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DIDIX: A DIGITAL DIVIDE INDEX FOR MEASURING INEQUALITY IN IT DIFFUSION

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ABSTRACT

This article proposes a relatively simple indicator, DIDIX, that was developed in an EU-funded project to benchmark and track national digital divides within EU member states. Based on the relative diffusion of computers and the Internet in four disadvantaged socio-demographic groups (compared to national averages), the index is intended as a descriptive metric to compare basic levels of inclusion in EU-member states.

Because it reaches lower levels at higher rates of diffusion, however, DIDIX is neither proposed as a way to identify diffusion patterns at an early stage, nor to predict future developments. Its intent instead is to compare the diffusion of technology in at-risk groups with the population average. Results here suggest an increasing North-South gradient of cross-national inclusion prevailing in Europe. Applying the underlying methodology to other than simple access or use variables suggests that more attention should be paid to indexing the various skills and general benefits of IT.

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From a communications perspective, research about the socio-economic impact of having access to or using information is not at all new. Theorizing the digital divide has its clear roots in the knowledge diffusion research of the 1970s, when communication researchers in the United States began to debate the increasing "knowledge gap" hypothesis that: "Segments of the population with higher socio-economic status tend to acquire information at a faster rate than the lower status segments so that the gap in knowledge between these segments tends to increase rather than decrease." (Tichenor et al. 1970)

The main research question in this tradition was to find out whether, and in what way, factors such as education level or socio-economic status made a difference in acquiring knowledge. Tichenor et al. (1970) proposed that such factors were, in fact, the independent variables by which the diffusion of knowledge depended. Users of media programs who tended to be better informed would continuously increase their information advantage by making optimal use of the information available via the media.

In spite of considerable criticism, the knowledge-gap hypothesis proved very influential in communication research. With the emergence of digital media, the hypothesis reemged under the term of the "digital divide", here defined as "....the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ITs) and to their use of the Internet for a wide variety of activities" (OECD 2001).

The potentially unlimited access to information on the Internet, and the "sovereignty" of the consumer in selecting offerings on it, involves new complexities in navigational skills and extracting its benefits. Consequently, there is legitimate concern that this increased information opportunity will disproportionately be used by those who are already advantaged in society, rather than narrowing the gap(s) between them and disadvantaged groups of society

This argument nowadays relives in the frequently made observation that exclusion in the digital age is not so much from information but rather by information. The concept of the "digital divide" directly relates to the spiral of uneven access to and usage of IT and their socio-economic repurcussions. Although mere access to new technologies, both in terms of technical infrastructure and basic IT skills, will surely not be sufficient to prevent the widening of a digital knowledge gap, it is nevertheless the necessary prerequisite; and the value judgement that access to the Internet is in principle advantageous and therefore desirable for all is widely accepted.

Because IT penetrates increasingly more spheres of daily life, access and skills have become dimensions of social inclusion already, and it cannot be merely looked upon as differentiation of consumer behavior. Rather it has become a prerequisite, or at least a facilitator, of one's employability, one's social, societal and political participation, and one's access to public services like e-government, and increasingly to the education and health system.

Another important theoretical strand comes from diffusion theory of Rogers (1995). Implicitly, a simplified application of diffusion theory, if understood as a deterministic S-curve process, suggests that the digital divide is a merely temporary problem. It has been argued by people denying the long run relevance of the digital divide that different S-curves apply to different societal groups, which in the long-term or mid-term will eventually result in common saturation levels (as in Mason and Hacker 2003). In any case, it may be assumed that the gap between the observed groups first widens and eventually closes, as soon as the larger share of the population approaches saturation. It is obvious that even when applying S-curve diffusion models, neither the saturation level nor its speed are predetermined, so that in the long run it may not lead to universal social inclusion. Diffusion theory may well conform with scenarios where, either the velocity of uptake is deemed socio-politically undesirable and/or some societal groups will never reach the same saturation level as society on average. Figure 1 provides an example.

While Scenario I depicts a situation for those believing in a naturally vanishing digital divides, Scenarios II and III show less optimistic developments (still conforming with S-curve adoption). It is hence important to thoroughly track both the gap and the relative divide over time to assess the likely longer term developments.

