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Causes and Trends of the Digital Divide

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In modern societies, the digital divide indicates the emergence of a new form of social inequality. To analyse this concept we study causes of private computer and Internet access with a three-fold model including human capital, family context and social context. The 1997, 2001, and 2003 German Socio-Economic Panel waves contain data on private computer and Internet use, as well as information on past and present socio-economic circumstances. In 2003, membership of technical generations and ethnic background to a large extent determined the use of new technologies. By illustrating the importance of human capital and family context we are able to explain additional differences found for computer and Internet use. Effects of income, gender, and living in a single household are significant. Our study shows that some of the long-term consequences of the 40-year German separation are diminishing with regard to computer use. We demonstrate that human and social capital are more important than economic capital in explaining private computer and Internet use. Indications for higher social classes to secure or even increase their favourable social positions exist.

Introduction

The starting point of this research is the appearance of a new form of social inequality: the digital divide. This abstract notion is defined as a division between individuals and households at different socio-economic levels, regarding their chances to access or use information and communication technology (OECD, 2002). A theoretical distinction exists between the *first-level* and *second-level* digital divide (Attewell, 2001; DiMaggio and Hargittai, 2001; Hargittai, 2002). The first-level digital divide deals with problems of access to computers and the Internet, while the second-level focuses on the user profiles of new technologies. Before studying user profiles, however, the reasons for access versus non-access to computers and the Internet should be clarified. Therefore, we investigate the first-level digital divide. We deal with reasons for, and developments of, private computer and Internet access in Germany between 1997 and 2003. We ask who uses computers and the Internet for his or her private ends and whether we can identify possible causes and trends.

At times, research on this topic has been challenged by charges of studying a non-existent myth or 'luxury' problem (Compraine, 2001). However, empirical results paint an entirely different picture. Computer literacy is positively related to social activity and school performance (Wagner *et al.*, 2002), math and language skills (Attewell and Battle, 1999), success in finding a job (Boes and Preißler, 2002), and hourly wages (Kim, 2003). Our own research confirms these findings. Between 1979 and 1998 income levels became positively influenced by the use of computers at work (Korupp, 2001). This relationship did not weaken but slowly increased over time, remaining at a fairly stable level between the 80s and the 90s (Korupp, 2001). Given these

positive relationships we are left with the question of what influences people's access and use of computers and the Internet.

Most of the studies on this topic deal either with social inequality, regional aspects, or ethnic background.[1] If the digital gap is connected to socio-economic inequality, 'classical' attributes like education and income are introduced to help understand unequal computer access. A general finding is that the development of the digital divide parallels that of economic inequality (e.g. Bucy, 2000; Luke, 2000; Attewell, 2001; DiMaggio *et al.*, 2001; Jung *et al.*, 2001; Bonfadelli, 2002; Ekdahl and Trojer, 2002). Part of this discussion revolves around the diametric antipodes of a utopian versus dystopian view, i.e. an optimistic versus a pessimistic outlook (Ebo, 1998; Katz and Rice, 2002a,b). The question is whether the introduction of computers and the Internet to modern societies increases or decreases the general quality of life. Some authors hold that computers and the Internet will complement other media and will become as ordinary as TVs or radios (DiMaggio *et al.*, 2001; Katz and Rice, 2002b). However, rather than being an ordinary household tool a computer can be perceived as a complex, multi-tasking device. Compared to handling, for example, mobile phones, using computers and the Internet requires specific skills that go beyond mere 'push-and-go' applications.

In studies on regional aspects, authors often stress exclusionary trends. Dolnicar *et al.* (2002), for example, show that compared to the EU the use of computers in Slovenia has fallen far behind. For the US it is predicted that low income urban communities will be disqualified for further technological advancements (Servon, 2001). Results show an increasing relationship between lacking the means to invest in infrastructure and the underdevelopment of rural areas (Hollifield, 2003). Another study underlines that a general shortage of human capital in rural areas adds to a developmental lag (Malecki, 2003).

Research that connects ethnic background to the use of computers is marked by a broad variety of analytic goals and questions. By combining, for instance, the digital divide and race inequalities in a global perspective, one study shows that race antagonisms between the north and the south of the world are currently reinforced (Nelson, 2002). Research on Anglo Americans and Hispanics underscores the importance of ethnicity regarding Internet use (Hacker and Steiner, 2002). A small-scale study on an Internet seminar demonstrates that gender and race influence students' modes of participation (Carstaphen and Lambiase, 1998). Obviously, ethnic background is important for analysing the digital divide.

