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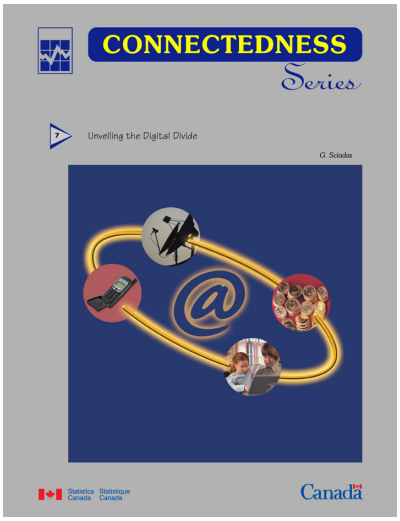
Unveiling the Digital Divide



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Unveiling the Digital Divide

by G. Sciadas

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Abstract

The digital divide, commonly understood as the gap between information and communications technology (ICT) 'haves' and 'have-nots', has emerged as an important issue of our times largely due to the uneven diffusion of the Internet.

Many variables, including income, education, age and geographical location, exert significant influences on household penetration of both ICT and non-ICT commodities. Thus, divides can be defined for any permutation of the above. In the case of ICTs, divides depend on the specific technology, its timing of introduction, as well as the variable of interest. This study shows that the digital divide is sizeable; ICT penetration rates grow with income. Generally, the effect of income is larger on newer ICTs (Internet, computers, cell phones) than older and established ones (television, telephone). Then, using the Internet penetration of households by detailed income level, it finds that in an overall sense the Internet divide is slowly closing. This, however, is the result of the accelerated adoption of the Internet by middle-income households – particularly upper middle. The Internet divide is widening when the lowest income deciles are compared with the highest income decile.

At the same time, the rates of growth of Internet adoption among lower-income households exceed those of higher-income households. This is typical of penetration patterns of ICT and non-ICT commodities. Rates of growth are initially very high among high-income groups, but at later stages it is the penetration of lower-income groups that grows faster.

Unveiling the Digital Divide

By G. Sciadas

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1. A DIVIDE THAT UNITES?

The commercial arrival of the Internet, in conjunction with the convergence of information and communications technologies (ICTs), has generated a creative turmoil in all walks of life, including a research thirst among the business, policy and academic communities. Prominent among the plethora of issues that have emerged as worthy of understanding is the Digital Divide. The issue has implications for important public and private sector initiatives, including government online and e-commerce.

Early work examined the gaps between ICT 'haves' and 'have-nots' for a variety of socio-economic groups. It was accompanied by research on aspects of access, use and impediments, which brought to the fore the key role of skills. While such studies initially focused on internal country divides, the issue inevitably expanded soon to cross-country divides. Comparisons of connectivity among developed countries (e.g. The Conference Board of Canada 2000, 2001, 2002) are now done in parallel with investigations involving developing countries, as the link was made between ICTs and development. Today, even casual observations make it abundantly clear that the issue has made it to the forefront of many an agenda. Countless conferences, symposia and workshops occupy individuals from every field imaginable. National and regional governments, international bodies, businesses and non-governmental organizations are in the midst of numerous initiatives. To name a few, the UN has established the ICT task force (2001), the World Bank the InfoDev program (2002), the OECD has published indicators (2001a, 2001b, 2002), and the private sector is active through the Global Digital Divide Initiative of the World Economic Forum (2002). The issue found its highest political manifestation through the G-8 whose Digital Opportunities Task Force (DOT Force) referred explicitly to 'digital opportunities' and 'digital dividends' and is following through with an action plan (2000, 2001a, 2001b). With all these efforts underway the issue of the Digital Divide offers many research links.

The term itself[1] contains notions of desired universality and is reminiscent of the century-old policies for telephones. But why? Our world abounds with divides of all kinds. At a time when many North American driveways resemble small dealerships, many have not yet driven, and at a time when many households are already in their multiple computer upgrade and increasingly turning into sophisticated local area networks, a good part of the population has yet to touch a computer. While our societies still struggle to rid themselves of left-over tolerance for homelessness, we are capable of feeling great empathy for people without Internet connections - a few short years after its birth. What is it, then, about the Internet and other ICTs that touches sensitive chords, precipitates such reactions and arouses social consciences?

This study places the Digital Divide in perspective (Section 2), quantifies how big it is (Section 3) and examines how it is evolving (Section 4). Some related matters are taken up in Section 5. Throughout the study, concepts are defined and measurement methods are suggested. They are then applied to arrive at conclusions.

1 -- 'Digital' is a misnomer.

2. THE DIGITAL DIVIDE IN PERSPECTIVE

The Digital Divide serves as an umbrella term for several distinct domains of investigation. Generally, the approaches come in two variants. One is ICT-centric and focuses mainly on actual connectivity - digital or otherwise. It reflects the quest to quantify and understand the factors that separate the 'haves' and the 'have-nots'. While findings from this approach point to potential corrective actions, they come with no pretenses to study outcomes and economic or societal impacts. Examples of this approach are the Falling through the Net series (US 1995, 1998, 1999, 2000) and A Nation Online (US 2002), Dickinson and Sciadas (1996, 1997, 1999), Sciadas (2000)[2] . Another approach ventures beyond connectivity and encompasses aspects such as ICT literacy and skills (e.g. Castells 2001, ETS 2002, Sciadas 2002), with linkages to knowledge and even social cohesion. While the latter approach is broader in scope, its effectiveness can be enhanced if nested with the former one, that is, if based on rigorous analysis of quantitative information. This is where the present study is situated.

2.1 Which Divide?

In reality, many divides exist[3] . A proper appreciation of the issues involved requires an understanding of the role of at least two important dimensions: i) individual ICTs, and; ii) variable of interest. There are many ICTs and variables, and divides can be identified for any permutation of these. (A key third dimension will be added shortly).

i) There are old and new ICTs, digital and analogue. Each is distinct in its attributes, functionality and numerous other characteristics, including pricing. All these matter. A television, for instance, offers different services than a cell phone, which in turn is different from coaxial cable. There is no reason, a priori, to lump different ICTs in one group and expect similar patterns in their penetration either across groups or over time. The diffusion pattern of each ICT depends on its particular characteristics, which impact on its actual and perceived uses, as well as the relative ease of such use. Diffusion patterns are also influenced by the complex and shifting relationships among ICTs, such as the extent to which they are complementary in use or alternatives for the same use. One influential force in this context is the process of convergence. Still far from complete, its evolution will continue to determine outcomes whose exact nature is unknown.

The television started as a passive receiver of signals – its use was straightforward and unique. Years later it found an additional role with the arrival of the VCR, which allowed individual users to exercise options with regard to both the timing and the content of watching. With the arrival of camcorders, video games and, lately, the digitization of signals that makes possible the offering of interactive services, the uses of 'the box' are many. However, its fast and massive penetration in our lives took place when it was still a one-use technology – it needed no more.

Computers, on the other hand, were initially meant for computing. Naturally, then, their diffusion was concentrated among those with such a need or desire. With the arrival of networks – the Internet, in the case of individuals - the computer found a new use and its functionality was radically transformed. Even within the Internet era, there are substantial differences between the early years and the recent years – much has changed and much is expected to change as broadband takes hold. Thus, the diffusion pattern of personal computers among people has been greatly influenced by new developments. Everything that affects functionality influences diffusion[4] .

2 -- This is also discussed in Noll et al. (2000). Many other studies worry about specific issues, such as the race or the educational dimension of the divide, and point to research agendas (i.e.Hoffman and Novak 1999a, 1999b, National Science Foundation 2001).

3 -- Here we analyze digital divides associated with people. However, divides are also found in the business sector where gaps exist by industry, firm size and the like.

4 -- The computer is still, by and large, the predominant means of accessing the Internet. Should alternative access become more attractive (e.g. though wireless technologies or Web TV), diffusion could again be affected. The same development could be positive for the diffusion of the Internet and negative for that of computers.