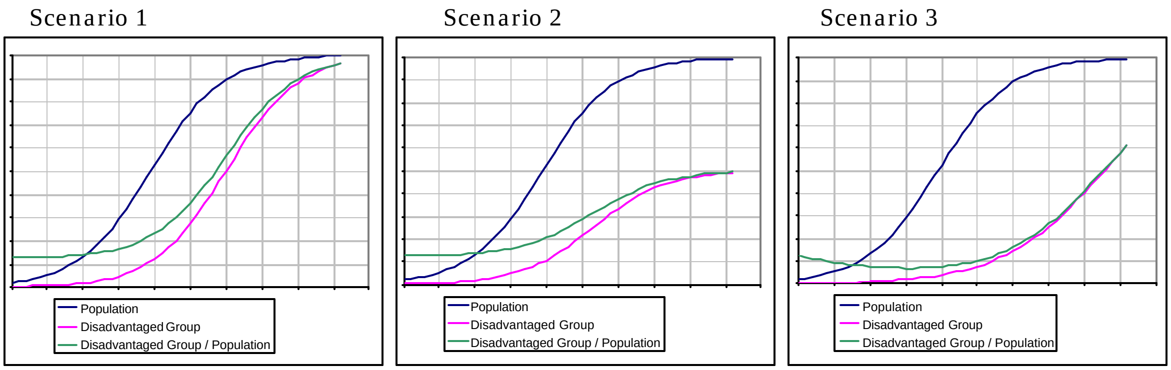
Policy is concerned with the evaluation of such diffusion developments. Whether the digital divide is closing or widening is regarded as putting Information Society politics to the test. However, that depends on having a clear definition and acceptance of whether a gap is widening or closing. As will be shown, criteria to inform such a judgement are anything but self-evident once both gap indicators are moving.

The search for a reasonable metric of the digital divide has been a subject of recent debate. Martin (2003) uncovered the selective and politically driven use of growth rates and a metric similar to the Gini index by the authors of *A Nation Online*. Martin proposed and employed odds ratios instead. The measure proposed here is similar to odds-ratio measures, but it has some different properties [2] discussed below.

For clarification, it is based on the first of the three scenarios described in Figure 1. The absolute distance between the penetration rates first increases and peaks somewhere between the two graphs' points of inflection. Due to its underlying mathematical properties, a constant time lag exists between the two curves, with the disadvantaged population group lagging behind for a constant amount of time.

Does this mean that the divide is neither closing nor widening? [3] And if so, does it mean that at any time point in the scenario the situation is equally desirable in terms of e-inclusion? Or is e-inclusion not better realized at the right tails, where the two graphs approach and both groups approach saturation? As already noted, reasoning about whether or not a divide is closing or widening requires a definition of what the respective terms mean. The proposal here is to define that the digital divide is closing of the quotient of penetration rates of a disadvantaged group and the population total is increasing.

FIGURE 1: THREE POSSIBLE DIFFUSION SCENARIOS



That is exactly the rationale of the index proposed, which provides a meaningful metric that should:

* Univocally and unidimensionally indicate which one of two situations is more desirable in terms of e-inclusion, and

* Assume a univocally understood target value (like 1 or 100) in case that a situation of equality is achieved.

Graphically, it can be concluded from the relative adoption curve that a closing digital divide implies a closing angle, alpha, in Figure 2. A value of 100 is assumed if a 45° angle is achieved.

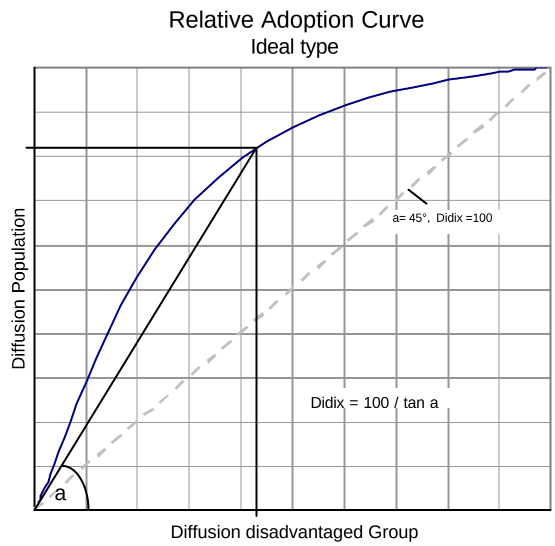
These scenarios may be mathematically modelled, using a logistic growth function[4]. In this, the two curves can be constructed as

$$x = \frac{K}{1\text{-}e^{-rt}(1-\frac{K}{x_0})} \quad \text{and} \quad y = \frac{L}{1\text{-}e^{-st}(1-\frac{L}{y_0})}$$

where:

	Population	Deprived Group
Diffusion level	x	y
Saturation level	K	L
Growth coefficient	r	s
Stock at $t = t_0$	x_0	y_0
Time variable	t	t

FIGURE 2: RELATIVE ADOPTION CURVE: IDEAL TYPE



The divide index, then, is the quotient of the two terms, or y/x. According to this definition, the digital divide is closing when the index is increasing or the derivative of the quotient with respect to time is positive[5].

