THE DIGITAL DIVIDE INDEX – A MEASURE OF SOCIAL INEQUALITIES IN THE ADOPTION OF ICT

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ABSTRACT

Recent information society policies have been paying much attention to the threat of a "digital divide". The gap between citizens from different socio-economic backgrounds with regard to their opportunities and abilities to access and use information and communication technologies is commonly regarded as a potential barrier for participation in the information society. This paper suggests a method for measuring the digital divide on an aggregate level by defining a Digital Divide Index (DDIX) which focuses on the presumably disadvantaged groups of society. The DDIX applies diffusion theory to the current digital divide research paradigm. It presents initial results for the 15 EU Member States and the European Union as a whole. A comparison of the indices for the years 1997 and 2000 shows that the digital divide in Europe has not yet decreased and that particularly the elderly and the low education segment of the population have failed to catch up with the average. The paper reports about research in progress which is linked to several indicator projects funded within the IST Programme of the European Union, especially to the projects SIBIS, BEEP and SeniorWatch.

1. THEORETICAL BACKGROUND AND POLICY CONTEXT

1.1. Definition of the digital divide

In the political discourse about the opportunities and threats of the information society the terms "participation" and "inclusion" are frequently used to describe the objective of creating favourable economic and social conditions from which as many citizens as possible can benefit. Achieving "an information society for all" – i.e. an "inclusive information society" – has become a political priority for the European Union [European Commission, 2001a; 2000a]. Due to the growing use of information and communication technologies (ICTs) in all areas of private, public and economic life, the ability and skills to operate these technologies and the means to access them are regarded as important prerequisites and components of social inclusion. Carrying on the hype to name everything

with an "e-" in front, the terms "e-inclusion" and "e-participation" have been introduced by European policy documents as simple catchwords referring to policies addressing the quite complex role of ICTs in the context of social inclusion.

The flip side of social inclusion is obviously social exclusion, which is manifested when individuals or groups of people are experiencing disadvantages (for instance unemployment, low incomes, poor housing, bad health or bad housing) in relation to the average population or is socially rejected for other reasons. In the same way, the term "digital divide" has been established as a metaphor signifying the flip side of e-inclusion. The digital divide marks "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 (ICTs) and to their use of the internet for a wide variety of activities." [OECD, 2001]

Although using computers and having access to the internet are the main indicators in advanced industrial nations for determining on which side of the "digital divide" somebody is, it should not be neglected that that there are totally different levels of access to information and communication technologies. In developing countries, access to not necessarily digital but rather conventional communication infrastructure such as fixed telephone networks is everything but self-evident [OECD, 2001]. Research presented in this paper is undertaken from a European perspective and therefore concentrates on more advanced technologies and networks in the operationalisation of finding a measure for the digital divide.

It is not the objective of the index discussed in this paper to analyse the underlying causes of the digital divide. As one would intuitively assume, and dominantly in the public discourse about the digital divide, the main reasons are assumed to be the lack of economic resources or capabilities required to use technologies. At least equally important, as "offliner-studies" find, could be a mere lack of interest, i.e. consumers do not perceive any value in using computers or the internet for their personal life [e.g. Grajczyk / Mende, 2001; Lenhart, 2001].

1.2. The digital divide as a modern version of the knowledge gap theory

From a communication research perspective, research about the socio-economic impact of having (or using) access to information is not at all new. The digital divide clearly has its roots in the knowledge gap research of the 1970s, when communication researchers in the United States began to debate the theory of the increasing "knowledge gap": "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. Research was triggered by the findings of Tichenor et al. [1970] who proposed that such factors were, in fact, the independent variables by which the level of knowledge was dependent. The intensive users of media services, who tend to be well-informed, would continuously increase their information advantage by making optimal use of the information offer available through media compared to those who do not use this offer.