Similar arguments can be made for the cell phone, the Internet on cable and other technologies. Under the banner of convergence, the reach of their boundaries is continuously redefined. Most powerful influences are technological and emanate beyond those related to the more standard economic issues of affordability, or even social norms. Therefore, in studying the digital divide we must be cognizant at all times of the peculiarities of specific ICTs at some point in time.

ii) Then, there are many variables of interest: income, education, gender, age, geographical location, such as metropolitan or rural areas, and many more. Each of these results in the delineation of different groupings of people, with different size and other characteristics.

While there is overlap among such groupings, as the same individual or household can be present in many, it is nonetheless important to carry in mind the specific group examined and the reasons for such examination. There are serious policy and business reasons why such itemization of groups may matter - and the two may well differ. Connecting rural areas at 'reasonable' cost is non-trivial – especially when broadband is concerned; the use of the Internet by individuals of a certain age is not insignificant in the deployment of specific services and the associated business investments.

Clearly, even on the basis of these two dimensions alone, analyses of digital divides can be complicated. Specificity is a virtue, with regard to both ICT and variable used.

NOTE TO READERS

The data utilized in this study originate in several sources at Statistics Canada. A major database contains information on households, compiled over many years and through different survey instruments going as far back as 1953. Until recently, the information was collected by the Household Facilities and Equipment survey (HIFE - Statistics Canada 1996). As of 1997, its content has been embodied in the annual Survey of Household Spending (Statistics Canada 2001a). The timing of the surveys differs over the years; while the HIFE was carried out in the spring with measurements referring to that time, the new SHS is carried out early in the year for the previous reference year.

Other data for household Internet use, including all data that refer to use from any location, come from the Household Internet Use Survey (HIUS), which has been conducted annually since 1997. In the first three years, the survey was conducted in the Fall (October/November), but for reference year 2000 it was conducted in January 2001. For details see Statistics Canada (2001b). Data regarding the use of the Internet by individuals come from the 2000 General Social Survey (GSS), which was dedicated to the use and impacts of technologies. They refer to individuals 15 years of age and over (Statistics Canada 2001c, Dryburgh 2001).

The detailed data on the number of households by commodity and by income, both at the level of income deciles and at $5,000 increments, are available only from 1982 onwards. The reader should be aware that the composition of households in any income group changes over time. This is particularly true when two decades are involved, as the household composition of any given income group in the last year of data (2000) would bear little resemblance to its composition in the first year of data (1982). In the case of income deciles, the number of households in each decile increases over time as population increases; in the caser of nominal income increments, the number of households decreases over time for low-income groups and increases for high-income groups.

Data of such long time-series and with this level of detail are subject to various other caveats too. The estimation methodology of the annual surveys is based on the population counts of the most recent census at the time. When new census information becomes available, breaks occur in the series which are adjusted through periodic re-weighting. In the dataset used here, the 1997 data from the first year of the SHS are based on the 1996 census counts, whereas the data for previous years are based on the 1991 census counts. Therefore, the annual rates of growth between these two years are not meaningful. However, the effect on the computed penetration rates is minimal, as both the numerators and the denominators are affected more or less the same. As well, the overall effects on rates of growth over long periods are also minimal.

Moreover, in earlier periods, data are not available for each year. Annual growth rates for intervening years were calculated as average annual compounded rates over the period. The same is true for computers, where measurements were initially made only for 1986, 1988 and 1990. Data for vehicles from 1997 onward refer to households with at least one vehicle, either owned or leased, and are not directly comparable with data for earlier years.

2.2 Divides among households

Income is always a key variable for analyses of divides. Chart 1 shows the penetration of several ICTs by detailed income levels. Clearly, household penetration increases with income[5].

The effect of income is more pronounced on new technologies rather than older and established ones. However, the income divide is also present in the case of vehicles - a high price-tag example of a non-ICT commodity. This shows that the effect of income on penetration is not simply an ICT phenomenon.

Many other variables come into play – more, less or not at all related to income - and can be the foci of analyses. For instance, that education exerts a strong, positive and independent influence on Internet use, even when controlled for income, has been well documented (Dickinson and Sciadas 1997, Dickinson and Ellison 2000). The same is true for the place of residence, with urban penetration exceeding rural, as well as for the type of family, where the presence of children is associated with higher penetration.

Table 1 summarizes some of these divides for the Internet. Clearly, penetration increases across incomes, but it also increases substantially by the level of education, the presence of children and urban areas within each level of income. This is true whether home-use or use from any location is concerned. The latter is considerably higher, indicative of the importance of alternative access points (work, school, library, community resources). Moreover, by 2000, rates of Internet use from any location were already quite high for several high-income sub-groups. For example, the use rate among households at the top income quintile, headed by someone with at least a university degree exceeded 90%, followed closely by households in the same income group with children less than 18.

5 -- Chart 1 reveals a J-curve effect at the very low-income end for newer technologies. This has been observed many times, whether households or individuals are concerned, and to some extent it reflects the student population and those among the self-employed for whom a year is not a very appropriate unit to report income. Depending on the objective at hand, analysis of low income is perhaps best achieved for levels immediately after that group.

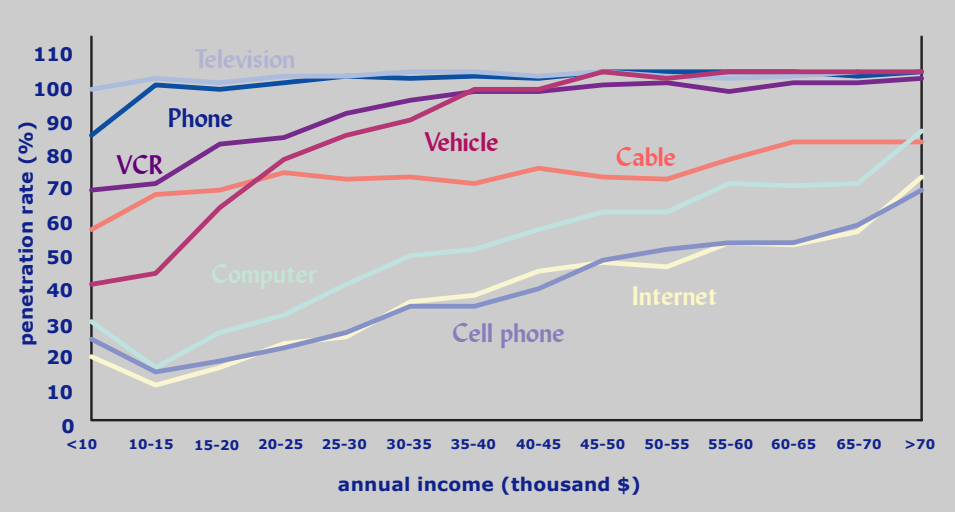


Chart 1.
Household penetration, by income, 2000

Table 1.
Internet divides, by income, 2000

	Regular use from home income quintiles						Use from any location income quintiles					
	bottom	2nd	3rd	4th	top	all	bottom	2nd	3rd	4th	top	all
				%						%		
				Education						*Education*		
Less than high school	6.8	10.7	22.4	30.0	40.5	16.1	10.9	15.4	32.5	39.7	50.1	22.5
High school/college	22.5	28.4	42.9	51.0	66.5	42.8	32.2	40.9	56.7	63.9	80.1	55.4
University degree +	42.9	47.4	56.6	63.7	78.9	65.1	56.7	62.3	71.1	81.1	91.0	79.3
Total	**16.5**	**24.4**	**41.2**	**50.3**	**68.2**	**40.1**	**23.9**	**34.5**	**54.4**	**63.6**	**80.9**	**51.5**
				Family type						*Family type*		
Single family, children <18	32.6	41.9	50.7	62.4	76.4	57.0	48.0	59.3	67.0	76.6	87.4	71.4
Single family, no children <18	16.2	19.4	35.1	45.8	63.0	37.8	22.0	24.8	43.8	57.3	75.8	46.9
One-person families	8.9	15.9	33.7	25.0	44.6	19.0	13.2	25.4	49.3	58.3	60.2	28.0
Total	**16.5**	**24.3**	**41.2**	**50.4**	**68.2**	**40.1**	**23.9**	**34.5**	**54.4**	**63.7**	**80.9**	**51.5**
				Geographical location						*Geographical location*		
Urban (CMA)	18.0	25.9	43.2	51.4	70.1	42.5	25.9	36.4	56.2	64.4	82.7	54.0
Rural (non-CMA)	11.6	19.3	33.9	46.0	57.5	30.9	17.6	28.4	47.7	60.8	70.5	41.8
Total	**16.5**	**24.3**	**41.2**	**50.4**	**68.2**	**40.1**	**23.9**	**34.5**	**54.4**	**63.7**	**80.9**	**51.5**

Notes: The top 18 Census Metropolitan Areas are used as a proxy for urban areas.

