | (%) | Economic Poverty | | | |
|---|---|---|---|---|---|---|
| | | | Extremely Poor Household | Not Extremely Poor Household | Not Poor Household | |
| Extremely Digitally Poor Household | 11 503 | 68.09 | *24.90*<br>96.37 | *32.91*<br>78.48 | *42.19*<br>53.34 | *100* |
| Digitally Poor Household | 1 352 | 8.00 | *0.59*<br>0.27 | *15.75*<br>4.42 | *83.65*<br>12.43 | *100* |
| Connected Household | 3 976 | 23.54 | *2.52*<br>3.36 | *20.75*<br>17.10 | *76.74*<br>33.53 | *100* |
| Connected Household 1 | 2 260 | 13.38 | *4.38*<br>3.33 | *29.07*<br>13.62 | *66.55*<br>16.53 | *100* |
| Connected Household 2 | 1 716 | 10.16 | *0.06*<br>0.03 | *9.79*<br>3.48 | *90.15*<br>17.00 | *100* |
| Digitally Wealthy Household | 63 | 0.37 | *0*<br>0 | *0*<br>0 | *100*<br>0.69 | *100* |
| Total | 16 894 | 100 | 2 972<br>*17.59*<br>100 | 4 824<br>*28.55*<br>100 | 9 098<br>*53.85*<br>100 | *100* |

Source: ENAHO 2003 (INEI 2003).

***Basic Characteristics of Each Group***

Before explaining the classification of the households in each group, let us briefly describe the characteristics of the median household, as opposed to the average, in each group. As opposed to the statistics describing the average household, which may or may not exist in fact, the median household is the actual household that divides the examined category into half. When facing heterogeneity within a group, it is advisable to use the median instead of the mean.[24]

The median household of the extremely digitally poor has four members, two of whom are income earners. It has one child and one young person (11–28 years of age). The household head is 46 years old. The median income for this group is 617 soles monthly, or about $180, and half of that is spent on food. This level of income is well above the poverty line in Peru, established at $61 per month.

The median household of the digitally poor also has four members, two of them being income earners; one is a child and the other is a young person. The household head is older (51 years old) than for the previous group. The monthly median income is $468, and a third of it is spent on food.

The median household for those classified as "connected households" is larger: five members, two of whom are young (13–28 years old). In the "connected 2" group, there is one more person, an income earner (for a total of 3), compared to the "connected 1" group (where there are 2 total). The head of the "connected 1" household is younger (46 years old) than in the "connected 2" (50 years old). The big difference in the median household for these two groups lies on the level of monthly income: lower for "connected 1" (approximately $378) than for the "connected 2" group $631). Let us notice that the income level for the "connected 1" median household is even lower than for the digitally poor.

Finally, the digitally wealthy median household has a total of four members: two young persons, one adult (29–49 years old), and one older adult (50 or more). Out of the four, two are income earners The head is 50 years old. The income level is much higher than in the previous groups: $1480 per month.

***Econometric Approach***

I also attempted to explain the probability of a household belonging to each of the groups, based on basic household characteristics. Although this may not represent a strict application of the conceptual framework developed, which requires learning the ICT functionality for each family member, this exercise helps in giving evidence about key variables explaining the connectivity attributes of households that may contribute in shaping policy emphasis.

Since the framework proposes an ordered classification, in which classification in one group means a specific position in a ranking was attained, I used the generalized ordered logit (*gologit)* tool.[25] This is a special case of a regression where the endogenous variable is discrete, in two respects. Firstly, the dependent variable attains different values depending on a specific position in a ranking, which in turn reflects an ordinal classification where higher values for the dependent variable means a better state. Secondly, the gologit allows for different coefficients for the dependent variables in each grouping, meaning that the independent variables affect the dependent variable differently.[26]

Our hypothesis explaining household position in the ordered classification rests on three variables: economic poverty, human capital, and supply characteristics. The empirical importance of any of them could guide policy makers into prioritizing specific policies to reduce the level of digital poverty among the population. Let us examine each of our variables in detail.

*Economic poverty* is a main determinant of the possibility of the household accessing the means to obtain connectivity. Whether it is buying a TV set or an Internet connection at home, how economically poor a family is determines that access. The hypothesis is that, ceteris paribus, the poorer the household, the higher the probability of it being classified as digitally poor.