In spite of a considerable amount of criticism, the knowledge gap theory proved to be very influential in communication research. With the emergence of the digital media, the knowledge gap theory finally experiences a full revival, albeit renamed as the "digital divide". The potentially unlimited access to information and the "sovereignty" of the consumer to select from this offer brings about a new complexity to navigate in this offer and to extract benefits. Consequently, there is legitimate concern that – paradoxically – the increased information offer will disproportionately be to the use of those who are already advantaged in society and at the cost of disadvantaged groups of society, rather than narrowing the gap(s) between these groups.

This argument is nowadays reflected by the frequently made observation that "info-exclusion" in the digital age is not so much an exclusion *from* information but rather *by* information. The concept of the "digital divide" directly relates to the spiral of uneven access to and usage of information and communication technologies and the socio-economic rebound caused. If so, the digital divide – conceived of as a digital version of the analogue knowledge gap – conflicts with common social policies and visions of an inclusive information society. Although it is not yet quite clear if mere access to new technologies in terms of technical infrastructure and basic ICT skills will be sufficient to prevent the widening of a digital knowledge gap, it is commonly accepted thinking that access to the internet is in principle advantageous and therefore desirable for all. Information society policies of the European Union strongly focus on bringing all European citizens to the net.

1.3. The policy context of the digital divide

Considering the still existing uncertainties about the knowledge gap theory and whether any significant progress has been achieved in reducing the gap over a period of about 30 years, it is legitimate to question the relevance of the digital divide debate for contemporary society. If different media demand and usage patterns simply have evolved parallel to the ongoing development and differentiation of the media landscape, it could be argued that the "digital divide" should be treated as a natural differentiation of consumer behaviour rather than be turned into a policy concern. Such a view, however, would contrast the current discourse in European and international policies about social inclusion which have identified the digital divide as a threat to a sustainable information society and are consequently seeking for a remedy against it. The arguments justifying such policies can be grouped into three generic categories.

- Improving and securing employability: Basic skills in computing and using the internet are an indispensable requirement for a growing number of jobs. Consequently, counteracting the digital divide should implicitly have a positive impact on the level of employability in the population.
- Equal participation of citizens in the information society: The second line of argument focuses on the opportunities of the individual citizen to benefit from advantages enabled by ICT. If an increasing number of day-to-day life transactions is performed over digital networks, people who do not have access to these networks will – in the long run – experience disadvantages.
- Economic reasons (demand side economics): Less obvious than the previous two arguments, bringing off-liners and non ICT-literate parts of the population online could also have positive effects on the economy. A growing number of consumers on the net could trigger the motivation of enterprises toward e-business, which is commonly assessed as advantageous for the region's economy.

For mainly these reasons, initiatives that aim at minimising the digital divide have become an important component of regional, national and European policies at in different policy areas that address the larger objective of social inclusion. The digital divide – as a manifestation, cause and effect of social exclusion – plays a role in social and employment policies [European Commission, 2000b], education policies [cf. European Commission, 2001b] and general information society policies, particularly in the framework of the eEurope initiative, under the heading of "participation in the knowledge-based society" [cf. European Commission, 2001a; 2000a].

In the context of social policies, counteracting the digital divide has been identified as an element in the fight against poverty and social exclusion, which was included in the provisions relating to the European Union's social policy through the Articles 136 and 137 of the Amsterdam Treaty. Employment policies of the European Union also focus on e-inclusion. The Communication of the European Commission on "Strategies for jobs in the information society" [2000b] stresses "job potential of the information society" due to opportunities created by the new information and communication technologies, but also points out that the "European information society is still largely exclusive", and raises the issue of "information society skills gaps". Education policies also stress the

importance of digital inclusion, since "[...] the knowledge based society implies that every citizen must be 'digitally literate' and [possess] basic skills in order to be on a better footing in terms of equal opportunities (...)." [European Commission, 2001b]. Finally, the objective of digital inclusion is an integral part of the eEurope Initiative and the related Action Plan of the European Union [EC, 2000a] which states that "only through positive action now can info-exclusion be avoided at European level." eEurope focuses on ten priority areas of which e-education, e-work, e-accessibility and e-health are those with a direct connection to digital divide issues. It is in relation to these policies that the research presented in this paper (which needs to be further developed) intends to make a contribution. The authors believe that – although a lot of data about the digital divide are already available – a more systematic and longitudinal approach based on compound indices that allows to measure the dynamic aspect of the digital divide should be taken in order to inform policy.