2.3 Divides among individuals

The significance of income, whether personal or household, as a divide variable can also be seen at the level of the individual. Chart 2 shows that Internet use increases steadily with income. By 2000, high-income individuals had achieved use rates substantially higher than those of low-income individuals.

Age also causes divides. This has been analyzed by Silver (2001), in conjunction with gender issues, and is displayed in Chart 3. Internet use declines dramatically with age, from over 90% for teenagers to less than 5% for aged individuals. This reflects a combination of factors, including issues of access opportunities, skills, perceived needs, attitudes and overall lifestyles.

Whether the analysis focuses on individuals or households, some variables matter more for some technologies (e.g. age is important for the Internet but not for cable).

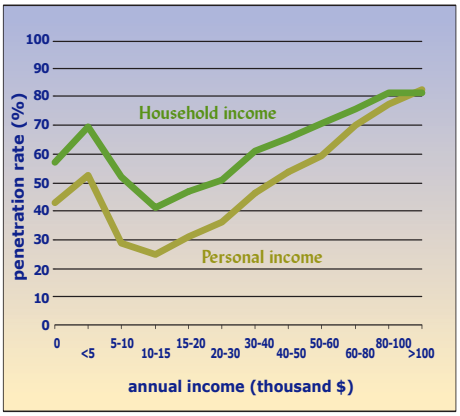


Chart 2.
Internet use, by individuals, by income, 2000

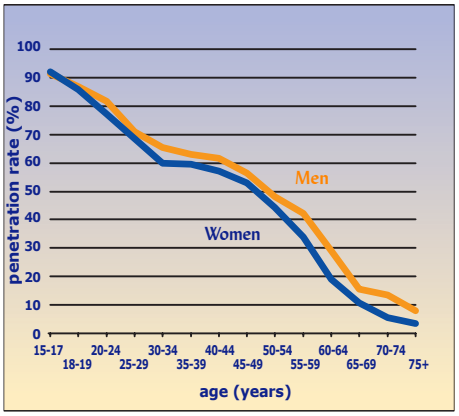


Chart 3.
Internet use, by age and gender, 2000

2.4 Timing of introduction

A dimension concerning the timing of the introduction of individual ICTs must be added for a more complete understanding of digital divides. For example, a telephone divide today must be seen under the light that the technology in its basic form, the twisted copper wire, has been around for over a century. This differs from the divide associated with the Internet, which has been around for less than a decade in its commercial incarnation. Thus, analyses of the divide require the explicit recognition of all three dimensions – the specific ICT, the timing of its introduction and the variable of interest.

Historically, the introduction of new technological commodities in consumption (as well as their diffusion and use by businesses and governments) has been gradual. Chart 4 presents a collection of recorded penetration histories, with many data points over a long period of time. Despite perceptions about the meteoric rise of the Internet, fast as though it may have been, the penetration of television in people's lives was faster[6].

The penetration of the VCR was also very fast, particularly during its first decade. While the speed of adoption among commodities differs, their penetration is generally characterized by accelerating growth in the initial periods, which eventually gives way to decelerating growth[7]. On the basis of the information behind Chart 4, and in conjunction with the information contained in Chart 1, the selected ICTs can be classified according to their overall penetration and growth patterns in the following stages:

i) **Saturation stage:** Included here are older technologies (telephone, television) that have practically achieved complete penetration for some time. For the last two decades, the penetration of both hovers around 98%-99% and their rates of growth have dropped to levels that generally match the rate of growth of households[8].

ii) **Plateau stage:** This refers to technologies whose overall penetration is quite high for several years, without having reached saturation. Moreover, their penetration is changing slowly, with growth oscillating around the rate of growth of households (cable) or somewhat higher (VCR)[9].

iii) **Dynamic stage:** Newer ICTs with lower penetration but very high growth - the Internet, cell phones and computers. Much of the bewilderment and research of late is precipitated by the perceived opportunities they offer. So is the issue of the Digital Divide.

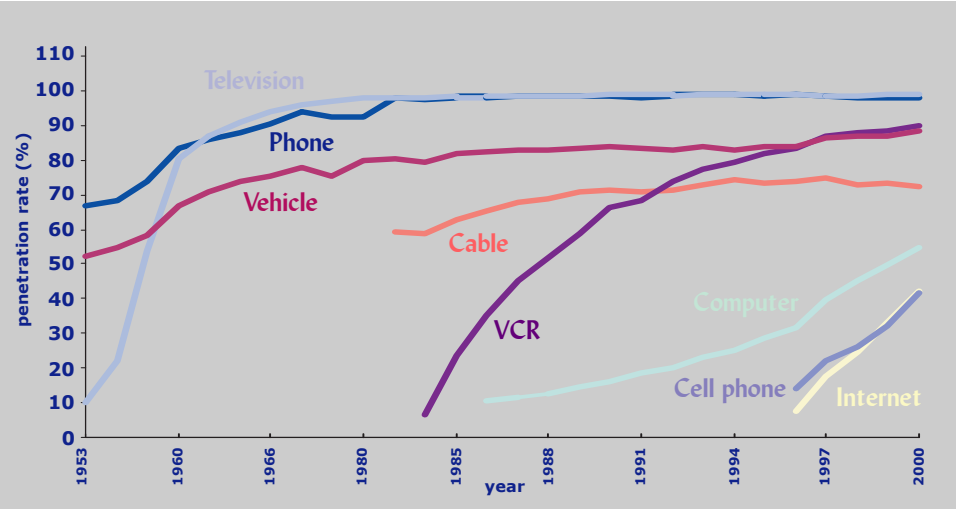


Chart 4.
Penetration over time

6 -- From almost nothing in 1952, it reached 10% in 1953 (the first year for which data exist) and within a decade of its introduction it exceeded 80% (1960). Then, it achieved near-complete penetration even before the telephone, which had been around much earlier.

7 -- This is known as the S-curve - the period of accelerating growth corresponds to its convex part, up to the inflection point, whereas decelerated growth corresponds to the concave part of the curve. Recorded observations make it difficult to discern any such shape. For example, the low part of the S-curve is barely captured during the very early years of the television, while that of the computer (a technology with slower penetration) is visible from 1986 to 1996. In vehicles and the telephone this part has long given way to a very flat top part. In the case of the Internet the low part is missing, although early-enough observations exist. This means that the period of accelerating growth was very short-lived.

8 -- This should not be confused with market growth, which is higher than the rate of growth of households for several reasons: replenishment of older sets, increase in multiple sets, and non-household users.

9 -- Since 1997, though, the VCR did reach saturation among the households in the top income decile. Cable penetration hovers in the low to mid 70% range for over a decade and is lately slipping. Even among the top income decile with the highest penetration, it fell from an all-time high of 85.5% in 1997 to 82.1% in 2000.