Let us now turn to the situation in Germany. In 2002, only 35 out of 100 people owned a private PC, accounting for a 15 per cent increase within the last 12 years (IdW, 2003). Several notions are evident when reviewing studies on the digital divide in Germany. Most of the research deals with numbers and counts of computers, hosts, and Internet connections without trying to find an explanation for the current developments (SPIEGEL, 1996; AG.MA, 2000; golem.de, 2000; heise online, 2003; Van Eimeren *et al.*, 2003; Statistisches Bundesamt, 2003). Nevertheless, the more recently a study is published, the more positive its undercurrent. For example, in 1996 concerns were voiced about the possible generation of status barriers regarding the use of new technologies (SPIEGEL, 1996). In 2003, a study appeared with the header: 'More than half of all Germans are online!' (heise online, 2003). But international comparisons show that in Germany the private use of computers is at a moderate level at best (Statistisches Bundesamt, 2003: 25).[2]

One exception is an approach explaining the number of Internet hosts in an international comparison. Here the diffusion rate of technology is related to general levels of trust and average material well-being (Bornschier, 2001). The study shows that an early diffusion of Internet applications is connected to high degrees of average trust and tolerance within countries.

To promote a more theoretically based view on the digital divide we embed our study into an individual, institutional, and social framework. We build an encompassing three-fold model based on theoretical concepts that draw on *human capital*, the *family context,* and the *social context* (see Figure 1). Regarding human capital we look at effects of education and computer use at work. Within the family context we include household settings, e.g. living with children and household income, and reflect their constraints on private computer and Internet use. Within the social context we look at domains of group membership, like technical generations, gender, ethnic background, and regional differences between East and West Germany.

Additionally, we contrast two theoretical ideas on innovation diffusion. On the one hand, a 'top down' notion exists. It indicates that people from higher socio-economic strata are the first to adopt new technologies. After a trial period in which its success is determined, the new technology 'trickles down' to people from lower socio-economic levels (Rogers, 1995). On the other hand, we see that age is determined as a key issue,

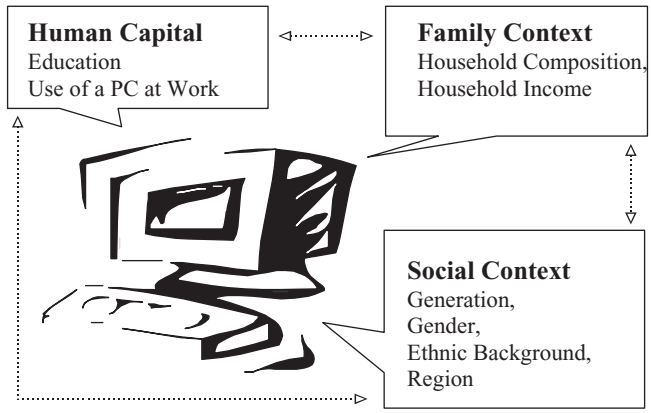

Figure 1 Three levels of explanation for privately using a computer or the Internet

assuming that youth grants a quick innovation adoption. Here innovation diffusion occurs because the adopting young generation grows older (Sackmann and Weymann, 1995; Watt and White, 1999).

Theory and Hypotheses

Let us first concentrate on the accumulation of *human capital* and how it influences private computer use. Human capital includes general and specific schooling and training, e.g. high school diplomas or vocational training (Becker, 1964). We assume levels of education and vocational training to be positively connected to people's use of computers or the Internet. In fact we presume computer literacy to be merely an additional educational skill. What is more, people with moderate levels of human capital are likely to work with computers in white collar jobs (Korupp, 2002). Getting acquainted with computers at work probably increases a person's likelihood of using one for his or her private ends. Therefore, we should find a positive relation between a person's human capital and his or her private use of computers or the Internet (hypothesis 1).

Particularly central to our study is the *family context*. Studies on computer use in families are embedded within the ecological framework of family theory (Watt and White, 1999). The ecological periphery of a family includes habitation and, more importantly, its technological environment. The incentives for children to deal with computers and the Internet are straightforward. Computer use involves playing games interactively or alone and, with respect to the Internet, searching for information (Leu, 1991).[3] Recent surveys on children's (6–13 years) user profiles show that 70 per cent play games on computers, 50 per cent use computers for their homework, 44 per cent use them for learning programs, and one-third draws and writes on the computer or surfs on the Internet (Medienpädagogischer Forschungsverbund Südwest, 2003). Hardly any of the children report programming activities. Teenagers (12–19 years) report off-line activities like listening to music (46 per cent), computer games (41 per cent), writing texts (37 per cent), or schoolwork (36 per cent) (Medienpädagogischer Forschungsverbund Südwest, 2004). They use the Internet for e-mail (44 per cent), to look for information (31 per cent), for instant messaging (26 per cent), to download news or music (23 per cent), or for educational and occupational purposes (22 per cent) (Medienpädagogischer Forschungsverbund Südwest, 2004).