3. THE DIGITAL DIVIDE INDEX: METHODOLOGICAL APPROACH

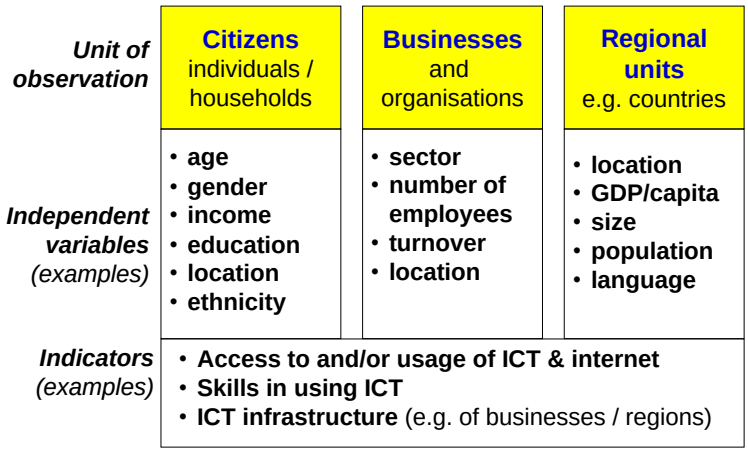
Research on the digital divide has up to now mainly focused on counting "how many are online" and monitoring gaps between different segments of society, i.e. describing "who is (not) online". The forerunner in collecting extensive and systematic data about who is online and who not are the United States, for instance with the "Falling through the Net" series of the NTIA of the US Department of Commerce [2000]. For Europe, findings are that "internet usage is increasing across all socio-economic categories, but the access gap has grown in absolute terms, over the last months. Digital exclusion is frequently cumulative, affecting various kinds of social disadvantages. Lack of access and training are the main barriers." [European Commission, 2001a]

In this study, we do not go beyond this concept of measuring how many and who is online, although we do not neglect the shortcomings of this approach (see last chapter: perspectives for future research – beyond access). However, we want to contribute to the debate by discussing what should be the appropriate measure of the divide. We contrast the "digital gap", measured as the access difference between different groups in percentage points, and the "divide index", measured as the ratio between the percentages. We argue that a combination of both measures is required to better understand the dynamics and the development of the digital divides.

Any study that tries to measure the digital divide has to specify the scope of what is actually measured by taking decisions on at least three levels:

1. The *unit of observation* needs to be defined: There are different types of digital divides, e.g. between citizens, between businesses or between regions.
2. The *independent variables* need to be specified by which the digital divide among the unit of observation is assumed to be dependent. The sets of variables will be different depending on the unit of observation. For instance, if citizens are the unit of observation, the independent variables could be age, gender, income, education, ethnicity or type of residence.
3. The *indicators*, i.e. the operationalisation of the term "digital divide" need to be selected. The most frequently used indicator is internet usage. However, the selection of indicators necessarily reflects what is conceived as state-of-the-art technology in the research context. If, for example the digital divide in developing countries is analysed, it probably makes sense to include more traditional telecommunication indicators (e.g. access to a telephone at home).

Diagram: Studying the digital divide: Methodological framework



This study deals with the digital divide between different groups of society. We use as independent variables four socio-economic factors: gender, age, income and education. The method is to focus on the presumably disadvantaged segment of society with regard to each of these factors. We refer to these segments as the "risk groups", although the term is problematic in so far as these are not distinct groups, since an individual can belong to more than one of them. We have compared the technology adoption among the risk groups to the adoption among the population average as a measure for the digital gap. A definition of the risk groups is given in the table below.