ICTs	Stages: Saturation	Plateau	Dynamic
Penetration	Practically complete and stable	Very high but not complete	Lower but increasing
Growth	Stagnant	Very low or oscillating	Very high

The diffusion pattern of ICTs in this stage underscores the previous analysis of the peculiarities of each technology. Moreover, it does not provide support to the argument that, given a sufficiently long period of time, all technologies will reach saturation. There are technological, economic, behavioural and other barriers at work that may place a ceiling on penetration at levels below The diffusion pattern of ICTs in this stage underscores the previous analysis of the peculiarities of each technology. Moreover, it does not provide support to the argument that, given a sufficiently long period of time, all technologies will reach saturation. There are technological, economic, behavioural and other barriers at work that may place a ceiling on penetration at levels below 100% (or the 98%-99% that is practically achieved by ubiquitous technologies)[10]. What is important is that all new technologies are subject to a divide in their early penetration. Thus, at early stages of diffusion there is strong justification to examine people grouped by characteristic of interest. Only when ICTs approach saturation do their diffusion patterns start to resemble the population at large and the distinction between 'haves' and 'have-nots' fades. Our analysis of the digital divide will focus on income.

3. THE MAGNITUDE OF THE DIGITAL DIVIDE

Research to date results in conflicting messages concerning the size of the Digital Divide and, especially, its evolution. The OECD, for instance, identifies sizeable divides of the type discussed previously and states that "…the digital divide could be said to be either growing or shrinking depending on how you look at it" (2001b, p.5). To overcome such inconclusive findings, clarity is needed on two fronts: establish well-defined concepts, and; apply appropriate measures.

3.1 The relative divide

Quantifying the magnitude and monitoring the evolution of the gap between ICT 'haves' and 'have-nots', as the issue was initially expressed, can be achieved by the absolute number of users or the overall penetration rates[11]. As long as from one period to the next more people use, say, the Internet, there are more 'haves' and fewer 'have-nots'. When groups of people are delineated by income (or any other variable), each one has its own penetration rate. (In effect, the overall penetration rate is a weighted average of these). Typically, higher income groups have higher penetration rates but, over time, penetration rates increase across all income groups. As this happens at different rates, though, the digital divide becomes a relative concept referring to the difference in the starting penetration rates and the growth rates across income groups. Thus, its measurement involves comparisons of the 'haves' between 'have-more' and 'have-less' groups[12]. It does not involve the 'have-nots', as is frequently – and inappropriately - stated. To understand the relative divide better, it is analytically instructive to look at an extreme situation with no such divide. By definition, then, the penetration rate of a certain ICT would be the same regardless of the level of income. (Graphically, this would be depicted by a line parallel to the horizontal axis at a value X – Figure 1 in Technical Box 1).

10 - The uneconomical deployment of cable in very remote areas, for instance, puts a ceiling on its penetration. However, as measured by households passed by cable, it could have been as high as 95% (April 2001). Convergence renders the environment more competitive, with forces pulling or pushing in different directions. Technological advances together with the regulatory regime make possible the provision of more services through the coaxial cable (Internet, digital TV and telephony), which could increase its appeal. On the other hand, the competition brought about by satellite dishes (legally since 1998) pulls the other way.

11 - While the former is better suited for market analyses, the latter is a preferred policy measure. Penetration rates account for changing demographics. It is conceivable that the absolute numbers of both users and non-users of a technology increase from one period to the next. If the rate of growth of users was lower than the rate of growth of households or individuals, a falling penetration rate would result. This is unlikely to happen at pre-saturation levels.

12 - Alternatively,it oculd involve comparisons between the 'have-nots' in these groups, but not the 'haves'.

TECHNICAL BOX 1: Trends and Ratios

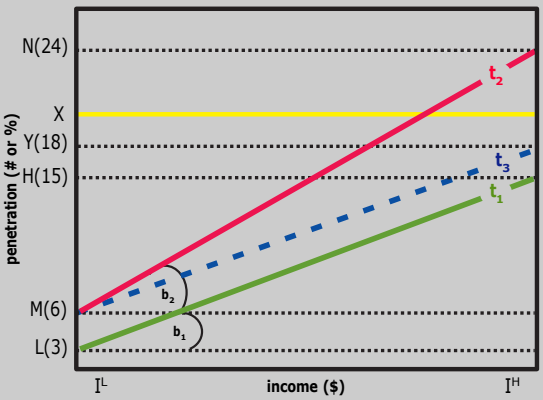
By definition, the absence of a relative digital divide means that penetration rates are the same across all incomes. This is depicted in Figure 1 with the straight line having an X intercept and a constant slope (zero). In reality, penetration increases with income and the lines are sloping upwards. In the simplified case of a straight line, a measure of the relative digital divide between high and low incomes is provided by its (constant) slope. The steeper the line, the greater its slope, and therefore the bigger the relative divide.

The evolution of the relative digital divide is then measured by slope changes. In the hypothetical example, line t_1 shows the pattern of penetration by income in the initial period and line t_2 in a subsequent period.

Clearly, t_2 is steeper than t_1 and therefore $b_2 > b_1$, indicating a growing divide. Measured at the same incomes, the slopes are given by: $b_1 = (H-L)/(I^H-I^L)$ and $b_2 = (N-M)/(I^H-I^L)$, respectively. Since the denominators are the same, the change in slopes can be approximated only with the numerators, that is, the differences in the penetration rates between high and low incomes.

At the same time, the ratios of the high- and low-income penetration rates between t_1 and t_2 are falling ($N/M < H/L$). How can this happen at the same time as the slope increases, and how do all these relate to the rates of high- and low-income penetration growth?

Figure 1. *Trend measures of the divide*



The upward movements of both intercepts are the result of growth, with the rate of growth of the low income exceeding that of the high income - $(M-L)/L > (N-H)/H$. This is all that is needed for the ratios to fall, even though t_2 is steeper. The lines would move in parallel (unchanged steepness, slope, and relative divide) only if the proportionate changes in the low and high incomes result in the same absolute changes in percentage points (line t_3), something that would require a much higher rate of growth for the low income group compared to the high income group. How much higher?

With L and H denoting the penetration rates of the low and the high incomes in the initial period, and ℓ and $\hbar$ their respective rates of growth between the two periods, the following condition would have to hold: $L(1+\ell) - L = H(1+\hbar) - H \Rightarrow L\ell = H\hbar \Rightarrow \ell/\hbar = H/L$. In other words, the rate of growth of the low-income penetration must be higher than the rate of growth of the high-income penetration by as many times as the ratio of the penetration rate of the high- to the low-income was in the initial period. Any growth in low-income penetration lower than this would result in a steeper line. However, any growth in the low income higher than the growth of the high income, however small the margin, would decrease the ratio of their penetration rates. Both of these can - and do - happen at the same time.

In the numerical example: the penetration of the low income increased by 100% (from 3 to 6) and that of the high income by 60% (from 15 to 24). Their ratio declined from 5 (15/3) to 4 (24/6), but the relative divide increased from 12 (15-3) to 18 (24-6) points. Although the penetration of the low income grew faster than that of the high income, it would have to be five times as much for the relative divide to remain unchanged.

Linearity is not the only simplification in the above. Numbers of users or penetration rates can be used in the vertical axis, while income can be expressed in dollars or percentiles. Practically, the choice matters. Without crowding the Figure, the following are involved: differences in penetration can serve as a proxy of the relative digital divide if and only if the incomes used for comparisons between periods are identical. Whether measured in dollar terms or percentiles, incomes generally increase - especially in nominal terms – and this introduces an upward bias in the measure of the relative divide. This bias is higher, the higher the income differential between high- and low-income groups – the denominator in the slope equation. (Even if they both change proportionately the same, high incomes increase absolutely more, and thus the bias is still there). Alternatively, keeping incomes constant in the analysis from period to period, when penetration rates are used on the vertical axis, the number of households or individuals (used as the denominator in penetration rates) must stay the same. This is not the case when incomes expressed in dollars are used, as more households or individuals move up into higher brackets and fewer remain in the lower incomes. This introduces another bias, also upwards. Even if percentiles are used, their mean income changes - so we revert to the previous bias**.** Changes in the composition of households by income introduce yet another (unpredictable) bias.