Using computers and the Internet offers children an indirect participation in the adult world because most of the private and public sphere is comprehensively covered (Barthelmes and Sander, 1988).[4] The question is how children might induce their parents to use these technologies. To start with, we can locate patterns of computer use in families at the level of control and regulation (Beisenherz, 1988). This means parents may want to protect their children from unwanted informational contents. The best way of doing so is to know how the computer or Internet works and control the content offered. Additionally, though, the image of the computer has developed from being a distant 'cold' machine into a socially 'friendly' device and is, according to newer research, '[…] successfully connected to middle-class ideals' (Reed, 2000). Therefore, parents may simply want to adjust to middle-class ideals, believing computer

proficiency to be an essential future skill for their children. These assumptions lead us to expect that living together with children enhances people's likelihood of using a computer or the Internet at home (hypothesis 2). A lack of primary social ties on the other hand should decrease people's use of computers or the Internet.

In our introduction we mention a close connection between income and the possibilities of bridging the digital divide. As household income constrains purchasing power we expect family income to positively affect the private use of computers and the Internet (hypothesis 3). In the empirical section below we will follow up on the question of whether income or living with children is more essential for closing the digital divide.

The *social context* is our third level of departure. Who are the early adopters of a new technology and why are they the first to use computers and the Internet? We identify several potential determinants: generation, gender, ethnicity, and region.[5] Regarding generation, we follow an approach by Sackmann and Weymann (1995), who depict four *ideal* types.[6] The 'pre-technical generation' (born before 1939) grew up in an environment bare of household technology. The 'generation of the household revolution' (born between 1939 and 1948) was raised while basic kitchen technology diffused into private households, like water boilers and refrigerators. The third 'generation of advanced household technology' (born between 1949 and 1964) grew up with more sophisticated inventions like the washing machine, stoves, or central heating. The following 'computer generation' (born after 1964) was raised with a set of digitalized home technology. Computer chips are implemented in microwaves, washing machines, fridges, telephones, heating systems, etc. The assumption is that the home environment where people are raised determines their habits towards new technologies. Thus, for every succeeding generation we expect to find according changes in computer and Internet use (hypothesis 4).

The next determinant on the level of the social context is gender. We continue to observe a troubling gender inequality when we look at the participation rates of women in any of the related fields of information technology (Fountain, 2000). Census data show that fewer women than men own a computer, particularly if they live in a single household (Statistisches Bundesamt, 2003: 24). In 1997, only approximately 30 per cent of all Internet users were women (Suler, 1997). Research suggests that women are not socialized to become involved in matters of technology (Brunet and Proulx, 1989). On the other hand, studies show that both men and women are fascinated by the multitudinal applications of computer technology (Löchel, 1992). Nevertheless, women seem to be less emotional about computers and more interested in their practical applications (Löchel, 1992). The *ambivalent role model* poses that women face contradictory role models in technology operating fields, experiencing inconsistencies when linking their job and household obligations (Waibel, 1992; Collmer, 1995). Other than in their jobs, they are not socialized to become involved in technological issues at home. Accordingly, we expect fewer women than men to use a computer or the Internet for their private means (hypothesis 5).

At this point we are left with two more issues: ethnic background and regional aspects. Following a larger immigration wave in the 1960s, Turkish people have been settling in Germany for over 40 years. They form a major ethnic minority group with approximately two million members. As the culture of their homeland for the most part is shaped by an agrarian and patriarchal structure, many Turkish immigrants in Germany experience some distinct cultural conflicts (Geißler, 2002: 304). By and large, strong tendencies prevail towards cultural isolation resulting in a below average command of the German language (Geißler, 2002: 304). However, most of the computer programs that can be bought in Germany have either a German or English language interface. Therefore, we assume that Turkish people perceive computer systems as culturally different, belonging to a so-called *outer sphere* (Nohl, 2001). Perceived cultural differences may cause a delayed diffusion of computers and the Internet into ethnic minority groups, although this relationship probably weakens as acculturation proceeds (hypothesis 6).

As East and West Germany were separated for over 40 years, regional differences exist. In the GDR, the first 'home' computer (HC900) was manufactured in 1985. Because of supply shortages, it soon became obvious that the HC900 would not be used as a home computer. It was then labelled KC85/2. In 1989, the first computer that could be purchased in East German shops was the KC85/4. Before reunification, only 50,000 models were produced and sold (Amann, 2003). Thus, we cannot assume any noteworthy diffusion of home computer technology into the private households of the GDR. In 1993, we see that 22.4 per cent of West German households owned a PC, compared to 16.3 per cent in the East (Statistisches Bundesamt, 1994).[7] Ten years after reunification, other large differences continue to exist, including average prosperity, labour market chances, and political power (see for example Deutscher Bundestag, 2001; Geißler, 2002). Regarding our model on the digital

divide we can detect further long-term consequences of the German separation. Given the importance of initial regional settings, we expect people in East Germany to use computers and the Internet less often than people in West Germany (hypothesis 7).