Independent variable	*Definition of the disadvantaged group ("risk group")*	*Percentage of population in EU (2000)*
Gender	women	~ 52%
Age	people aged 50 years or older ("50+")	~ 40%
Education	low education group (= people who finished formal school education at an age of 15 years or below)	~ 30%
Income	low income group (= the lowest quartile of the survey respondents)	~ 25%

Admittedly, this approach can be challenged in several ways:

- The main methodological difficulty is that the risk groups are not mutually exclusive. i.e. the same person can be a woman, older than 50 years and be in the low income group. Thus, variables can be partially determined by each other. A statistical separation of the independent variables' contribution to the explanation of IST uptake in society will be the next step to be taken.
- There are more "disadvantaged groups" than the four used in this pilot – particularly the unemployed and the disabled, but also people living in less developed regions and in some cases members of ethnic minorities.
- The disadvantaged groups as defined above are not equal in their size. It could be argued that the independent variables should be modified in a way that they describe stable proportions of the population. One way to adjust for the different size of the risk groups would be to weight the indices when building the compound Digital Divide Index. This needs further consideration.

- The definition of what is "disadvantaged" in terms of age, education and income is necessarily arbitrary. It can be questioned if the same definition can be applied to different countries, or if concepts should be used that reflect the socio-economic conditions in the respective country.

We have then selected four indicators which we consider the currently most important ones to calculate a basic measure of the digital divide in advanced information societies. Each indicator was given a weight to calculate the compound index. The selection of weights is necessarily arbitrary. The rationale was to emphasise the usage of technologies (by increasing the weight from an the default average of .25 to .30), but to include home usage indicators, because access at home will probably become more important as more and more everyday life transactions are performed online. A comparison of unweighted index values to the weighted index shows, however, that the difference is minimal and that general trends are not effected.

Indicator	*Definition / source*	*Weight*
Percentage of computer users	Data are based on the Eurobarometer survey question: "Do you use a computer at [different locations given for selection]?" Computer users have been defined as those who use a computer at least at one of the given locations, e.g. "at work", "at home", "at the university".	30%
Percentage of computer users at home	Data are based on Eurobarometer survey question: "Do you use a computer at home?"	20%
Percentage of internet users	Data are based on the Eurobarometer survey question: "Do you use e-mail and/or the internet at [different locations given for selection]?" "Internet users" are defined as those who use a computer at least at one of the given locations, e.g. "at work", "at home" ...	30%
Percentage of internet users at home	Data are based on Eurobarometer survey question: "Do you use e-mail and/or the internet at home?"	20%

Again, the selection of indicators can be challenged. For instance, it could be argued that the indicators are too closely related too each other. Computer users tend to be internet users, and internet users are necessarily computer users. The question then is if the four indicators could be substituted by only one indicator, if there is sufficient similarity between the single indicator and the compound results. Another issue of debate is if other digital technologies should be considered, for instance mobile devices. The rationale for our selection of indicators was mainly to follow the current digital divide research paradigm and to focus on those aspects which can be regarded as preconditions for a wide variety of applications. It could make sense, however, to include skills indicators (rather than usage indicators only), but unfortunately the data basis for such indicators is not satisfactory yet.

As indicated in the table above, we have used as source for data the Eurobarometer surveys of the European Union [1]. The raw data have been provided by Zentralarchiv für Empirische Sozialforschung in Cologne, Germany. [European Communities, 2001; Melich, 2000]

1 The Eurobarometer public opinion surveys (“Standard Eurobarometer surveys”) have been conducted on behalf of the European Commission each spring and autumn since 1973. They cover the population of the respective nationalities of the EU Member Countries. The sample is now more than 16,000 individuals who were interviewed, representative of the European population aged 15 and over.