I used three indicators of economic well-being. The first is the most commonly used to measure economic poverty: household income. I took the natural logarithm to smooth out the variable. The second indicator is whether the household head works in the service sector. The service sector includes all the activities comprising independent laborers, such as different types of repair activities, which are very important in LDCs,

particularly among the poor. In these types of activities having connectivity, so that the person can be called upon to perform the work, is fundamental to subsistence. Finally, I used the number of income earners, indicating the ability of the household to rise out of poverty by having more people contributing income to finance family expenses.

In the framework developed, *human capital* is an important variable for determining the classification of individuals into a particular level of digital wealth (or poverty). As explained, human capital works in two different ways. On the one hand, the level of education helps people accessing and utilizing technology, so the attainment of a higher level of education is associated with a higher level of digital wealth. Therefore, I used the maximum education level attained by any household member, with the hypothesis that the higher the education level, the more likely it is for the household to be digitally wealthy. I also control for illiteracy in the household, using a dichotomous variable indicating whether there is at least one family member that is illiterate (=1), or not (=0); expecting that households with illiterate members will be digitally poorer than others.

On the other hand, age runs the opposite way: the younger you are the more probable it is that you are familiar with and use ICTs. Therefore, I used the following indicators: the age of the head of the household, expecting that the older the head, the higher the probability that the household is digitally poor; and the proportion of young people (15–28 years old) living in the household, expecting that the higher the ratio, the more likely the household is to be digitally wealthy.

Another dimension of human capital is the type of gender relations within the household. Obviously, this could not be captured in a household survey such as ENAHO. At the risk of oversimplification, I selected a variable that could somewhat capture the importance of women in the household. We used the ratio of males with respect to total household members. Following a tradition of male domination, and the fact that ICT access is mostly performed in the public domain and not in the privacy of the house, the hypothesis was that the higher the ratio, that is the more males are present in the household, the higher the level of digital wealth would be.

It is important to control for supply conditions, specifying as much as possible the estimated model. Given the conditions in Peru and the level of infrastructure deployment,

the geographic region was included as a control variable, specifying whether the household is located in the jungle or on the highlands or coast: the hypothesis being that households located on the coast will have better access. The population density is also considered important, and the specific location, either rural or urban, was also included in the set of control variables. Additionally, to approximate the possible supply of Internet access, I used the household connection to the national electricity grid. Finally, I built up a proxy for Internet access supply, by identifying whether the household is located in a district capital, since a specific policy had been implemented to provide Internet access in every capital district in Peru.

All this information and the way the indicators were measured are presented in Table 4.

The econometric results for the generalized ordered logistic model, using the "autofit" option, are shown in Table 5. The estimation is done by groups and is cumulative, i.e., the extremely digitally poor are run against all the other categories; the extremely digitally poor and the digitally poor taken together are run against the three remaining categories and so on. That is why only four categories appeared reported in Table 5. While using the "autofit" option, the program selects independent variables for which coefficients do not vary across groups. The econometric results mostly confirm our initial hypotheses.

**Table 4**

**List of Variables, Measurement, and Expected Sign**

| Theoretical variable | Variable | Indicator | Expected sign |
|---|---|---|---|
| ***Explained Variable*** | | | |
| **Level of digital poverty** | Probability that a household belongs to a specific category of digital poverty | 1=extremely digitally poor, 2=digitally poor , 3=conected1, 4=conected2, 5= digitally wealthy | |
| ***Explanatory Variables*** | | | |
| **Economic poverty** | Income level | Total net household income | + |
| | Economic activity | Household head's main occupation 0 = Non-service sector 1 = Service sector | + |
| | Number of income earners per household | Number of income earners per household | + |
| **Human Capital** | Age | Age of head of household | - |
| | | Ratio number of youngsters (ages 13–28) to total number of household members | + |
| | Gender | Ratio number of males to total number of household members | + |
| | Quality | 0 = Household with no illiterate members 1 = Household with at least one illiterate member | - |
| | | Years of schooling attained by the member with the highest level of education | + |
| **Supply** | Zone | 0 = Rural 1 = Urban | + |
| | Region | 1 = Amazon 2 = Highlands 3 = Coast | + |
| | Electricity | Access to the national grid 0 = Does not access 1 = Access | + |
| | Internet supply | Availability of Internet in the district 0 = No availability 1 = Availability | + |

The probability of "stepping up the ladder" on the digital poverty classification is higher if income is higher, if employment is in the service sector, and if there are more income earners in the household. Regarding our human capital indicators, the

econometric results mostly confirm our initial hypothesis. Digital poverty will be more likely the older the household composition, the less educated the family head, if there is a family member who is illiterate, and if there are proportionally more males in the household. This last result contradicted our expectation and indicates a further line of research as to why, ceteris paribus, more access to new information and communication technologies is better explained by having relatively fewer men in the household.