How will these hypothetical relations develop over time? According to Rogers (1995), all theoretical relationships mentioned in our hypotheses should weaken over time. He assumes that after reaching 'critical mass', a self-sustaining innovation dispersion occurs.

Data and Methods

We test our hypotheses using data from the 1997, 2001, and 2003 waves of the German Socio-Economic Panel (GSOEP) (DIW, 2004). The GSOEP is a representative longitudinal survey of private households. It was first conducted in 1984 and has since been continued on a yearly basis with retrospective surveys. From the start, the panel includes information on the foreign population in Germany (DIW, 2005). In 1989, the GSOEP was expanded to East Germany. In 2001, an additional number of 4,911 households were interviewed to 'refresh' the old longitudinal sample that was suffering from sample attrition. The wave of 2001 contains more than 12,000 households and 22,000 persons. In 1997, 2001, and 2003 the use of computers for private and professional means was surveyed. Questions on Internet use were posed only in 2001 and 2003. We excluded foreigners who did not belong to the Turkish minority from our database.

Table 1 contains the cross-sectional weighted number of observations, means, standard deviations, and ranges of the variables used in the analyses. The private use of computers or the Internet is coded as a bivariate dummy

Table1 Descriptive statistics

Contents of variables	Range	Mean (Standard deviation)		
		1997	2001	2003
Privately use computers (no/yes)	0/1	0.23	0.41	0.51
Privately use the Internet (no/yes)[a]	0/1	n.a.	0.27	0.42
Human capital				
Education (year-proxy)	6–19	12.52 (3.2)	12.49 (3.3)	12.59 (3.3)
Use a computer at work (no/yes)	0/1	0.28	0.36	(0.36) [b]
Family context				
No child reported	0/1	0.26	0.27	0.27
Youngest child 0–11 years	0/1	0.18	0.17	0.16
Youngest child 12–24 years	0/1	0.20	0.20	0.20
Youngest child 25+ years	0/1	0.06	0.04	0.05
Adult children not living at home	0/1	0.30	0.32	0.32
Household equivalence income[c]	300–30,000	2421.43 (1202.3)	2658.36 (1344.0)	1433.65 (812.3)
Single household	0/1	0.23	0.24	0.23
Social context				
Age	17–99	47.98 (18.3)	48.73 (18.3)	49.49 (18.2)
Pre-technical generation	0/1	0.34	0.28	0.27
Generation of the household revolution	0/1	0.17	0.17	0.17
Generation of advanced household technology	0/1	0.17	0.17	0.17
Computer generation	0/1	0.32	0.38	0.39
Women	0/1	0.53	0.53	0.53
West German	0/1	0.78	0.79	0.79
East German	0/1	0.19	0.18	0.19
Turkish	0/1	0.03	0.03	0.02
Weighted number of cases (millions)		47.7	50.4	63.9

Source: GSOEP, weighted by person weights (DIW, 1997, 2001, 2003).

[a] *In 1997 no question is posed on private Internet use.*

[b] *In 2003 no question is posed on computer use at work. Because the value is retrieved from the 2001 wave it remains constant between 2001 and 2003.*

[c] *In 2003: Euro (€).*

variable ('yes' = 1, 'no' = 0).[8] In 1997, 23 per cent of the German population between 17 and 99 years of age uses a computer, increasing to 41 per cent in 2001 and 51 per cent in 2003. In 2001, 27 per cent and in 2003, 42 per cent of the respondents use the Internet for private means.

To study effects of human capital the formal education of respondents is coded as a year-proxy for the yearly equivalent of schooling and vocational training (table available from the first author). Formal education ranges between six and 19 years.[9] Respondents have an average formal education of 12.5 years in 1997, 2001, and 2003.[10] About 28 per cent of them report using a computer at work in 1997 and 36 per cent in 2001.[11]

To measure the effects of the *family context* we use information on household settings. Household composition hardly changes between 1997 and 2003. In 1997, 26 per cent (2001 and 2003: 27 per cent) do not live with children or report adult children living away from home. About 18 per cent report their youngest child to be between newborn and 11 years old (2001: 17 per cent; 2003: 16 per cent). Approximately 20 per cent report their youngest child to be between 12 and 24 years old and only six per cent live with adult children (25 years +) at home (2001: four per cent; 2003: five per cent). On average, 30 per cent of the respondents report adult children living away from home.