That usage of the differences in penetration rates as proxies of the relative divide require the assumptions of constant incomes and constant number of households or individuals from period to period is crucial. The fact that these assumptions do not hold introduces biases when trend analysis is applied to real data.

In such a hypothetical case, we are immediately confronted by a two-fold question: What examples can we think of, and what would be possible values for X? Certainly not luxury cars, exotic vacation packages or stock options. Perhaps items that have become staples of daily life – foodstuff, mattresses and shoes, ignoring quality considerations. Moreover, the admissible values for X would be at the rate of complete penetration - close to 100%. It is not possible to imagine anything with an X value at 20%, 50% or even 80% penetration… Consumption patterns simply do not work like that.

That penetration increases with income is hardly a glamorous story. But the uneven Internet penetration between high and low incomes did become a story, precipitating the issue of the digital divide, before the overall Internet penetration rate was at 7.4% in Canada, in May of 1996!

3.2 Measures of the digital divide

The magnitude of the relative divide can be approximated with the difference in the penetration rates between high- and low-income groups. (The explanation is provided in Technical Box 1 for the interested reader). Differences were computed for the top and bottom income deciles[13] for selected years over a lengthy period and are shown in Table 2. Again, the findings indicate that the relative divide is very big for newer technologies and drops for saturated technologies. In 2000, it was bigger in computers and the Internet, with 65.2 and 62.5 percentage points separating households in the two extreme deciles, followed by cell phones. Considering that the penetration rate of computers was higher than the penetration rates of the Internet and cell phones, it is evident that their concentration among higher incomes is heavier. The divide in telephones, where almost 12 percentage points in penetration separate households in the top and the bottom income deciles, is high for such an established technology. The fact that it widened sharply in the last year of data serves as an example that closing divides should not be taken for granted, but they can regress[14].

The figures in Table 2 also indicate that the relative digital divide is widening across ICT and non-ICT commodities – with the exception of the VCR. This, however, cannot be generalized outside the two extreme income deciles, as it is subject to several caveats (explained in Section 4).

Table 2.
Differences in penetration rates, top vs. bottom deciles

	1982	1986	1990	1996	2000
	percentage points				
Telephone	7.4	7.5	4.6	5.2	11.9
Television	3.9	2.9	2.2	1.5	3.8
Cable	-	-	-	24.6	23.2
VCR	-	47.1	54.3	36.4	33.4
Computer	-	18.8	31.8	48.2	65.2
Internet	-	-	-	18.2	62.5
Cell phone	-	-	-	24.8	55.9
Vehicle	56.5	56.4	51.3	47.1	58.8

Another measure used for the divide - although with much less theoretical justification - are the ratios of the penetration rates among high- and low-income groups. The measure is then interpreted as the 'likelihood' of being connected. In the case of perfect equality, the ratio would be 1; the greater the number, the greater the divide. Such ratios were computed for 1996 and 2000 and are shown in Chart 5.

The basic findings are the same as before; the divide is greater in the newer technologies, especially the Internet, whereas it barely registers for saturated technologies. (However, more detailed analysis later will reveal regressive behaviours). According to this measure, though, the digital divide would appear to be closing, contradicting the findings of the previous analysis. For example, households in the top income decile were 7.6 times more likely than

13 - Income groups are practically dictated by data availability. Generally, use of income percentiles is superior to absolute income levels. The distribution of households can be very uneven when income increments are used (for example, in 2000, 27% of households had incomes in excess of $70,000 – the highest income in Chart 1, whereas only 7% in the $10,000-$15,000 range). Closely related to this, percentiles are more suitable for intertemporal comparisons, as the number of individuals or households are kept more or less stable, as they are affected only by the increase in population. On the other hand, as nominal incomes increase, the distribution of households is biased towards higher incomes.

14 - Whether this is the beginning of a trend remains to be seen. However, although there has been no documented evidence so far of substituting cell phone for wireline, this may just be an example of such a phenomenon, particularly among the student population present in the bottom decile. Evidence provided by the quarterly telecommunications survey also points to the same direction. In 2001, fixed telecommunications access declined, whereas cellular phone subscribership increased by 24% (Statistics Canada 2002).

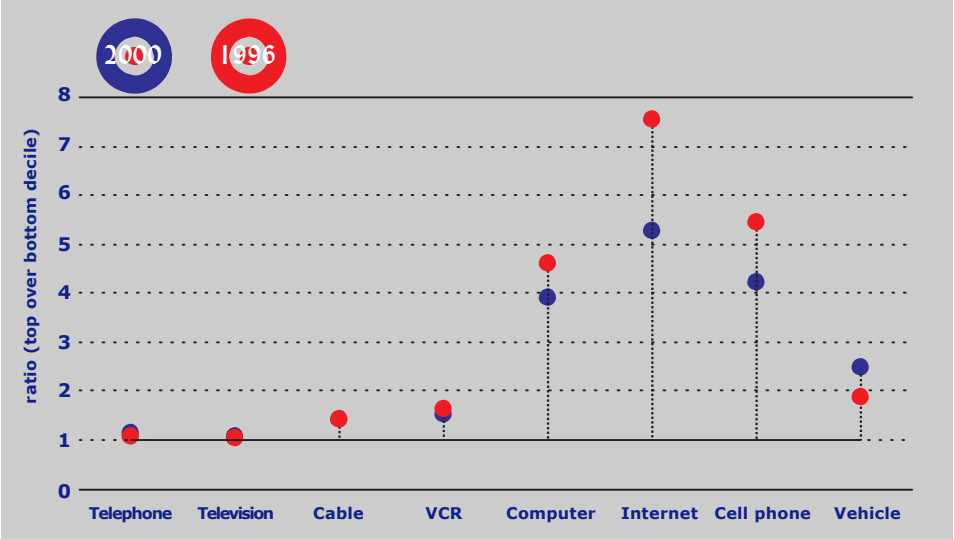


Chart 5.
Ratios of penetration rates, top vs. bottom income deciles

households in the bottom decile to use the Internet in 1996, but only 5.3 times more likely in 2000. This apparent contradiction occurs because ratios are ***not*** measures of the relative digital divide. Decreasing ratios will be obtained always as long as the rate of growth of penetration among the low-income group exceeds that of the high-income group – regardless of how small the margin may be. (This is explained in Technical Box 1). They do, however, point to future evolution.