4. INITIAL RESULTS

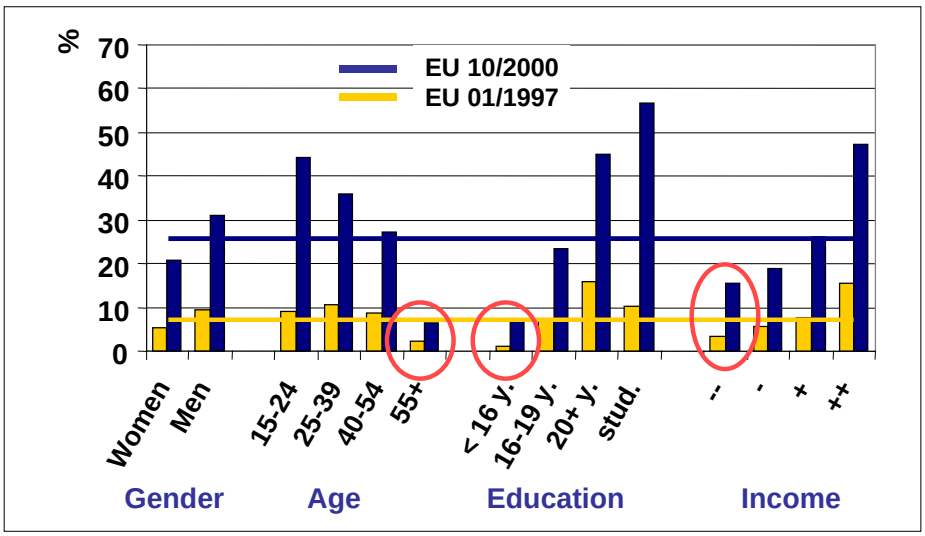
Since this paper is research in progress, the results presented on the following pages are only preliminary. The authors take it upon themselves to make methodological revisions which may impact on the results.

4.1 Diffusion of PC and internet access – basic figures

Before discussing the results of the Divide Index, it is worth comparing the basic diffusion data on which the index is based. The indicator "internet usage" can be used as an example. In October 2000, 25.7% of the EU population (aged 15+) said that they would use the internet, compared to 7.3% in early 1997. The take-up was a very different one, though, in various socio-demographic sub-groups. Internet usage by seniors (people aged 55+) and by people with a low education level was in late 2000 still below the level which the population average had reached already in 1997. The level of education seems to be a particularly relevant factor for internet usage, with the low-education group falling far behind. The age gap, sometimes referred to as the "grey gap", has further increased since 1997. Senior citizens are most resistant to the internet, while the young are the most enthusiastic to go online, as the high diffusion among 15-24 year olds and particularly among students shows. These general trends hold true for the other indicators as well and is confirmed by other studies, also for the United States, for instance in recent surveys of the Pew Internet & American Life Project [cf. Lenhart, 2001] [2].

Diagram: Internet usage in EU (in %) by socio-economic groups

1/97 and 10/00 (Data: Eurobarometer)



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4.2 The Digital Divide Index on the European level

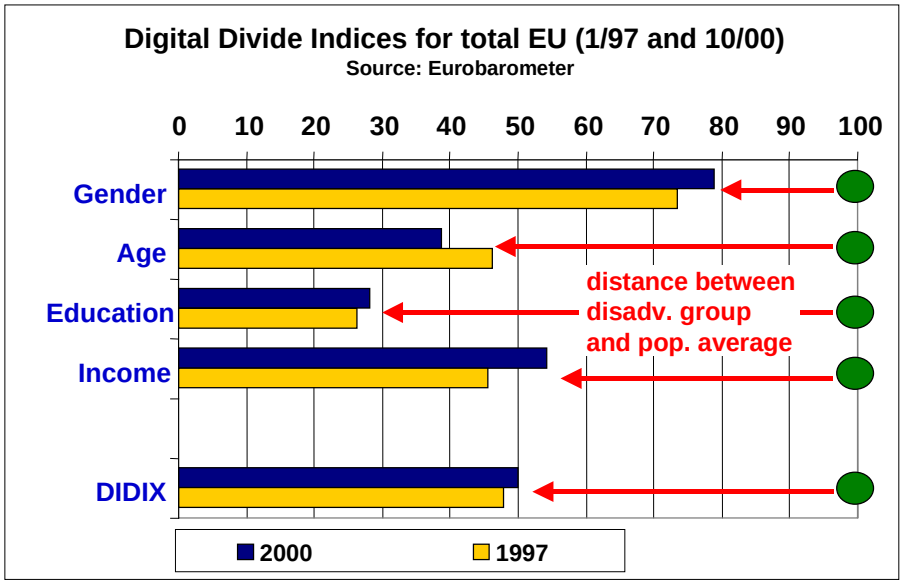
Using these diffusion data, we have calculated the four weighted compound Digital Divide Indices for the four risk groups on EU level and for the 15 Member States. The overall Divide Index has been calculated as the mean of the four indices. Each index describes the percentage of internet and

2 The survey shows that more than three-quarters (78%) of those who live in households earning more than $75,000 have Internet access, but only 31% of those who live in households earning less than $30,000.

computer users (total users and "at home") at the risk group as a ratio of the percentage of users in the total population.