The average net household equivalence income increases from 2,421.43 DM in 1997 to 2,658.36 DM in 2001 indicating a rise of average income of about 235 DM (see also: Deutscher Bundestag, 2001). In 2003, the mean value is € 1,433.65 (≈ 2810 DM). We see that 23 to 24 per cent of the respondents live in a single household.[12] Approximately half of these (54 per cent in 1997, 56 per cent in 2001 and 2003) are 'genuine' single households; the others are due to what is called an 'empty nest' (table not shown).

Let us now look at the *social context.* Most of the respondents belong to either the pre-technical generation (34 per cent in 1997, 28 per cent in 2001, and 27 per cent in 2003) or the computer generation (32 per cent in 1997, 38 per cent in 2001, and 39 per cent in 2003). The generation of the household revolution and the generation of advanced household technology make up 17 per cent of our population in the three waves. The age of the respondents ranges between 17 and 99 years with an average of 48 years in 1997 and 49 years in 2001 and 2003. The percentage of women in the data is 53 per cent in all three waves. In 1997, 78 per cent of the German population lives in West Germany and 19 per cent in East Germany. In 2001, 80 per cent live in the West and 18 per cent in the East. In 2003, 79 per cent live in the West and 19 per cent live in the East. The remaining two to three per cent are Turkish citizens (all living in West Germany). Before turning to our multivariate results, it is helpful to take a closer look at the characteristics of private computer and Internet users (see Table 2).

In Table 2, we observe that approximately 60 per cent of private computer and Internet users have an education of 13 years and more. Roughly 65 per cent of them use a computer at work. They are over-represented in the category of living with children and under-represented as members of single households (15–17 per cent). This finding is a first hint towards the importance of primary social ties for private computer and Internet use. About one quarter of all computer and Internet users have families with young children under 12 years old (24–26 per cent). Approximately 28 to 29 per cent live with children between 12 and 25 years of age. Three to five percent of the respondents live with adult children (25 years and older).

In Table 2, we divided the distribution of net equivalence income into quintiles. If all income groups were evenly distributed over the quintiles, we should find 20 per cent of the population in each of these groups. However, a disproportionately low fraction of private computer and Internet users have an income in the first three quintiles (12–19 per cent). The higher income groups within the last two quintiles are over-represented (22–33 per cent). If we compare the last quintile (5th) income group of computer users in 1997, 2001, and 2003, we observe a decreasing trend of status inequality. Their fraction decreases from 30.2 per cent in 1997 to 25.4 per cent in 2003.

Furthermore, we observe large proportional differences between generations. Only four to five per cent belong to the pre-technical and 11 to 16 per cent to the generation of the household revolution. In large parts private computer and Internet users can be found in the generation of advanced household technology (21–26 per cent) and the so-called computer generation (52–64 per cent).

About 35 to 46 per cent of all private computer and Internet users are women. With respect to ethnicity and region the distribution of computer users is comparative to their proportion in the population. In sum, we see that typical computer and Internet users are male, have an above average education and use a computer at work. They share a household with children or another adult and belong to the so-called computer generation. In the following multivariate analyses we observe whether these relations hold if we control for all variables in our model simultaneously.

Table 2 The socio-economic background of private computer and Internet users

	1997	2001		2003	
	Computer user	Computer user	Internet user	Computer user	Internet user
Human capital					
Education (13+ years)	62.2	60.6	65.1	56.5	59.1
Use of a computer at work (yes)	64.7	65.6	72.4	–[a]	–[a]
Family context					
No child reported	29.1	28.9	32.7	28.8	30.3
Youngest child 0–11 years	24.8	25.0	24.6	23.9	24.4
Youngest child 12–24 years	28.9	28.6	27.5	28.3	28.9
Youngest child 25+ years	5.4	3.3	3.2	4.1	3.9
Adult children not living at home	11.8	14.2	12.0	14.9	12.5
Household equivalence income					
1st quintile	11.6	14.9	12.4	15.9	15.1
2nd quintile	18.8	16.0	14.0	16.8	15.6
3rd quintile	14.4	19.0	17.1	18.2	18.6
4th quintile	25.0	21.5	23.1	23.7	23.9
5th quintile	30.2	28.6	33.4	25.4	26.8
Single household	14.4	16.7	17.9	17.5	17.6
Social context					
Pre-technical generation	5.0	5.5	4.1	5.6	4.2
Generation of the household revolution	16.6	14.0	12.4	13.2	11.4
Generation of advanced household technology	26.5	22.1	21.8	20.8	20.4
Computer generation	51.9	58.4	61.7	60.4	64.0
Women	35.3	44.4	41.9	46.7	45.2
West German	82.7	81.2	82.8	79.6	81.1
East German	16.1	17.6	14.9	19.2	17.8
Turkish	1.2	1.2	1.0	1.2	1.1
Weighted number of cases (millions)	13.1	22.2	14.7	32.9	27.1
Percentage of all cases (see Table 1)	22.7	41.0	27.1	51.4	42.3

Source: GSOEP, weighted by person weights (DIW, 1997, 2001, 2003).