Our indicators for supply conditions also confirm the initial intuition. It is less likely that a household is digitally poor if its members live in an urban area on the coast, if the electricity supply comes from the national grid, and (obviously) if there are telecenters in the district.

Since we have a set of four regression coefficients, further analysis is necessary. Firstly, using the "autofit" option lets us know which independent variables have the same effect, regardless of classification.[27] These variables are: household head participating in the service sector, presence of illiterates in the household, and maximum years of schooling of the most educated member of the household.

Secondly, as the household steps up the ladder of digital wealth, some variables lose importance as determinants of digital poverty. This effect is most acute for the human capital variables such as age and gender, but not for education. The same effect arises for the supply variables. Basically, digital wealth relies on income and education.

As we know, we can learn about marginal effects, i.e., by how much the probability of belonging to a specific category changes, with a 1% change in the independent variable. Thus, the value of the marginal effects show the importance of a particular variable: a higher value of a marginal effect means that changes in that variable affect more strongly the probability of belonging to a specific group. This information is presented in Table 6. Extreme digital poverty digital is most influenced by presence of youngsters, income, and region, in that order. Digital poverty in turn depends most heavily on living in an urban area, income, and presence of youngsters. For being connected 1, the presence of youngsters is most important, living in urban areas, second, while income and gender come in third. Access to the national electricity grid and residence in an urban area are most important for being connected 2. These results confirm that digital poverty transcends economic poverty: more income will not

necessarily assure coming out of digital poverty. Household composition and supply conditions turn out to be crucial in determining the household position in the ranking.

**Table 5**

**Generalized Ordered Logistic Estimation**

**Explained variable: Probability that a household belongs to a specific digital poverty category**

**1=extremely digitally poor, 2=digitally poor, 3=connected 1, 4=connected 2 , 5=digitally wealthy**

| | Extremely digitally poor | | Digitally poor | | Connected 1 | | Connected 2 | |
|---|---|---|---|---|---|---|---|---|
| Household income | 0.9942978 | *** | 0.7728839 | *** | 1.413938 | *** | 3.125121 | *** |
| | (0.0399) | | (0.0396) | | (0.0477) | | (0.2561) | |
| Household head works in service sector | 0.2252956 | *** | 0.2252956 | *** | 0.2252956 | *** | 0.2252956 | *** |
| | (0.0532) | | (0.0532) | | (0.0532) | | (0.0532) | |
| Number of income earners in household | 0.0253 | | (0.1746) | | -(0.0047) | | -(0.5559) | *** |
| | (0.0222) | | (0.0221) | | (0.0267) | | (0.1366) | |
| Age of household head | 0.0001074 | *** | 0.0000252 | | 0.0001311 | *** | -0.0000443 | |
| | (0.0000) | | (0.0000) | | (0.0000) | | (0.0001) | |
| Ratio of number of youngsters to total household members | 1.520564 | *** | 1.94211 | *** | 1.166516 | *** | 0.5775458 | |
| | (0.0887) | | (0.0918) | | (0.1285) | | (0.5828) | |
| Ratio of number of males to total household members | -0.4722799 | *** | -0.6947856 | *** | -0.8487361 | *** | 0.7748316 | |
| | (0.0903) | | (0.0941) | | (0.1366) | | (0.6578) | |
| Illiterate member(s) in the household | -0.4055122 | *** | -0.4055122 | *** | -0.4055122 | *** | -0.4055122 | *** |
| | (0.0417) | | (0.0417) | | (0.0417) | | (0.0417) | |
| Years of schooling attained by the most educated household member | 0.3711203 | *** | 0.3711203 | *** | 0.3711203 | *** | 0.3711203 | *** |
| | (0.0123) | | (0.0123) | | (0.0123) | | (0.0123) | |
| Region | 0.3641093 | *** | 0.280665 | *** | 0.4483385 | *** | 0.2272541 | |
| | (0.0299) | | (0.0309) | | (0.0438) | | (0.2039) | |
| Zone | 1.272371 | *** | 1.037945 | *** | 1.79648 | *** | 0.9744025 | |
| | (0.0699) | | (0.0779) | | (0.1812) | | (1.0424) | |
| Access to national electricity grid | 0.89096 | *** | 0.7994768 | *** | 2.22699 | *** | 11.2123 | |
| | (0.0872) | | (0.0949) | | (0.4172) | | (378.3278) | |
| Internet supply | 0.5179296 | *** | 0.5184693 | *** | 0.8575958 | *** | 1.326744 | |
| | (0.0640) | | (0.0673) | | (0.1181) | | (1.0459) | |
| Constant | -13.31577 | *** | -12.13187 | *** | -20.6117 | *** | -45.29557 | |
| | (0.2741) | | (0.2700) | | (0.5345) | | (378.3348) | |
| Number of observations | 16,894 | | | | | | | |
| Pseudo R2 | 0.3336 | | | | | | | |