Results suggest that education is the independent variable which may have the highest impact on usage. The Digital Divide Index (DDIX) for people with an education termination age of 15 years or lower was 28 in the year 2000, which means that they were only 28% as likely to be internet and/or computer users as the population average. This is even below the DDIX for seniors, who were 39% as likely to be users as the average. The Gender Divide Index was 79 and the Income Divide Index 54. The compound DDIX (the mean for the disadvantaged groups) was 50 in 2000.

A major finding is that the DDIX has not changed very much between early 1997 and late 2000. The gender and the income divides have slightly decreased, while the age divide has increased. The education divide remains nearly unchanged. That means that the digital divide on the European level has not decreased since 1997.



At first sight, this finding seems to conflict with the fact that the absolute digital gap has widened since 1997 (see table below). Especially the gaps of the low education and the age 50+ groups compared to the general population have increased. In 1997, the percentage of computer and internet usage among the low education segment was 12.8 percentage-points below the population average, in the year 2000 this distance has increased to 20.8%. The gap between the 50+ group and the average has widened by more than eight percentage points. The mean gap for the four focus-groups (unweighted) has increased from –8.8%points in 1997 to -14.0%points.

Table: Digital gaps for total EU

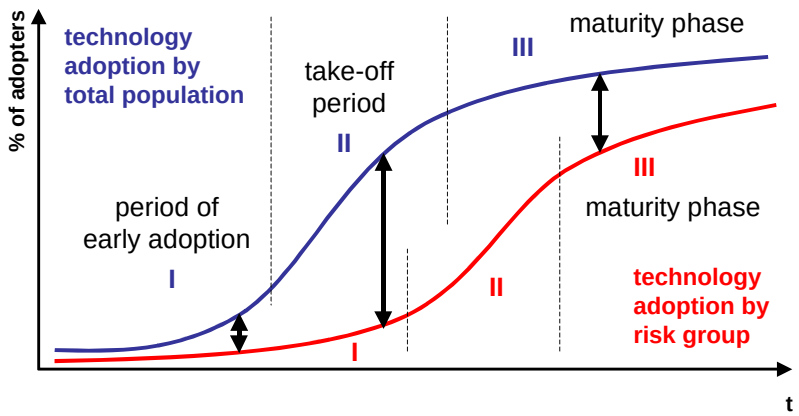
Average difference in diffusion in percentage points (compound value of 4 indicators)

	1997	1998	1999	2000	2001
Gender	-3,3			-4,9	
Age	-9,2			-17,5	
Education	-12,8			-20,8	
Income	-9,7			-12,9	
Mean gap	**-8,8**			**-14,0**	

Diffusion theory helps to explain this apparent conflict. Adoption of new technologies tends to follow a diffusion curve with three periods (see diagram below). This curve can be split into different curves for different segments of the population. The digital divide research is basically an analysis of the path of these curves and the temporary distances between them. The two important questions are: (i) What is the time lag between the adoption among presumably disadvantaged groups of society and the population average, especially for reaching maturity phase, and (ii) what is the peak of cumulative adoption for risk groups, i.e. what is the percentage of permanent non-adopters?

The model below show that the absolute distance (the "gap") between a risk group and the population average will increase during the take-off period of the early adopters and decrease once the late adopters have reached this stage. The Digital Divide Index – if available for at least two different points of time – measures which curve has described the steeper slope during this period of time, in other words, where adoption has been faster. It does not provide a measure for the absolute distance at a certain point of time.