[a]*In 2003, no question is posed on computer use at work. Values are retrieved from the GSOEP wave of 2001, to control for this effect.*

Results

Because the dependent variables—private computer and Internet use—are coded in a bivariate mode, an appropriate statistical procedure for studying effects of the independent variables is the logistic regression model (Morgan and Teachman, 1988; Andreß *et al.*, 1997). In Table 3, the odds ratios of the cluster adjusted logistic regression models for the net effects in 1997, 2001, and 2003 are displayed.[13] Coefficients which are less than '1' signify a lower probability of private computer use compared to the reference group of the dummy variables. For variables at interval level, the coefficients display marginal effects.

The results support hypothesis 1 which states that *human capital* is positively related to the private use of computers or the Internet. In every wave, education has a substantial and significantly positive influence (odds ratios in Table 3 range from 1.11 to 1.16). Even larger is the effect for the variable 'use of a computer at work'. People who work with computers are roughly four times more likely to use PCs for their private ends compared to those who do not.[14]

Turning to the *family context*, we expect to find a positive relation between living with children and the personal odds of privately using the computers or the Internet (hypothesis 2). The variable measuring the effects of the presence of children of 11 years and younger in the household is significant only for computer use in 2001. Perhaps for a while, parents became more interested in using computers and the Internet to try out some of the new software and websites for very young children that were becoming publicly available.[15] Living with teenage children and young adults (12–24 years) seems

Table 3 Odds ratios for private computer and Internet use in 1997, 2001, and 2003

	Cluster adjusted odds ratios[a]				
	Computer use 1997	**Computer use 2001**	**Internet use 2001**	**Computer use 2003**	**Internet use 2003**
Human capital					
Education (year-proxy)	1.11**	1.16**	1.13**	1.13**	1.12**
Use a PC at work (yes)	4.04**	4.26**	3.42**	4.25**[b]	3.63**[b]
Family context					
No child reported			Reference		
Child 0–11 years	1.01	1.33**	0.97	1.16	0.95
Child 12–24 years	1.70**	1.65**	1.25**	1.63**	1.35**
Child 25+ years	1.14	0.80	0.73	0.76	0.70**
Adult child not in household	1.00	0.99	0.74**	0.95	0.82
Household equivalent income/100	1.02**	1.02**	1.02**	1.03**[c]	1.03**[c]
Single household (reference: shared household)	0.67**	0.63**	0.75**	0.75**	0.79**
Social context					
Pre-technical generation			Reference		
Generation of household revolution	3.37**	2.75**	2.74**	2.81**	2.80**
Generation of advanced household technology	5.35**	4.67**	4.27**	5.56**	5.99**
Computer generation	8.72**	8.34**	7.72**	14.70**	14.66**
Women (reference: men)	0.48**	0.62**	0.61**	0.61**	0.60**
West German			Reference		
East German	0.71**	0.83**	0.72**	0.96	0.84**
Turkish	0.20**	0.30**	0.33**	0.22**	0.27**
McFadden Pseudo R^2	0.25	0.30	0.25	0.34	0.31
Wald Chi^2	1832	4130	3218	3771	3594
Number of cases (unweighted)	11636	20708	20708	18503	18503

Source: GSOEP (DIW, 1997, 2001, 2003).

**$P < 0.01$.

[a]*Standard errors adjusted for clustering on the household level (Huber, 1967).*

[b]*In 2003 this effect is estimated prospectively from the variable in 2001 to control for use of a computer at work. Computer use at work was not surveyed in 2003 (1348 excluded cases due to panel mortality).*

[c]*Coefficients for Euro (€). Coefficients for D-Mark in 2003 are 1.016 (computer) and 1.018 (Internet), respectively.*

best to support the notion of our second hypothesis. The presence of teenagers and young adults is a good predictor for people's computer and Internet use. The presence of adult children (25 years +) does not significantly affect the private use of computers, apart from their negative influence on Internet use in 2003. Possibly this effect indicates a certain attitude of parents who live with adult children. Perhaps they leave it to the younger generation to 'meddle' with new technology. However, this is a singular effect for which further empirical evidence is needed.