4. THE EVOLUTION OF THE DIGITAL DIVIDE

Regardless of the magnitude of the digital divide, a more pertinent question is whether it is widening or closing. Early analysis in the US (1998) looked at the temporal movement of the differences in penetration rates among various groups (high vs. low income, whites vs. blacks and Hispanics, suburban areas vs. inner-city cores) and concluded that the (relative) digital divide was widening. Effectively, the methodology relied on trend analysis. Dickinson and Sciadas (1999) employed the same methodology for Canada and arrived at the same conclusions for groups based on income, education, age, family type and urban/rural areas - on the basis of limited data at the time[15]. But they also felt it important to extend the analysis to the underlying rates of growth among the various sub-groups, identifying the higher growth of Internet use among all 'have-less' groups. Growth differentials, properly placed in perspective, can provide important clues regarding future evolution. Recently, the OECD also incorporates this type of analysis (2001b), but proceeds to state: *"Whether the gap is closing or widening depends largely on how you choose to examine it. As we shall see, when examined by absolute percent access the gap appears to be widening, and when examined by growth rate it appears to be closing"* (2001b, p.34). As explained in Section 3, the two measures are not equivalent. Quoting from Dickinson and Sciadas (1999, pp. 3.4-3.5) is still relevant:

"…analyzing the evolution of the gap between those who are connected and those who are not involves several nuances.

i) *Penetration rates have increased across income quartiles, levels of education, age groups and geographical locations... That is, some of last year's 'have-nots' have turned into this year's 'haves'.*

ii) *A more meaningful question to get a better understanding of the gap is what population sub-groups did the new 'haves' mostly come*

15 - It will become evident shortly that the particular data sets used for 1996 and 1997 paint a different story that that of subsequent periods.

from. Here we must consider both absolute and proportionate changes. Penetration is increasing by more percentage points for the high- than the low-penetration population segments….In that sense the gap is widening…These findings show that, in absolute terms, more of the newly connected households come from the 'have' segments. However, such findings mask important underlying growth trends.

iii) *Penetration rates and their differentials are driven by connectedness rates of growth among population sub-groups. What happens to the gap depends crucially on the magnitude of the initial mass of connected households, the associated gap in penetration rates by population sub-groups, as well as the respective rates of growth. Higher rates of growth among low-penetration groups may still result in a widening gap. For instance, starting from a much higher number of connected households, high-penetration groups can gain one percentage point in penetration with only a small percentage increase in user households, whereas low-penetration groups need a much higher rate of growth. The underlying growth trends are unmistakably much higher among the low-penetration population segments…Should this trend continue, the percentage point difference in penetration rates ultimately must begin to fall".*

The nuances involved in the definition and the associated measures of the digital divide are now apparent. The arguments in i) and ii) point to the relative nature of the divide, whereas iii) identifies growth patterns as drivers of future developments. While the precise conditions have now been explained (Technical Box 1), more insights on the evolution of the divide can be obtained. The Internet becomes the centerpiece of such analysis.

4.1 Trend analysis

Not only does Internet penetration increase with income but, based on all available statistics to date, its penetration by income increases across the entire spectrum - high, middle and low incomes alike.

Trend analysis similar to that of the US (1998) and Dickinson and Sciadas (1999) is reproduced here on the basis of more detailed data available now (covering the period 1996-2000 as opposed to only 1996-1997, and broken down by income deciles as opposed to quartiles). Graphical analysis (Chart 6) confirms that penetration rates

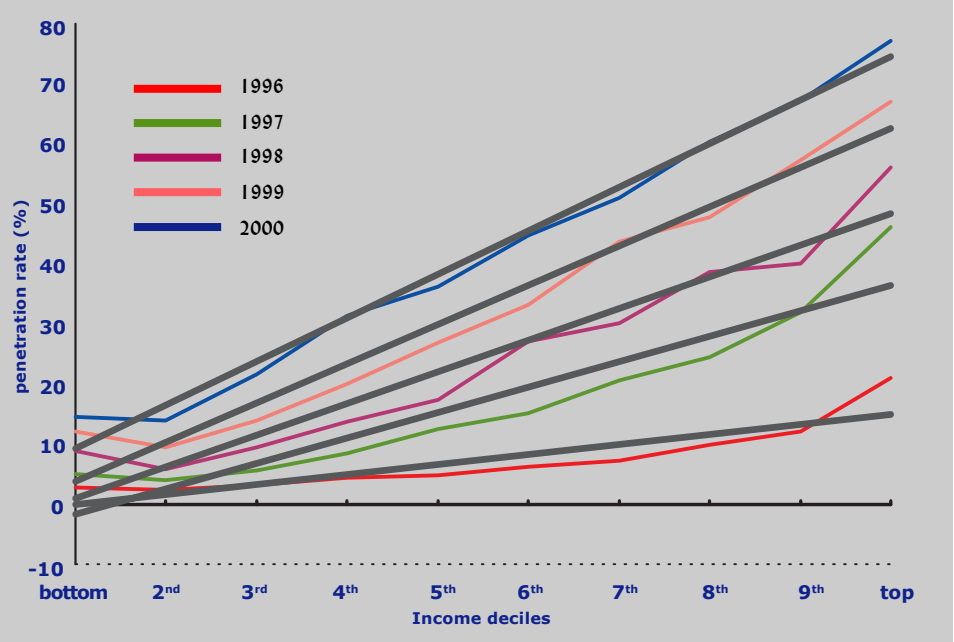


Chart 6.
Trends of Internet penetration, by income

continue to increase every year across all incomes, and that the fitted trend lines are becoming visibly steeper – although progressively less so, particularly between 1999 and 2000. These findings would indicate a growing relative divide.

However, the conclusions from this type of analysis are subject to caveats. ***First***, the pattern of Internet penetration is not linear (although in recent years the plotted lines look more like straight lines compared to earlier ones). Moreover, a line approaching the penetration rate of the top decile from above the trend (concave) would produce the same trend as a line approaching it from below (convex, as is mainly now). Therefore, the fitted trend lines mask important movements – particularly in the middle incomes. For this, more detailed analysis was performed.

The differences in Internet penetration were computed for many pairs of income deciles and for every year of available data. Then, the changes in these differences were estimated, annually and for longer periods. In this specification, a positive number indicates a growing relative divide (the bigger the number, the bigger the growth) and a negative number indicates a closing relative divide. The results are shown in the top part of Table 3.

The relative divide is smaller, the smaller the income difference between the groups examined. (This can be seen in the first five lines and, more visibly, in the 2000-1996 column). As well, the relative divide generally increases less over time. The important new finding, though, is that the pattern of increase of Chart 6, is no longer uniform. While there is still a growing divide between pairs of very

Table 3.
Evolution of differences in Internet penetration rates

Deciles	1997-1996	1998-1997	1999-1998	2000-1999	2000-1996	2000-1997
top-bottom	22.9	6.1	7.9	7.4	44.3	21.4
9th - 2nd	18.5	6.1	13.6	5.5	43.7	25.2
8th - 3rd	12.1	10.4	4.6	4.8	31.9	19.8
7th - 4th	9.4	4.3	7.3	-4.1	16.9	7.5
6th - 5th	1.3	7.0	-3.3	2.0	7.0	5.7
top - 9th	5.1	1.9	-6.2	0.1	0.9	-4.2
top - 8th	10.5	-4.3	2.1	-2.6	5.7	-4.8
9th - 8th	5.4	-6.2	8.3	-2.7	4.8	-0.6
8th - 7th	1.1	4.7	-4.6	5.3	6.5	5.4
6th - 4th	4.8	6.7	-0.1	0.1	11.5	6.7
5th - 4th	3.5	-0.3	3.2	-1.9	4.5	1.0
4th - 3rd	1.6	1.4	1.9	3.6	8.5	6.9
top 5-bottom 5	12.8	6.8	6.0	2.8	28.5	15.6

income adjusted

Deciles	1997-1996	1998-1997	1999-1998	2000-1999	2000-1996	2000-1997
top-bottom	21.0	4.3	6.9	1.1	32.5	12.3
9th - 2nd	17.1	5.0	11.9	3.7	36.1	20.7
8th - 3rd	11.1	9.6	3.8	3.4	26.9	16.9
7th - 4th	8.9	3.6	7.0	-4.7	14.6	6.0
6th - 5th	1.1	6.6	-3.4	1.8	6.0	5.1
top - 9th	4.4	1.1	-6.2	-1.6	-1.5	-6.7
top - 8th	9.4	-5.2	1.9	-5.0	1.7	-8.3
9th - 8th	4.9	-6.3	7.8	-3.1	3.4	-1.5
8th - 7th	0.8	4.6	-4.7	4.9	5.0	4.7
6th - 4th	4.4	6.1	-0.2	-0.1	9.9	5.7
5th - 4th	3.4	-0.4	3.1	-2.1	3.9	0.6
4th - 3rd	1.5	1.3	1.8	3.1	7.2	6.2

high and very low incomes (e.g. top vs. bottom, 9th vs. 2nd and 8th vs. 3rd deciles), a closing divide begins to be visible between other pairs (e.g. 4th and 7th deciles from 1999-2000 - a trend line fitted between these points would be flatter than the year before). Repeating the exercise for pairs of deciles both in the top and the bottom halves of the income spectrum, the mixed pattern that emerges is more crowded with closing divides (negative numbers). The relative divide closes between several adjacent deciles, as early as 1997-1998 (e.g. 8th and top, 8th and 9th). Also, the relative divide between the 4th and 6th deciles disappears in the last two years (two deciles still separated by more than $18,000 in 2000), as it does between the 4th and 5th deciles in 1999-2000. Dropping 1996 from the calculations, closing divides between high-income deciles can be detected even over a longer period (2000-1997 column).