INDEX METHODOLOGY

The definition of the digital divide used here is primarily an intra-national or intra-European one. For Europe, one calculates an intra-European digital divide index (DIDIX) on the one hand, and on the other hand, one compares intra-national divides, i.e., DIDIX values. This contrasts with other approaches where the notion of a digital divide is a global one, comparing diffusion rates rather than relative diffusion rates of disadvantaged groups. One can examine the adoption of four socio-economic variables: gender, age, income and education. While ethnicity, labor-force participation and spatial issues are crucial, data was either not available or not comparable. The choice of indicators is hence driven by data availability.

One can refer to these as the "at-risk groups", although the term may be deemed problematic because of normative connotations. One compares technology adoption among the at-risk groups to the adoption among the population average as a measure for the digital gap. A definition of the risk groups and their dimensions is given in Table 1.

Data sources are the Eurobarometer surveys 47.0 of 1997 (Melich 2000) and 54.0 of 2000 (European Communities 2001) and the SIBIS surveys 2002 and 2003[6].

TABLE 1: CONSTITUENT AT-RISK GROUPS AND DIMENSIONS OF THE DIDIX

At-risk group (Percentage of EU population in 2000)	Dimensions of the digital divide index
Gender - Women (~ 52%) Age - People aged 50 years or older (~40%) Education - People who finished formal school education at an age of 15 years or below (~30%) Income - Low income group (lowest quartile of the survey respondents) (~25%) Weight: 25% each	Computer use (Weight 50%[7]) Internet use (at all) (weight 30%) Internet use at home (1997, 2000); access at home (2002/03) (weight 20%)

The index is calculated as follows:

$$Didix = \frac{1}{n}\sum_{i=1}^{n} D_i$$

with D being the Sub index value for each subpopulation i (i=1,...,4), with

$$D_i = 100 * \sum_{j=1}^{m} w_j * \frac{p_{ij}}{p_j}$$

where wj = Weight of Indicator j (j=1,2,3 ; Sw=1)
pij = Value of indicator j in subpopulation i (i=1,...,4)
pj = Value of indicator j for total population.

If all groups show the same level of adoption, the index takes on a value of 100, with the minimum value being 0; values > 100 are not excluded in principle, namely if the uptake in the at-risk groups exceeds population average.

An example is shown in Table 2.

A frequent criticism of research on the digital divide has up to now focused on counting "how many are online" and on monitoring gaps between different segments of society, i.e. describing "who is (not) online". While this study does not go beyond this concept of measuring how many and who is online, the authors understand the shortcomings of this approach as admittedly driven by data availability.

A wish list of an ideal indicator time series would follow the by now widely adopted readiness-intensity-impact paradigm of IT diffusion research (cf., e.g., OECD 1999), and hence it would include such data as attitudes towards IT, open-mindedness, frequency of usage, skills/experience, and benefit indicators. One might also think of making value judgements about desirable and undesirable usage behavior.

TABLE 2: CALCULATING THE INDEX (EXAMPLE: VALUE FOR EU15, 2002)

	Computer (%)		Internet (%)		Internet at home (%)		**Sub index .5*A + .3*B + .2*C**
	Pcnt	A % of total	Pcnt	B % of total	Pcnt	C % of total	
Usage Total	56.5	=100	50.3	=100	38.6	=100	
Age 50+	31.3	55.4	25.1	49.8	20.6	53.4	**53.3**
Women	50.4	89.1	43.6	86.7	32.7	84.6	**87.5**
Education age <16	25.9	45.9	22.3	44.4	15.6	40.4	**44.3**
Income low quartile	17.1	30.3	11.9	23.6	8.5	22.1	**26.6**
Sub index (Average % of total)	**55.2**		**51.1**		**50.1**		**52.9**

Also, an indicator wish list could be defined by functionality rather than by technology. In a rapidly changing technological environment -- where (especially) mobile devices will substitute for the home PC in developing towards ubiquitous computing -- focusing on PC use would soon become obsolete. Here, access (by whatever means) to particular services will be a more suitable indicator. In this sense the index proposed is to be conceived of as a methodological structure that may be fed with different indicators, as soon as appropriate data are available.

It is not the aim of the index to "explain" statistically what the underlying causes of the digital divide are. Studies on this subject regularly are influenced by the usual dimensions of social inequality -- as well as by social networks, life-style patterns, including a growing share of deliberate self-exclusion (e.g. Lenhart 2003). The index cannot claim to do any of this but only to reduce the amount of data available to one meaningful and easily comparable metric of e-inclusion.

SIGNIFICANT INCREASES IN IT DEPLOYMENT

Figures 3-5 show IT usage for the four demographic variables over time. The share of Internet users, for example, increased from 7% of the EU population early 1997 to over 26% in 2002. For computer usage, the increase was more moderate[8] (36% to 57%), but nevertheless considerable.