In hypothesis 3 we draw a positive relationship between household income and computer use. The positive income effect in Table 3 supports this notion. The marginal effect of this variable is 1.02 in 1997 and 2001, and 1.03 in 2003.[16] In order to get an idea of how large the effects of teenage children are compared to net household income we calculate how high the latter has to be to match the effect of teenagers. Computing this renders a figure of 3,500 DM (€ 1,785) in 1997, 3,250 DM (€ 1,658) in 2001, and € 2,100 in 2003.[17] These numbers show that equivalence income must be well above average to match the effect of teenagers and young adults living at home. The positive and innovation friendly effects of teenage children thus seem to make up in large parts for the purchasing power measured by net equivalence income.[18] As expected, living in a 'single household' has a strong and significantly negative influence on the private use of computers and the Internet, underlining the importance of primary social ties.

Our next hypotheses are located at the level of the *social context*. The effect of generation decreases between

1997 and 2001, but no longer in 2003. This change is indicated in Table 2, where we see that an increasing number of people belong to the computer generation. The size of this change becomes clear only if we look at cross tabulations of users versus non-users of computers and the Internet in 1997, 2001, and 2003 (tables not shown). The large increase of the effect of the computer generation in 2003 is explained by the changes within the non-user group.[19] In 2001, the computer generation shows a ratio of users to non-users of roughly one out of three. In 2003, this ratio rapidly decreases to one out of four non-users to users of computers. Although not captured by any of the descriptive statistics shown above, these changes are disclosed by the multivariate models. Thus, we receive distinct support for our hypothesis that home technology equipment during childhood years determines general habits towards new technologies later in life (hypothesis 4). Compared to the pre-technical generation (reference group) all other generations successively display significantly increased odds ratios for using computers or the Internet.

We find women to be half as likely as men to use computers or the Internet in 1997 (odds ratio: 0.48), supporting hypothesis 5. This discrepancy decreases between 1997 and 2003 (in 2003 the odds ratio is 0.61). It indicates a trend towards a slowly closing gender division.

We also offered the hypothesis that ethnic background is negatively connected to the private use of computers and the Internet (hypothesis 6). This relationship is empirically supported. The strength of this effect decreases between 1997 and 2001, but this trend is discontinued in 2003. Altogether, the differences between West Germans and the Turkish minority for private computer and Internet use remain remarkable.

Additionally, we hold that the unequal starting position in East and West Germany is still detectable roughly 10 years after reunification (hypothesis 7). This relation is supported by the data. The negative influence of living in East Germany in contrast to West Germany becomes weaker between 1997 and 2001 and is non-significant in 2003 (for computer use). Although we still see a slight difference between East and West Germany regarding their private use of the Internet, we find indications for a rapidly closing technology gap between the East and the West.

Roughly ranking all the coefficients for computer use in 2003 in descending order shows that effects of generation and ethnicity have the strongest influence.[20] These are followed by 'using a computer at work', education, and living with children. Effects of income, gender, living in a single household, and region follow in their wake. Region is no longer significant for private computer use in 2003. This ranking varies little between 1997 and 2003.

Discussion

Analysing causes and trends of the digital divide provides valuable insights into newly emerging trends in social inequality. Our general questions were who uses computers or the Internet for his or her private ends and how do we explain the possible differences. The expected positive influence of *human capital* on computers and Internet use was empirically supported. Usually, early adopters are found in the upper educational echelons where people often use computers at work. We conclude that successful new technologies do not diffuse haphazardly but systematically into our society. The diffusion process appears as a vertical movement along the socio-economic strata, drifting from the highest to the lowest status position. We also observe a strong dependence between computer and Internet use at home and computer use at work. Thus, new technologies seem to push their way into private households by being used at work. This way, inequalities on the labour market are transmitted into private households and reinforce computer access disparity.

Regarding the level of *family context* we find that sharing a household with teenagers and young adults is a good predictor of whether people use a computer or the Internet for their own purposes. It may be a result of parents' efforts to increase computer proficiency because of a sense of responsibility for their children's future skill needs. Additionally, teenagers (especially) perhaps urge their parents to invest into computers creating an innovation friendly atmosphere at home. We find a positive relationship between net equivalence income and people's chances to use computers and the Internet. Still, income has to be well above average to be at the same level as household composition. People living with teenagers and young adults thus seem to have a competitive advantage to close the digital divide. Apparently, human or social capital is more important than economic capital to secure computer and Internet access.