Note: 12 cases with probability less than 0.
Standard errors in parentheses.
*** significant at 0.01 level.

## Table 6

### Marginal Effects

| | Extremely digitally poor | | Digitally poor | | Connected 1 | | Connected 2 | | Digitally wealthy |
|---|---|---|---|---|---|---|---|---|---|
| Household income | -0.1350514 | *** | 0.0677282 | *** | 0.0555302 | *** | 0.0117882 | *** | 0.00000481 |
| | (0.0057) | | (0.0030) | | (0.0036) | | (0.0018) | | (0.0006) |
| Household head works in service sector 1/ | -0.0323893 | *** | 0.0113632 | *** | 0.0189791 | *** | 0.0020466 | | 0.000000379 |
| | (0.0081) | | (0.0028) | | (0.0048) | | (0.0006) | | (0.0000) |
| Number of income earners in household | -0.0034358 | | -0.0117708 | *** | 0.0152454 | *** | -0.000038 | | -0.000000856 |
| | (0.0030) | | (0.0017) | | (0.0019) | | (0.0002) | | (0.0001) |
| Age of household head | -0.0000146 | *** | 0.0000124 | *** | 0.00000111 | | 0.00000109 | *** | -0.0000000000682 |
| | (0.0000) | | (0.0000) | | (0.0000) | | (0.0000) | | (0.0000) |
| Ratio of number of youngsters to total household members | -0.2065319 | *** | 0.0373615 | *** | 0.1594411 | *** | 0.0097285 | *** | 0.00000089 |
| | (0.0123) | | (0.0067) | | (0.0083) | | (0.0017) | | (0.0001) |
| Ratio of number of males to total household members | 0.0641478 | *** | -0.0036275 | | -0.0534414 | *** | -0.0070801 | *** | 0.00000119 |
| | (0.0123) | | (0.0073) | | (0.0079) | | (0.0015) | | (0.0001) |
| Illiterate member(s) in the household 1/ | 0.0559735 | *** | -0.0198986 | *** | -0.0325956 | *** | -0.0034787 | *** | -0.000000643 |
| | (0.0059) | | (0.0021) | | (0.0035) | | (0.0006) | | (0.0001) |
| Years of schooling attained by the most educated household member | -0.0504078 | *** | 0.0180808 | *** | 0.0292317 | *** | 0.0030948 | *** | 0.000000572 |
| | (0.0019) | | (0.0008) | | (0.0012) | | (0.0004) | | (0.0001) |
| Region | -0.0494555 | *** | 0.0250077 | *** | 0.0207084 | *** | 0.003739 | *** | 0.00000035 |
| | (0.0041) | | (0.0025) | | (0.0026) | | (0.0006) | | (0.0000) |
| Zone 1/ | -0.1632173 | *** | 0.0769735 | *** | 0.0715667 | *** | 0.0146757 | *** | 0.00000144 |
| | (0.0084) | | (0.0051) | | (0.0060) | | (0.0022) | | (0.0002) |
| Access to the national electricity grid 1/ | -0.1089508 | *** | 0.046308 | *** | 0.0476017 | *** | 0.0149872 | *** | 0.0000538 |
| | (0.0091) | | (0.0050) | | (0.0062) | | (0.0016) | | (0.0000) |
| Internet Supply 1/ | -0.0647694 | *** | 0.0237055 | *** | 0.0350416 | *** | 0.0060208 | *** | 0.0000016 |
| | (0.0074) | | (0.0041) | | (0.0048) | | (0.0011) | | (0.0002) |

Standard errors in parenthesis.
*** significant at 0.01 level.