To demonstrate how much such comparisons depend on the exact cut-offs chosen, the exercise was repeated with only two income groupings; the top half and the bottom half. In this case, the relative digital divide is clearly widening (last line of top part of Table 3). Therefore, this type of analysis is crucially conditional on the groups compared.

Second, (as explained in Technical Box 1) an upward bias is introduced over time in estimating slopes with data arranged in income deciles, because of increasing income differences between high and low deciles[16]. These differences matter, particularly over a period of five years. An adjustment was made for this bias and applied to the previous analysis[17]. The results are shown in the bottom part of Table 3. It becomes immediately evident that measures of the relative divide are getting smaller. More importantly, an even more mixed pattern between growing and closing divides emerges, particularly for the last year.

Thus more than meets the eye is camouflaged behind trend lines. While the conclusions are valid when the differences found are so emphatic that existing biases cannot possibly change their direction (such as the growing divide between the highest and the lowest incomes – first three lines in bottom part of Table 3), they do not represent comprehensive measures of overall movements.

4.2 Concentration analysis

While inequalities of the type encountered in the relative divide are difficult to prove conclusively with any single measure, a well-known analytical technique is that offered by the Lorenz curve (Technical Box 2). It was adapted and utilized here for the penetration of the Internet across income levels. In the process, the distribution of Internet users by income is examined and the contribution of different income groups to the expanded number of users is identified.

The distribution of Internet users by income decile, for the 1996-2000 period, is shown in Table 4. The most notable change is observed at the top decile, which accounted for 18.2% of all Internet users in 2000, down from 28.4% in 1996. The decline of its relative importance was steady throughout the period.

Table 4.
Distribution of Inernet users, by income

Decile	1996	1997	1998	1999	2000
			%		
bottom	3.8	2.9	3.6	3.6	3.5
2nd	3.3	2.3	2.4	2.9	3.3
3rd	4.4	3.3	3.8	4.2	5.1
4th	6.0	4.9	5.5	6.0	7.4
5th	6.5	7.1	7.0	8.1	9.7
6th	8.3	8.7	10.9	10.0	10.5
7th	9.7	11.9	12.2	13.2	12.1
8th	13.4	14.1	15.6	14.4	14.2
9th	16.3	18.4	16.2	17.3	15.9
top	28.4	26.5	22.6	20.3	18.2
all	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

However, this is not the pattern of other high-income groups. Only the share of the 9th decile was somewhat smaller in 2000 compared to 1996 - and this after it had increased. The

16 - IAlthough graphically each decile is represented by the same point on the horizontal axis over time, the underlying incomes increase. In 1996, the mean income of the bottom decile was $7,989 and of the top $130,656, while they were $8,686 and $160,041 in 2000, respectively. Their difference increased by a factor of 23%.

17 - The differences in penetration rates between any two deciles in period t_2 were divided by the ratios of the income difference between these deciles in t_2 over their difference in t_1.

relative loss of the importance of the two highest income deciles notwithstanding, the lot of the lowest two deciles did not improve at all over the 1996-2000 period – indicative of a less than generalized closing of the divide. It is thus the middle incomes that picked up share, and accounted for proportionately more of the Internet users in 2000 than in 1996.

Analogous findings hold true when the income deciles from which newcomers emanated are explicitly identified – those who help close the absolute divide. Table 5 shows that while over the entire period there is a very clear, positive relationship between income and Internet newcomers (last column), from year-to-year the relative contribution of the higher-income groups declined (7th to top decile) and that of the others increased. The gains, once again, were more pronounced among the middle incomes rather than the two lowest deciles. For example, the top decile accounted for one-quarter of all new users between 1996 and 1997, but the 5th decile topped the list from 1999 to 2000. In the same period, the four middle deciles (4th to 7th), contributed almost half (48%) of all new users.

Table 5.
New Internet users, by income

Decile	1996 - 1997	1997 - 1998	1998 - 1999	1999 - 2000	1996 - 2000
			%		
bottom	2.2	5.2	3.8	2.9	**3.4**
2nd	1.5	2.6	4.3	4.7	**3.3**
3rd	2.5	5.0	5.2	8.4	**5.3**
4th	4.1	7.0	7.4	12.2	**7.7**
5th	7.5	6.9	11.0	15.1	**10.3**
6th	8.9	16.0	7.6	12.3	**11.0**
7th	13.5	13.1	16.0	8.3	**12.6**
8th	14.6	19.2	10.9	13.7	**14.4**
9th	20.1	11.2	20.2	11.2	**15.8**
top	25.0	13.9	13.7	11.3	**16.1**
all	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

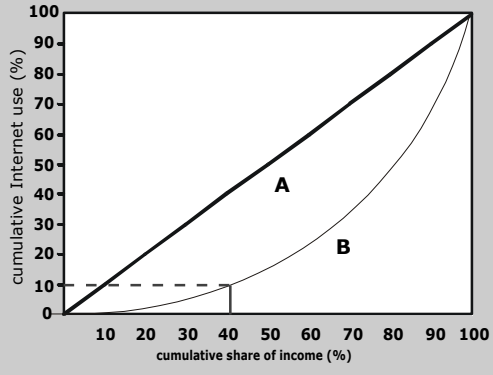
Technical Box 2: The Lorenz Curve

This is a method commonly used to study the inequality of the distribution of income. Making appropriate modifications to the standard application, this analytical tool is adapted to fit the context of the digital divide. Rather than plotting penetration against each income percentile, the cumulative distribution of penetration is plotted against the cumulative income percentiles, from lowest to highest (Figure 2).

In the case of no relative divide (perfectly egalitarian distribution), the curve would coincide with the diagonal 45° line, on which X% of incomes account for X% of penetration (0 and 100 are points on the curve, as 0% of incomes account for 0% of penetration and 100% of incomes account for 100% of penetration). In reality, the curve will always be slanted below the diagonal. The further away the bend is, the bigger the divide. (The bulge in this case is the measure). The example shows that the bottom 40% of incomes accounts only for 10% penetration.

Plotting curves for successive periods allows the measurement of the evolution of the relative divide. When from one period to the next curves are cleanly inside or outside one another, the conclusion is unequivocal – the divide is closing or widening, respectively. In case of crossing lines, however, there are trade-offs involving winners and losers and specific areas must be examined. In such cases, an overall measure is provided by the calculation of Gini coefficients. These are effectively measured by the ratio of area A over A+B. Gini coefficients can assume values from 0 (perfect equality) to 1 (extreme inequality). The larger the area between the 45° line and the Lorenz curve is, the further away from perfect equality, and the higher the value of the Gini coefficient.

Figure 2. *The Lorenz curve*



Such measures are not free of problems. The Lorenz curve emphasizes the totality of the situation and does not directly compare percentile pairs (e.g. highest vs. lowest). In addition, any measure that tries to encompass the entire Lorenz curve in a single statistic would inevitably contain elements of arbitrariness. Especially when curves intersect, curves of different shapes (and therefore different patterns of divides) could generate the same Gini. Clearly, these are aggregate measures best suited for an overall assessment. They do not replace detailed comparisons of specific groups.