Diffusion within the four demographic variables shows an increase at a lower level than in the whole population, The share of Internet users in the low education group increased from 1% to 12%, and computer use in this group increased from 12 to 17%. For all groups diffusion can be described as the lower part of an S-curve.

FIGURE 3: GROWTH IN COMPUTER USAGE: 1997-2002

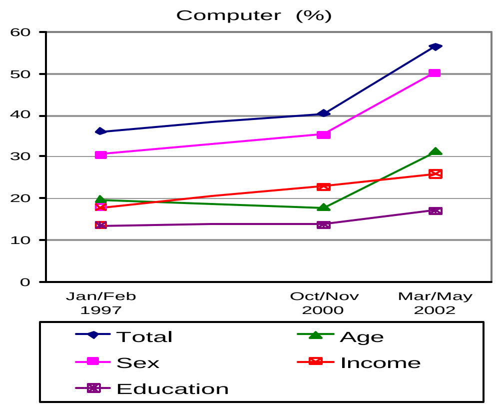


FIGURE 4: GROWTH IN INTERNET USAGE: 1997-2002

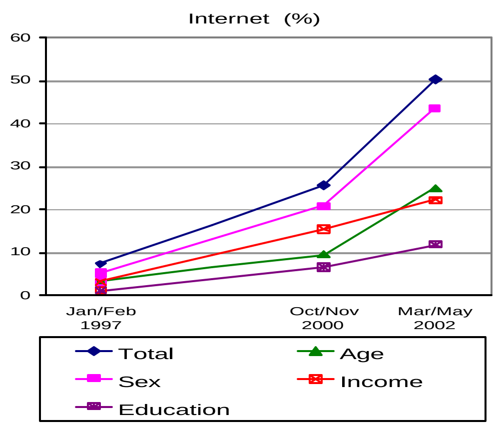
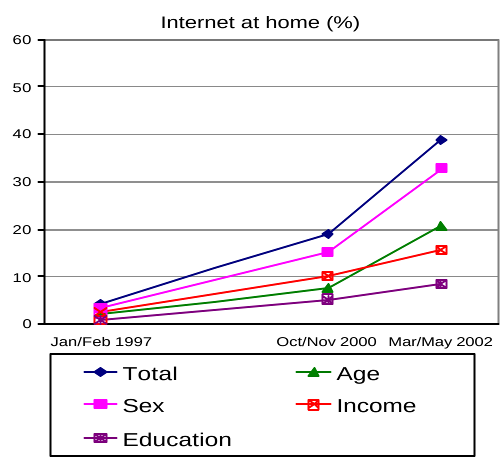


FIGURE 5: GROWTH IN INTERNET USE AT HOME: 1997-2002



Quite interestingly, the overall European Index has not changed much since 1997, as can be seen in Figure 6. Its value stagnates at 53, roughly meaning that the at-risk groups have adopted IT at 53% of the population average. While the overall value remains at this level, developments in opposite directions in sub-indicators balance each other out; but even more interesting is how the movements in opposite directions in member states also balance each other out, and how signs of polarization can be found.

The coefficients of variation increase from 10.3 (1997) to 22.9 (2003). While, on the one hand, the "traditional" forerunner countries (like the Nordic countries, the United Kingdom and the Netherlands -- as well as Austria and Ireland, which showed recent surges in IT diffusion) have improved their inclusiveness, the situation in southern countries has deteriorated considerably. While Eastern European countries are below the EU 15 average, some of them (Estonia, the Czech Republic) almost do reach it.

Table 3 decomposes the EU15 Index values by country and by index group. For example, in 1997 women in Belgium had a relative risk of being IT users of 86%[9].

The results suggest that education exerts a very decisive influence on IT usage. Its sub-index values over the study period remain rather constant at 30. Thus, among people who have left school at an age of 15 and younger, usage stagnates at a level of 30% of the population average. Whereas gender appears to lose most of its significance as a determinant of IT use between 1997 and 2002, men remain slightly overrepresented. The index climbs from 80 to 87 (EU15), varying between 62 in Greece and 96 in Finland. Observations regarding income are uneven, but income clearly has its weakness in surveys, with its high nonresponse rates and unclear definitions that detract from validity and reliability. Bearing that in mind, a slight decrease can be observed. As for age, the older-younger gap seemed until 2000 to widen, but the value increased again in 2003 and now exceeds the 1997 value.

In order to check whether the so operationalized digital divide merely reflected the general level of IT diffusion, results were adjusted for the level of IT use. If the digital divide was only a function of overall adoption, this would support the hypothesis of the digital divide being a temporary problem of quasi-natural diffusion processes; and it would be expected that those countries that are currently more heavily affected by digital gaps would catch up on the digital divide, as they catch up on IT diffusion.