## CONCLUSIONS AND PERSPECTIVES

Building upon work in progress carried out by the DIRSI network in Latin America and the Caribbean,[28] I have developed a framework to define and measure digital poverty. As opposed to gap analysis, which measures absolute differences in several characteristics regarding access and use of ICTs, the digital poverty approach tries to set a threshold under which ICT use and access are limited.

The approach I used to measure digital poverty follows the Basic Needs approach to measure economic poverty. That means the different levels of digital poverty are measured by the lack of different kinds of ICTs. Moreover, ICTs were defined as a bundle of attributes, or characteristics, such as connectivity, communication, and information use. A simple classification of these attributes allows us to define four levels of digital poverty: extremely poor, poor, connected and wealthy. I introduced human capital variables, such as age and education, to further refine the classification. Finally, the different functionality of the ICTs, such as reception, content creation, etc., was introduced as a key variable to explain the level of digital poverty.

I used the framework to try to measure digital poverty in Peru using the National Household Survey. Unfortunately, the survey does not collect information on ICT functionality, which is posed as a key attribute of ICT goods and services. As a consequence, the exercise developed in this paper is limited as to the full application of the conceptual framework developed, but very useful in shedding light on the variables relevant to explain the level of connectivity attained by households.

The empirical exercise shows several important facts which may be useful in shaping public policy. Firstly, almost 70% of households are extremely digitally poor, i.e., only receive information through TV and radio sets, and do not have access to the Internet or use fixed or mobile phones. Although the survey does not collect information on access to public payphones, this result is astonishing and should be taken into consideration when shaping policies towards expanding the information society. It calls for attention to be paid to the basics, that is, reaching effective telecommunications connectivity for the whole population.

Secondly, digital poverty does not exactly match economic poverty. There are many more digitally poor households than economically poor ones. Moreover, digital

poverty cuts along economic lines. The converse is not true, however; digitally wealthy households are also economically wealthy ones.

Thirdly, variables such as electricity supply from the national grid, or the location of the household in an urban or rural area are important in explaining the level of connectivity attained. From a public policy perspective, policies to increase telecommunications connectivity should come hand in hand with those aiming at expanding the electricity grid. With a wider perspective, rural development policies should look at the quality of the infrastructure in a particular location.

Fourthly, key variables in explaining digital poverty are the "usual suspects," i.e., income and education, but also the presence of youngsters in a household. Given the population pyramid in Peru, where youngsters outnumber adults, the expansion of ICTs may need to be part of educational policy. Income, while important, is not the main determinant, opening up a whole set of policies relating to inclusion into the information society, which may complement social and poverty alleviation programs.

Besides further exploration of the interesting facts arising from this application to Peruvian households, such as the reduced importance of the presence of males in the household to explain connectivity, this framework needs a comprehensive test. To that end, a comprehensive household survey could be employed, ensuring that information at the individual level is collected and putting emphasis on ICT functionality. This certainly requires collaboration with other disciplines, as measurement of ICT use and interaction—or digital literacy—goes well beyond economists' expertise.