Computing the cumulative distribution of Internet use by income decile (not shown), the Lorenz curve in Chart 7 was constructed. With the exception of 1996, curves for each successive year are cleanly enveloped by those of the previous year, indicating a closing relative divide. The 1996 curve behaves differently, crossing other curves, something that renders the comparison of the relative between 1996 and other years inconclusive (see Technical Box 2). This can be rectified by computing Gini coefficients - also contained in Chart 7. They indicate that the relative divide actually increased between 1996 and 1997, while it keeps closing from 1997 onwards.

This analysis was repeated with a different data set (HIUS) covering the use of the Internet by income quintile from any location for the 1998-2000 period. The conclusions are the same: the relative digital divide is closing. Lorenz curves for previous years cleanly envelop those for subsequent years and the Gini coefficients decline each year (Chart 8). Once again, the relative gain of the middle incomes (from 40% to 80% cumulative share) is evident.

While revealing, this analysis is not free of problems either. It offers an overall assessment of the evolution of the relative divide across all incomes, but it is less suitable for comparisons involving specific income groups, especially those far from each other. Therefore, it does not invalidate the conclusions of the trend analysis concerning the very low and the very high incomes. Even visual inspection of Charts 7 and 8, makes it clear that the inward bow of the curves over time is more pronounced in the middle incomes – particularly upper-middle. It is between these incomes and the top decile that the relative divide is closing and this influences significantly the overall result (quite consistent with the findings in Tables 4 and 5). At the bottom end of incomes, it is more difficult to decipher movements from this analysis. The trend analysis of Section 4.1 involving comparisons between the top and the bottom deciles is very direct, whereas in Lorenz curves they become two of ten deciles and their comparison is subsumed to that of the aggregate direction.

These findings jive well with all other pieces of evidence presented so far. Collectively, they conclude that the relative digital divide is generally closing but this is the result of the progress middle-income groups have made (particularly upper-middle) when compared to the highest income group. The lowest income groups (the three bottom deciles here) continue to lose ground vis-à-vis the very high income groups**.**

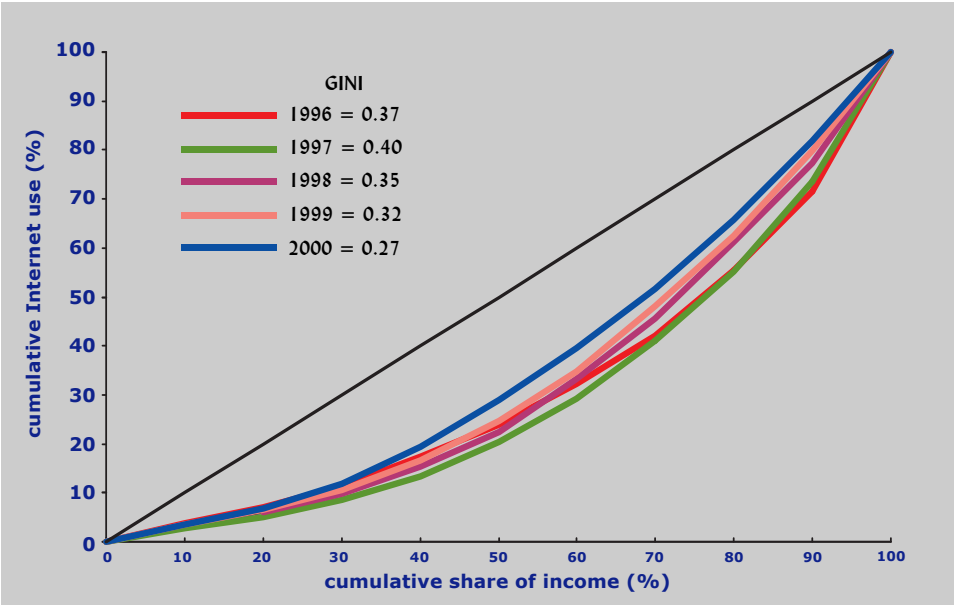


Chart 7.
Evolution of the relative Internet divide, home use.

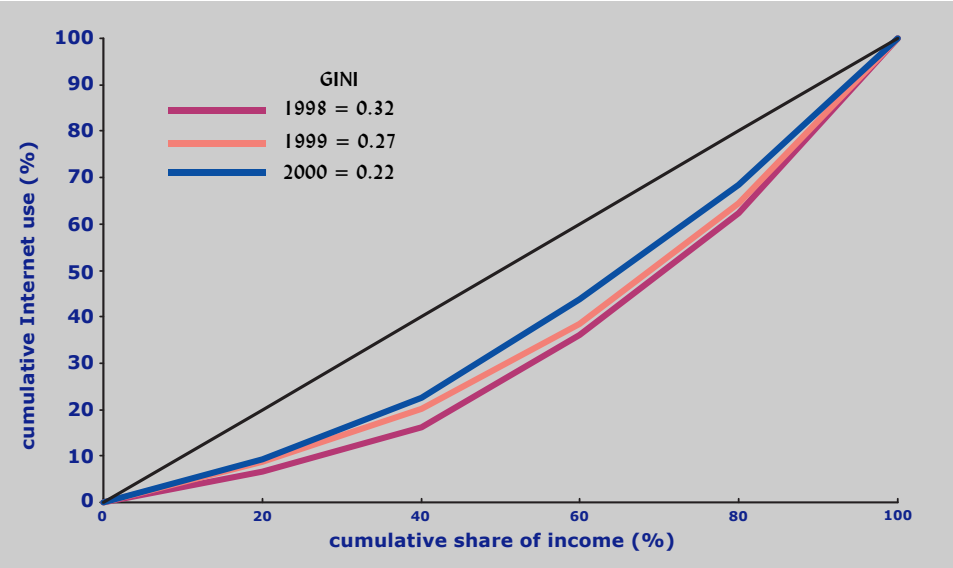


Chart 8.
Evolution of the relative Internet divide, use from any location.

5. RELATED MATTERS

As the Internet has become the epitome of modern communications, there are many pragmatic reasons why the Digital Divide matters. This study dealt with the Digital Divide and arrived at certain conclusions, within the scope of its investigation. The divide is generally closing, but the gap between the highest and the lowest incomes persists. However, this is quite consistent with many technologies in their early stages of adoption and it remains true that the rate of growth of Internet use at lower incomes is higher that than of the higher incomes.

In addition, this should be placed in the perspective that the composition of income groups changes over time. It is not the same individuals or the same group of families that comprise them. However important income is, there are plenty of closely interrelated aspects to this issue. Understanding barriers to access and use new technologies can be improved. While there is ample evidence that affordability is critical, it certainly does not explain the still-sizeable proportion of non-users at the highest income levels. Numerous other factors are at play, many of which change over time due to the evolution of the technologies, falling prices, social norms and much more.

Another dimension worthy of examination for the understanding of the Digital Divide is the sector of application. ICTs in education, health, public libraries and the like, come with their own specific research needs. Much remains to be understood following these early stages. In addition, while in developed countries enough attention is paid to connected homes in divide studies, the more communal attitudes of less-developed countries warrant a differentiated approach which would incorporate telecentres and other community resources more explicitly.

What comes through as the common thread of any investigation, though, is the issue of skills. For many, uneven opportunities in acquiring ICT-related skills, so crucial in functioning from now on, constitute the real divide. At the same time, skills are properly perceived as a continuum whereby their technology components are incrementally built on cognitive skills and general literacy. Research in this area is at an embryonic stage.

In the end, the issue of the Digital Divide, like all others, will come down to outcomes and impacts. *"The fundamental digital divide is not measured by the number of connections to the Internet, but by the consequences of both connection and lack of connection"* Castells (2001, p. 269). In examining such consequences, though, the degree of connectivity matters.

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