To do so, a simple usage index was constructed which calibrates the empirical values of the technology variables between 0 and 100. Every country at a certain time point was considered as a single case. The value of 0 would be assigned if a country at one time point reaches the minimum of all three technology variables (which is the case for Portugal in 1997), and a value of 100 would be assigned if a country at one time point reached the maximum on all three variables (which is not case for any country). Weighting is equal to the DIDIX weighting.

FIGURE 6: DIGITAL DIVIDE INDICES FOR EU AND CEEC

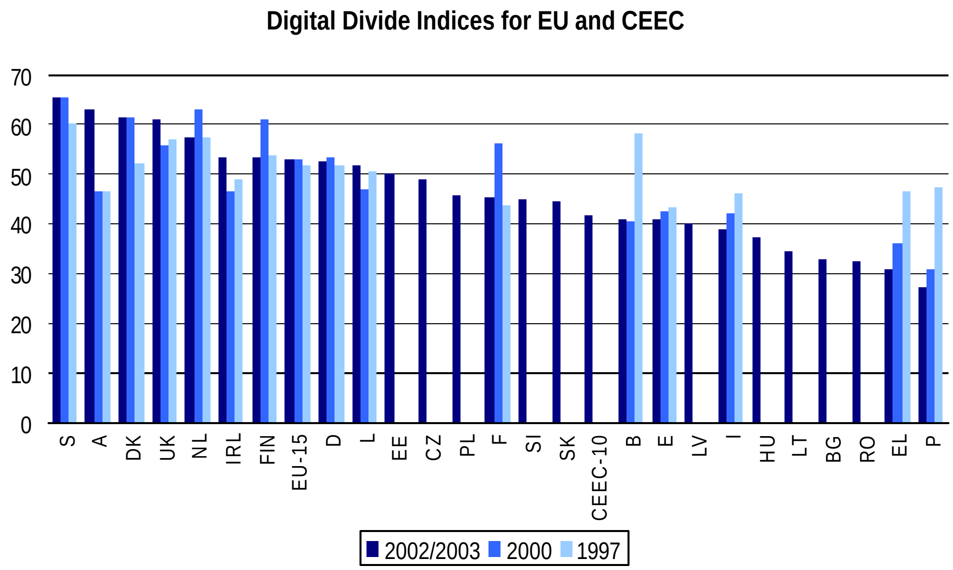


TABLE 3: DIGITAL DIVIDE INDICES EU 15

	Sex			Age			Education			Income			**DIDIX**		
	97	00	02	97	00	02	97	00	02	97	00	02	**97**	**00**	**02**
Belgium	86	82	82	58	39	37	43	10	12	46	32	33	**58**	**41**	**41**
Denmark	76	88	93	50	59	69	24	37	23	57	63	61	**52**	**61**	**61**
Germany	79	85	81	51	37	55	29	36	38	48	55	36	**52**	**53**	**52**
Greece	74	81	62	39	16	19	33	10	19	40	36	23	**46**	**36**	**31**
Spain	76	83	83	38	21	34	30	17	27	29	49	20	**43**	**43**	**41**
France	78	88	88	58	35	36	7	20	19	32	81	39	**44**	**56**	**45**
Ireland	88	91	95	49	32	54	28	29	37	31	35	28	**49**	**47**	**54**
Italy	68	73	77	55	31	34	19	21	19	42	44	24	**46**	**42**	**39**
Luxembourg	78	85	78	53	35	62	34	25	29	38	42	38	**51**	**47**	**52**
Netherlands	76	84	89	36	54	68	43	32	32	73	81	41	**57**	**63**	**57**
Austria	81	79	93	40	22	51	37	30	54	29	54	54	**47**	**46**	**63**
Portugal	95	76	78	49	9	17	22	8	7	23	30	6	**47**	**31**	**27**
Finland	81	92	96	41	56	49	25	39	24	68	58	45	**54**	**61**	**53**
Sweden	89	90	91	58	61	67	41	39	41	52	71	62	**60**	**65**	**65**
UK	87	85	93	54	51	62	40	52	39	47	35	49	**57**	**56**	**61**
EU15	**80**	**84**	**87**	**50**	**41**	**53**	**28**	**30**	**27**	**49**	**57**	**44**	**52**	**53**	**53**

Figure 7 highlights the results for three sample countries: Sweden as forerunner, Germany as average "performer" and Portugal as laggard. A noticeable correlation between the level of IT use and the digital divide index can be observed, which was to be expected from diffusion theory. If accounting for all three time points together, the correlation is r=.59, which supports the expected dependence of the index on IT diffusion. However, when analyzing the time points separately, a clear increase in the correlation, and an (almost parallel) movement of the regression line can be observed. The correlation for 1997 is r=.68, for 2000 r=.88 and in 2002 r=.93. This effect also remains when analyzing only single technology sub-indicators, and thus it does not hinge on the time-shifted diffusion of computers and the Internet.