Diagram: Comparison of diffusion among early and late adopters



We argue in this paper that both measures are important for policy purposes, since they help to explain and to monitor different aspects of the digital divide. The DDIX is a controlling tool to help better understand the dynamic perspective of the digital divide by comparing diffusion curves of the adoption of new technologies.

Diffusion curves are defined by three parameters: point of inflection, dispersion and saturation level. Uncritical are the assumptions that the inflection point of the risk group is reached later and that at any

point in time the share of adopters level will not exceed the total population's level. If these assumptions are true and describing diffusion by means of cumulated normal distribution curves, only positive slopes of DDIX function over time are possible.

However, reality does not always move in perfect normal distribution curves. Empirical data reveal decreasing values of the DDIX between 1997 and 2000 in some Member States and decreasing ratios especially regarding older people's adoption of IST. This fact calls attention to the point that S-curves are surely helpful to describe diffusion patterns, but must not be confused with deterministic forecasting. If the DDIX for a risk group monitored decreases, external influences are disturbing the development of uptake - in other words a discrete time function of the adoption has to be assumed. The adoption of technologies occurs at a slower pace (in terms of growth rates). This indicates that the group will continue to fall further behind unless the external factors are not counteracted immediately.

The table below uses the DDIX to compare the adoption dynamics broken down by indicators and risk groups. The difference in the values for 1997 and 2000 describes the different slope of the diffusion curves for the risk group during this period compared to the average. The finding is that the risk groups have hardly achieved any progress in the dynamics of computer adoption (with the exception of the low income group), but seem to catch up in the adoption of the internet, although not dramatically. The one group which is falling further behind in any aspect are the seniors (50+), whose adoption curve during 1997 and 2000 was significantly flatter than the average, especially in terms of computer adoption. Probably, this group has the highest percentage of non-adopters who cannot be reached.

Table: DDIX (EU) by indicators (1/1997 – 10/2000)

	Gender		Age		Education		Income	
	1997	2000	1997	2000	1997	2000	1997	2000
Computer users	84	87	54	44	37	34	49	57
Computer home users	85	83	53	43	37	31	53	56
Internet users	72	81	46	37	17	26	45	60
Internet home users	47	59	28	29	13	21	33	40
Compound Index	**73**	**79**	**46**	**39**	**26**	**28**	**45**	**54**

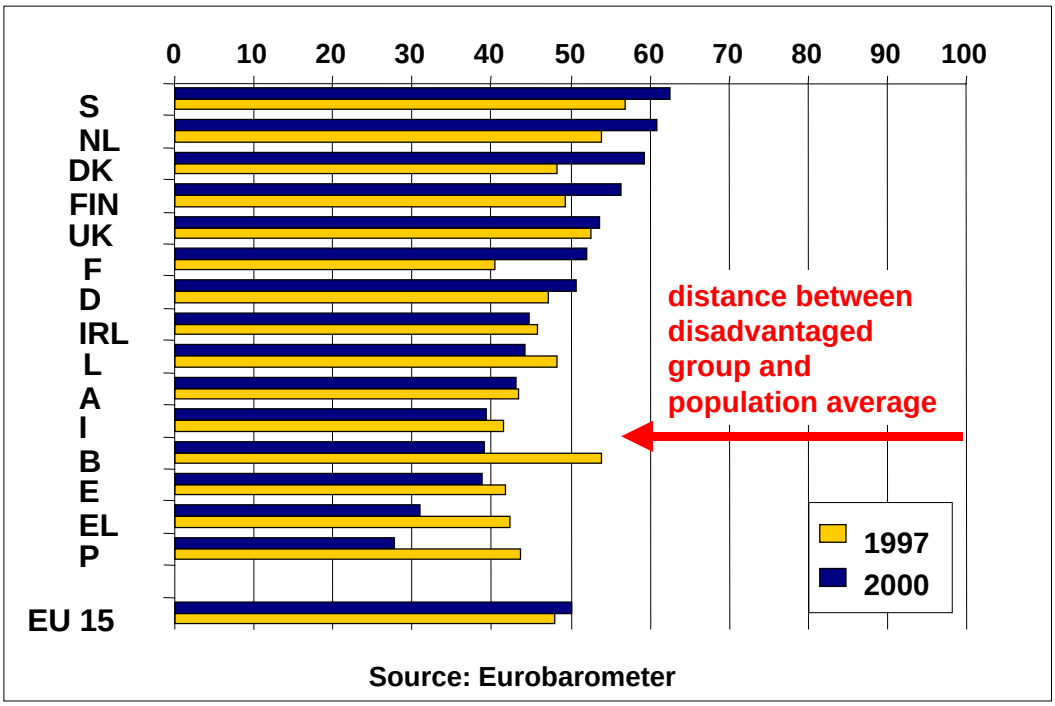
4.3 Comparison of the Digital Divide Index for EU Member States