# APPENDIX

## Selected sample descriptive statistics by digital poverty classification

| Extremely digitally poor (N = 11,503) | | | | | |
|---|---|---|---|---|---|
| **Variable** | **Mean** | **Median** | **Std. Dev.** | **Min** | **Max** |
| Household yearly income | 9,127.780 | 7,408.00 | 7,113.856 | 300.00 | 101,353.00 |
| Household head works in service sector | 0.078 | 0.00 | 0.269 | 0.00 | 1.00 |
| Number of income earners in household | 1.750 | 2.00 | 0.910 | 0.00 | 8.00 |
| Household head age | 48.373 | 46.00 | 16.177 | 16.00 | 98.00 |
| Ratio number of youngsters to total household members | 0.243 | 0.22 | 0.243 | 0.00 | 2.50 |
| Ratio number of males to total household members | 0.521 | 0.50 | 0.261 | 0.00 | 3.50 |
| Any illiterate in the household | 0.648 | 1.00 | 0.477 | 0.00 | 1.00 |
| Years of schooling attained by the most educated household member | 5.095 | 5.00 | 1.856 | 1.00 | 11.00 |
| Region | 2.076 | 2.00 | 0.712 | 1.00 | 3.00 |
| Zone | 0.421 | 0.00 | 0.494 | 0.00 | 1.00 |
| Access to the national electricity grid | 0.553 | 1.00 | 0.497 | 0.00 | 1.00 |
| Internet Supply | 0.661 | 1.00 | 0.473 | 0.00 | 1.00 |
| **Digitally poor (N = 1,352)** | | | | | |
| **Variable** | **Mean** | **Median** | **Std. Dev.** | **Min** | **Max** |
| Household yearly income | 20,712.220 | 17,592.50 | 13,053.230 | 304.00 | 108,139.00 |
| Household head works in service sector | 0.168 | 0.00 | 0.374 | 0.00 | 1.00 |
| Number of income earners in household | 2.083 | 2.00 | 1.099 | 0.00 | 8.00 |
| Household head age | 51.599 | 51.00 | 16.378 | 21.00 | 98.00 |
| Ratio number of youngsters to total household members | 0.223 | 0.20 | 0.256 | 0.00 | 2.00 |
| Ratio number of males to total household members | 0.493 | 0.50 | 0.269 | 0.00 | 2.50 |
| Any illiterate in the household | 0.382 | 0.00 | 0.486 | 0.00 | 1.00 |
| Years of schooling attained by the most educated household member | 7.067 | 6.00 | 1.896 | 1.00 | 11.00 |
| Region | 2.567 | 3.00 | 0.697 | 1.00 | 3.00 |
| Zone | 0.953 | 1.00 | 0.211 | 0.00 | 1.00 |
| Access to the national electricity grid | 0.978 | 1.00 | 0.147 | 0.00 | 1.00 |
| Internet Supply | 0.901 | 1.00 | 0.299 | 0.00 | 1.00 |
| **Connected 1 (N = 2,260)** | | | | | |
| **Variable** | **Mean** | **Median** | **Std. Dev.** | **Min** | **Max** |
| Household yearly income | 16,532.540 | 14,223.50 | 10,466.480 | 1,205.00 | 126,703.00 |
| Household head works in service sector | 0.206 | 0.00 | 0.405 | 0.00 | 1.00 |
| Number of income earners in household | 2.438 | 2.00 | 1.180 | 0.00 | 7.00 |
| Household head age | 47.061 | 46.00 | 12.708 | 17.00 | 91.00 |

| | | | | | |
|---|---|---|---|---|---|
| Ratio number of youngsters to total household members | 0.411 | 0.40 | 0.233 | 0.00 | 2.00 |
| Ratio number of males to total household members | 0.506 | 0.50 | 0.217 | 0.00 | 1.50 |
| Any illiterate in the household | 0.388 | 0.00 | 0.488 | 0.00 | 1.00 |
| Years of schooling attained by the most educated household member | 7.316 | 7.00 | 1.680 | 3.00 | 11.00 |
| Region | 2.362 | 3.00 | 0.719 | 1.00 | 3.00 |
| Zone | 0.865 | 1.00 | 0.341 | 0.00 | 1.00 |
| Access to the national electricity grid | 0.922 | 1.00 | 0.268 | 0.00 | 1.00 |
| Internet Supply | 0.869 | 1.00 | 0.338 | 0.00 | 1.00 |

**Connected 2 (N = 1,716)**

| Variable | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Household yearly income | 27,839.190 | 23,723.50 | 17,126.130 | 220.00 | 158,716.00 |
| Household head works in service sector | 0.260 | 0.00 | 0.439 | 0.00 | 1.00 |
| Number of income earners in household | 2.741 | 3.00 | 1.332 | 0.00 | 11.00 |
| Household head age | 51.045 | 50.00 | 12.925 | 18.00 | 94.00 |
| Ratio number of youngsters to total household members | 0.375 | 0.40 | 0.230 | 0.00 | 1.25 |
| Ratio number of males to total household members | 0.482 | 0.50 | 0.217 | 0.00 | 2.00 |
| Any illiterate in the household | 0.294 | 0.00 | 0.456 | 0.00 | 1.00 |
| Years of schooling attained by the most educated household member | 8.234 | 8.00 | 1.629 | 3.00 | 11.00 |
| Region | 2.587 | 3.00 | 0.669 | 1.00 | 3.00 |
| Zone | 0.980 | 1.00 | 0.139 | 0.00 | 1.00 |
| Access to the national electricity grid | 0.997 | 1.00 | 0.059 | 0.00 | 1.00 |
| Internet Supply | 0.948 | 1.00 | 0.222 | 0.00 | 1.00 |