DIGITAL DIVIDE IS NOT ONLY A TEMPORARY PROBLEM IN MANY COUNTRIES

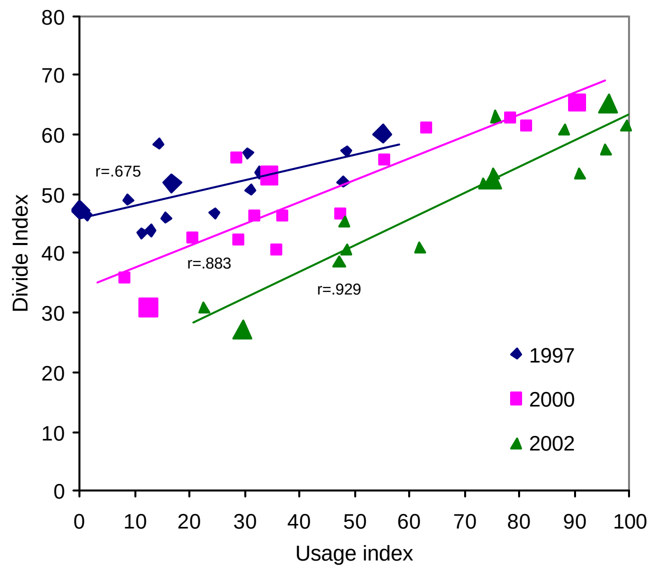
Obviously and remarkably, in many countries the increase in overall IT deployment involves only a constant, or even falling, relative participation of disadvantaged population groups. This suggests that in many countries these groups will not, even in the longer run, reach the adoption level of the population average. While, for instance in Sweden, the average participation in disadvantaged groups is 65% of the overall population, this average in Portugal accounts for only 27% and is falling.

Further, the movement of the regression line makes clear that a purely deterministic relation between the societal IT diffusion level and the digital divide does not hold. Rather obviously, those countries that only later (than other countries) reach certain levels of diffusion at this same level show more inequality in IT adoption. This may, on the one hand, be due to generally lower social inequality in the rich forerunning countries than in the poorer southern European laggards. On the other hand, this may point towards the pattern in geographic diffusion processes, in which the difference between the group of early adopters and the majority in disadvantaged or peripheral regions is more distinct than the same difference in central and forerunning regions. If so, larger differentials in the speed of diffusion may be a regular pattern. The underlying reasons of these patterns, however, need further attention.

THE DIGITAL DIVIDE AS AN EVER-EVOLVING PHENOMENON

It has been argued that e-inclusion is a dynamic process that has to keep pace with technological development (e.g. Mason and Hacker 2003). The following argument is an attempt to analyze skills and benefits under the same framework as the digital divide index. In the BISER project[10], the organization *empirica* and its partners have also gathered data on user skills

FIGURE 7: CORRELATIONS BETWEEN DIVIDE AND USAGE INDEXES ACROSS COUNTRIES: 1997-2002



and purposes of Internet use. Tables 4 and 5 display some preliminary results, with the overall DIDIX value for this sample being 60, and hence larger than the EU-15 value for 2002.

When looking at these skills and benefits data, it is obvious that no usage dimension reaches the value of the overall DIDIX. The sending of e-mails and the use of office software almost reaches the value, but online transactions -- participating in online discussions, as well as more sophisticated IT skills -- are much less common among disadvantaged groups in society. Particularly striking is the lower proportions of less educated people who did economic transactions, like buying or banking online. Women are disproportionately less likely to be experienced in creating web documents, installing software and writing computer programs. So are older people, who besides that, hardly participate in online discussions.

Following the policy discourse about the digital divide, a narrow definition of the term has focused here on access/usage measures of computer and the Internet diffusion. However, in the long run, access alone will hardly bridge the digital divide in the wider sense, that is if it is understood as a "knowledge gap" rather than a technology gap. Research suggests that it is equally important how the available technology is being utilized (e.g. Robinson et al. 2003; David 1999). The analysis here has used a few available indicators from the BISER project to illustrate the insights possible with the DIDIX index.