The table below compares the DDIX for the 15 EU Member States (2000), broken down by risk groups. A ring around a figure indicates that the value is below 70% of the average. The results indicate that the risk groups in countries which are late adopters (mainly the Southern European countries) have currently a – relatively – larger digital divide than the advanced countries. The DDIX is taking the highest values for Sweden (63), Netherlands (61), Denmark (59) and Finland (56). In these countries, the DDIX has increased since 1997, but only moderately in most cases. That means the technology adoption curve of the risk groups has become steeper than the average, but not dramatically.

Table and Diagram: Digital Divide Indices for Member States (10/2000)

Comparison of risk groups to total population: ratio of users

	Gender	Age	Education	Income	DIDIX
B	77	37	10	32	**39**
DK	84	57	35	60	**59**
D	80	36	34	53	**51**
EL	71	15	9	29	**31**
E	77	19	15	44	**39**
F	82	32	17	76	**52**
IRL	84	30	29	35	**45**
I	68	28	20	42	**39**
L	81	34	24	38	**44**
NL	81	53	32	78	**61**
A	73	21	28	51	**43**
P	68	8	7	28	**28**
FIN	83	52	36	54	**56**
S	86	60	37	67	**63**
UK	82	50	49	34	**54**
EU 15	**79**	**39**	**28**	**54**	**50**
MS Mean	**79**	**36**	**25**	**48**	**47**



4.4 Conclusions and perspectives for future research – going beyond "access"

In this paper we have presented an index (the DDIX) as a tool to assess the dynamics of the digital divide by comparing the slope of diffusion curves. The method applies diffusion theory to the current digital divide research paradigm. We have argued that it is insufficient to study the absolute gaps (expressed as the difference in percentage points) in order to forecast the dynamics of technology adoption. Initial findings suggest that the digital divide has not decreased since 1997, and – what is

probably more disconcerting – that disadvantaged groups are not making much progress in speeding up their adoption of computers and the internet compared to the average population. Especially people aged 50+ and the low education segment are threatened to fall further behind. Women, on the other hand, are showing signs of fast adoption.

We acknowledge that the methodology applied to calculate the DDIX will need some revisions. Obviously, the dimensions of the digital divide investigated in this paper are characterised by a high degree of interrelation. The four risk groups in our analysis are not mutually exclusive. The next step of further analysis will thus be to statistically separate the independent variables which are derived from socio-demographic dimensions to the statistical explanation of IST adoption among different segments of society. This will be necessary to investigate whether the current evidence of the digital divide processing the traditional cleavages of social stratification and inequality holds true or if other concepts of social structure can help to the understanding of the digital divide. For instance, research about the relation of IST uptake and social milieus or lifestyles is only in its initial stage, but first results promise to add to the understanding of the digital divide.

Following the policy discourse about the digital divide, we have used a narrow definition of the term which focuses on access to / usage of computers and the internet. 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 utilised [e.g. Davied, 1999]. Research will therefore have to develop indicators which describe what people actually do with the internet and in what way they can benefit (or not 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 organisations and policy institutes warn that simple access is not necessarily effective in producing change in low-income communities [Morino Institute, 2001]. A promising approach to collect indicators about how people actually make use of the internet are tracking surveys, where people are questioned about what they did during their online sessions [e.g. Howard, 2001].

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