**Digitally wealthy (N = 63)**

| Variable | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Household yearly income | 60,529.240 | 55,622.00 | 35,414.970 | 11,007.00 | 223,299.00 |
| Household head works in service sector | 0.429 | 0.00 | 0.499 | 0.00 | 1.00 |
| Number of income earners in household | 2.492 | 2.00 | 1.243 | 0.00 | 6.00 |
| Household head age | 48.079 | 50.00 | 12.188 | 22.00 | 79.00 |
| Ratio number of youngsters to total household members | 0.354 | 0.33 | 0.220 | 0.00 | 1.00 |
| Ratio number of males to total household members | 0.530 | 0.50 | 0.203 | 0.14 | 1.00 |
| Any illiterate in the household | 0.238 | 0.00 | 0.429 | 0.00 | 1.00 |
| Years of schooling attained by the most educated household member | 9.508 | 10.00 | 1.366 | 6.00 | 11.00 |
| Region | 2.635 | 3.00 | 0.655 | 1.00 | 3.00 |
| Zone | 0.984 | 1.00 | 0.126 | 0.00 | 1.00 |
| Access to the national electricity grid | 1.000 | 1.00 | 0.000 | 1.00 | 1.00 |
| Internet Supply | 0.984 | 1.00 | 0.126 | 0.00 | 1.00 |

## ENDNOTES

[1] A previous version of this work, narrower in scope as to the empirical application, is available at www.dirsi.net, as a chapter of the book "Digital Poverty," edited by Hernan Galperin and Judith Mariscal.
[2] When initial work began for this project, a simple search in Google of the phrase had no hits for those combined words in Spanish, and only one reference in English, related to the "digital divide." Search conducted on May 14, 2005.
[3] Please see Orbicom (2003), ALADI (2003), and UIT (2003).
[4] ETS (2002).
[5] Concepts discussed within this section are part of an introduction to economic theory course, for which an ample bibliography is available. Among a wide variety of references, see in particular Varian (2002).
[6] For ICT definitions, please check World Bank (2002), Nayki (2002), or Orbicom (2003), among many other references.
[7] The diffusion of digital television will change this assessment.
[8] A larger discussion can be found in Lok-Dessallien (1999).
[9] It is clear that this refers to a stock, rather than a flow, concept. A wealthy person, who is sick and under treatment, experiences reduced well-being. However, a poor person with no access to health services lacks well-being whether sick or not.
[10] It is interesting to note that while the minimum caloric intake does not change fundamentally over time, the minimum threshold for digital poverty may change significantly, due to technological change.
[11] ENAHO stands for "Encuesta Nacional de Hogares."
[12] Also excluded were 784 households with complete information, but classified as outliers.
[13] For year 2003, ENAHO only recorded Internet access in telecenters. This may lead to a sub representation of Internet access, since it may be available at the workplace. Internet access in schools is rare in Peru.
[14] Since mobile networks in Peru are first and second generation, there is no way to tell whether mobile phones are being used to access the Internet. On the contrary, it is probable that the technology deployed at the time of the survey will not even be suitable for Internet access.
[15] Galperin and Girard (2005).
[16] About $0.80 per hour in Peru.
[17] The document that describes in detail how the classification was applied and further analyzes the description of households in each group is available from the author upon request.
[18] It should be noted that ENAHO does not gather data on household access to public telephones. This fact significantly affects our analysis, since the expansion of public telephones was the policy used to increase telecommunications access among the poor.
[19] Let us note that this is the group that a strict application of the methodology would have missed.
[20] According to APOYO, a consultancy firm in Lima, less than 5% of households in Lima belong to the "A group," which on average reaches over $3000 in monthly income. One third of the Peruvian population lives in Lima.
[21] Access at work or in schools was not recorded in this version of ENAHO.
[22] This may even underestimate the real extent of digital poverty, given that functionality at the individual level could not be examined.
[23] In 2002, teledensity in Peru reached 15 lines per 100 inhabitants, as opposed to 65.8 in Chile.
[24] Descriptive statistics for each group can be found in the Appendix.
[25] Williams (2006).

[26] However, this may not be the case for every independent variable. The “autofit” option allows us to correct for this effect.
[27] That is, they comply with the parallel lines assumption.
[28] www.dirsi.net

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