It is acknowledged that more sophisticated statistical procedures can deliver more exact and multivariate controlled results to identify the socio-economic determinants of IT adoption. Therefore, DIDIX is simply proposed as a descriptive tool that can quickly deliver comparable and (it is hoped) meaningful metrics to track different aspects of diffusion. Future research

TABLE 4: DIGITAL DIVIDE INDEX 28 ACROSS BISER REGIONS

	Computer use	Internet access	Internet use
% for total population	60.2	52.1	51.0
Relative uptake (Using DIDIX measures)			
Sex	90	92	87
Education	34	39	26
Age	57	68	51
Income	61	56	57
Index value	**61**	**64**	**55**
DIDIX		**60**	

TABLE 5: DIGITAL DIVIDE INDEX METHODOLOGY APPLIED TO SKILLS AND BENEFITS (28 BISER REGIONS)

	Ordering products on the Internet	On-line banking	Posting in forum/chat rooms	Ever used office program	Ever sent/ received e-mails	Ever created a website	Ever installed new software	Ever written a computer program
% for total population	16.5	17.8	12.4	52.9	50.6	9.8	34.7	9.6
Relative uptake (Using DIDIX measures)								
Sex	81	78	76	89	89	63	66	48
Education	14	17	27	27	26	21	21	27
Age	53	57	17	53	53	32	46	49
Income	54	53	67	58	57	68	56	58
Index value	51	51	47	57	56	46	47	45

will have to develop indicators which describe what people actually do with the Internet, and in what ways they can benefit from this usage. Mere access is obviously not the purpose, but only the vehicle, for assumed positive effects for those who have access.

Once access has been established, the next question has to be: "To what end?" Social organizations and policy institutes warn that simple access is not necessarily effective in producing change in low-income communities (Jackson et al. 2003; Morino Institute 2001). A more promising approach is to collect indicators about how people actually use the Internet -- tracking surveys in which respondents are questioned about what they did during their online sessions (as in Hargittai 2003 and in Howard 2001).

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APPENDIX

SOME METHODOLOGICAL ISSUES WITH DIDX: A DISCUSSION

Reviewer: I believe there are some problems with the digital divide index DIDIX, including one serious enough to compromise its usefulness. Furthermore, I do not believe it is possible to come up with a mathematical index to overcome a basic identification problem: In the early stages of a diffusion process, it is impossible to distinguish an incomplete diffusion from a slow one.

Authors: It is not the intention of the index to identify diffusion patterns at an early stage. It is simply a descriptive tool, measuring relative uptake in at risk groups – relative in the sense of a percentage of uptake compared with the population average.

Reviewer: I will focus my attention on the most serious problem first.

The authors appear to argue that if the digital divide index takes on a smaller value over time, this suggests that the saturation level L of the deprived group is lower than the saturation level K of the population. However, this does not necessarily follow from the equation in footnote 6. Instead, the reverse logic follows from the equation in footnote 6: if L < K, then the digital divide index will be smaller (all else equal), but a small or declining index does not prove that L < K.

For instance, DIDIX declined from .46 to .31 in Greece from 1997 to 2002. We can arbitrarily assign 1997 as to without loss of universality, in which case DIDIX for 1997 simplifies to x_0 / y_0. This leaves us with four unknown parameters for the 2002 case: K, L, r, and s, and only two data points for 2002 to solve the system. The low DIDIX for Greece in 2002 could indicate that L < K, but it could as easily indicate that s < r. The presence of the 2000 observation theoretically gives us the ability to solve the additional parameters, but in practice it is essentially impossible to identify a separate effect of L until y for the disadvantaged group is more than half of L. The authors' own charts illustrate this problem: In Table 3 (log version), one cannot perceive a departure from parallel increase in the deprived category until log odds > -1, or y > .27. By comparison, our own percentages for Internet use in the lowest income quartile in 2002 are .073 for Greece and .025 for Portugal, far below any plausible levels of L. To repeat, the declining DIDIX that the authors attribute to Scenario 2 may in fact predict an incomplete diffusion, but are also fully consistent with the slow diffusion shown in Scenario 3.

Authors: Fully agreed. It is not the intention to extrapolate at such an early stage. Again, it is a descriptive measure, saying e.g. diffusion in the deprived groups was, say, 25% in 1997 and is 20% in 2003 and that such a development calls for political action because it may (in this model's terms) either identify a severely delayed (several years) diffusion or hint towards a significant share in the deprived group that will persistently stay outsiders. Both scenarios call for action.

Reviewer: DIDIX presents some other difficulties as well, such as the fact that the disadvantaged group represents a varying part of the population (from ¼ for the lowest income quartile to more than half in the case of women.), and th at by relying on the ratio of x/y, the DIDIX tends to vary with the stage of the diffusion process (so that the increasing correlation between ICT use and DIDIX is an unwanted artifact of logistic diffusion curves, and not an important substantive finding).

Authors: Yes, it usually increases with the diffusion process. Its can be most easily grasped by looking at the graph "Relative Adoption Curve". When alpha decreases, we argue, e-inclusion increases. This is of course a definition and hence useful or not useful. However, a clear definition of what is an improvement, or a closing gap, is needed. A closing gap is not common sense defined if goal posts are moving. Odds ratios are better than distances or percentages but still as well a matter of definition and not right or wrong. We think that the angle alpha is quite an easy measure.

The striking point with the correlation is not so much that it increases but that the correlation line is moving down or to the right as is clearly shown in the "correlation" graph! This means that countries that reach diffusion levels later than others do not reach the e-inclusion of the former. This is in my point of view a substantive finding.

Reviewer: Comparisons of Husing's results with our results are difficult because DIDIX combines results for several measures of computer and Internet use along with several dimensions of inequality. In general, however, our results neither agree nor disagree with the Husing results in any systematic fashion. DIDIX is closing most rapidly for Austria, Denmark and Sweden, which have varying records with respect to increasing inequality in a comparison of log odds ratios. DIDIX is widening most rapidly for Greece and Portugal, which have such low levels of Internet use in the lowest income quartile that it is difficult to make any firm statements about intranational inequality for those two countries.

Authors: Thanks. If after my reply you think some further elaboration/explanation of misunderstandings would remedy your concerns I will be happy to do so. If not, I anyway thank you for your comments and would like to keep in touch about possible future cooperation.

ENDNOTES

[1] This article largely builds on two previously published articles by the authors: Hüsing (2003) and Hüsing and Selhofer (2002) and work published in SIBIS (2002). Also the authors are indebted to the anonymous reviewers for very helpful comments and suggestions.
[2] Martin (2003) compares the increase in the odds of use in different groups. While this metric allows for the shortcomings of comparing growth rates, it does not provide an evaluation of the usage level. As he observes an increase in the odds of the richest households of 2.6 (increase from 59% to 79%), he would evaluate an equal odds ratio in lower income groups as same speed of uptake, whether the increase be from 1% to 2.6% (odds increase =2.6) or from 10% to 22.5% (odds increase=2.6).
[3] Sicherl (2003) has proposed a powerful metric, the S-distance, which measures exactly this, the time distance between different diffusion curves. However, the value judgement here is that a constant time distance may nevertheless imply improvements in e-inclusion, namely that a situation when curves approximate saturation and, say, a one year distance only accounts for fractions of a percent is defined as being more inclusive than a one-year difference in the middle of a diffusion process that may account for a significant (absolute and relative) gap.
[4] A simple MS-Excel tool to simulate and graphically study the properties of different digital divide metrics depending on the diffusion parameters may be received by e-mail from the authors (tobias (a) empirica.com).

[5] Relative index:
$$f(t,K,L,r,s,x_0,y_0) = \frac{L}{K} * \frac{1-e^{-rt}(1-\frac{K}{x_0})}{1-e^{-st}(1-\frac{L}{y_0})}.$$

[6] The Eurobarometer and SIBIS 2002 data cover the EU 15 countries. The 2003 SIBIS survey covers the acceding countries Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, and Slovenia, and the candidate countries Romania and Bulgaria.
[7] Weighting is necessarily arbitrary. One might weight computer and the Internet equally and add a little emphasis on usage anywhere, rather than at home use. An earlier version of the index, based only on Eurobarometer data (Hüsing and Selhofer 2001), also contained the variable 'computer use at home'. This was not covered by the SIBIS surveys and its weight hence added to the computer use variable.
As to the weighting of categories, this approach of assigning equal weights of 25% to all groups has been challenged. Recognizing that weighting based on the outcomes of, e.g. a logistic regression could be more accurate, the argument is that such weighting would: a) change over time and countries, as multivariate analysis is applied to new survey waves and would hence hamper comparability and b) suggest promises of scientific accuracy that such an index can never keep. It is fully acknowledged that there are more accurate and sophisticated methods. The focus of this index, however, is more policy oriented, an advantage that audiences on the one hand need not interpret an exp(b) coefficient to understand the outcomes, and on the other hand, the necessary arbitrariness of the index is not obstructed by non-retraceable construction of this measure.
[8] In terms of the increase in odds.
[9] In detail: The index value 86 can be decomposed as a weighted average of 83, 88 and 94. The relative computer uptake was 83% (of the general population uptake of 32%, i.e. women's adoption rate was 26%), Internet uptake was at 88% and Internet at home at 94%.
[10] See www.biser-eu.com . Interviews were conducted in February and March 2003. The sample consists of 28 European regions (NUTS2 level) in 14 member states, in which 400 interviews in each region were conducted. The sample is hence not comparable to EU 15 data, although the selection of regions was meant to represent the various types of European regions.