The influence of *social context* is investigated in terms of technical generations, gender, ethnic background and regional differences between East and West Germany. We detected empirical support for the hypothesized relation between different technology generations and their use of computers and the Internet. Confrontation

with computer technology at a young age seems to make its appliance more likely. Although this relation weakened between 1997 and 2001 it is too early to proclaim a lasting closure of the generation gap. Our results indicate that this gap is opening up again. Future research should continue to focus on this issue. Another question is the relation between technology generations and ethnic background. Further research is needed to address the general applicability of the concept of technical generations to various groups of Turkish immigrants, e.g. those who grew up in rural parts of Turkey.

Turning to sex differences for computer and Internet use, it seems as if the gender divide is slowly closing up. According to the ambivalent role model, we expected women to be less likely than men to privately use computers or the Internet. Although the data supports this notion, our conclusions are hedged with caveats. The data of the GSOEP does not contain measures for some of the possible motivations of women to dismiss private computer and Internet use. A follow-up study should focus on this question. But taken together, the results indicate that the use of computers and the Internet is enforced by younger generations, initially showing a strong gender bias that is slowly tapering off.

Furthermore, we expected to find a negative relationship between ethnic background and the private use of computers and the Internet. We observe that people with a Turkish ethnic background are less likely to use computers or the Internet compared to Germans. This effect persists in spite of controlling for human capital, family context, and social contexts. Due to data limitations, however, the assumption that computers are perceived as cultural tools belonging to the *outer sphere* (Nohl, 2001) cannot be pursued. Perhaps another explanation may be useful. In Germany, immigrants are at a great risk of being overqualified for their jobs (Szydlik, 1998). Therefore, even if their job qualifications are similar to those of the German population they have less of a chance to work with computers. Ultimately, this discrimination might discourage the Turkish minority to learn how to use computers or the Internet in order to increase their job qualifications.

Regarding regional differences we showed that the digital divide between East and West Germany is narrowing down. In 2003, only insignificant differences are left between the East and the West with respect to computer use. It is probably not overoptimistic to expect the remaining gap for Internet use to close within the next few years.

We offer insights on the first-level digital divide, i.e. on different levels of access to modern computers and Internet technology. Generally, studies dealing with the second-level digital divide, that is how and for what purposes people use computers and the Internet, point out how difficult it is to study this 'technological black box' (see Attewell, 2001; DiMaggio and Hargittai, 2001; Natriello, 2001; Livingstone, 2003). Unfortunately, the GSOEP does not contain measures on user profiles either. We presume that the second-level digital divide will become a pressing future issue. Follow-up studies should focus on the quality of computer and Internet use to assess its impact on occupational skills and information access.

Obviously, the digital divide goes hand in hand with other forms of social inequality. West German males with higher education and income have much better chances of being on the favourable side of the digital divide than Turkish women with a lower education and income. Our empirical results do not indicate a decrease in other forms of social inequality due to access to computers and the Internet. On the contrary, the members of the lower social classes are not climbing the social ladder via better access to computer and Internet technology. As a more likely scenario we find indications for higher social classes to secure or even increase their favourable social positions. However, the period covered by the data (1997–2003) may be somewhat short to draw parallels between the digital divide and social status inequality. Ultimately, the question of how far social positions of people are affected by the private use of computers and the Internet needs to be followed up.

At present, our study underlines that early computer and Internet use is determined by generation and ethnic background. Furthermore, the influence of high status positions on the *individual level* and primary social relations within the *family context* determine in large parts who do and do not use computers or the Internet. A remaining question is whether a potential lack of social relations can be compensated for by means other than income to help close the digital gap. The other side of this conclusion is that, at least regarding the digital divide, it seems to pay off in more than one way to live with children.

Notes

1. Another important domain of research not dealt with here connects the influence of policy or politics to the digital divide (e.g. Johnson, 2001; Vartanova, 2002). For an overview, see DiMaggio *et al.* (2001).
2. The average supply of private households with the Internet in 2002 in the EU-15 is 40.4 per cent. The Netherlands are leading with a 65.5 per cent diffusion rate and Spain and Greece are at a low 29.9 and

9.2 per cent, respectively (Statistisches Bundesamt, 2003: 25).

3. We do not attempt to evaluate any of the impacts of computer use, because up to this point, the effects of computer use on children's social development cannot be predicted precisely (e.g. Subrahmanyam *et al.*, 2000).
4. To computer use this can be applied only to some extent, although differences should not be overestimated.
5. We include 'gender' on the macro level because sex roles are crucial for a whole set of social norms and values. Ethnic background and region summarize issues framing group behaviour and consumption patterns by membership and geographical location.
6. Here, of course, not family generations but societal generations are being depicted (see Szydlik, 2000: 19).
7. Before that, the statistical yearbook of the GDR offers information on radio and TV ownership only. From 1990 to 1993, the statistical yearbook for the reunited Germany contains information on PC ownership in West Germany only.
8. The translated question reads as follows: 'Do you use a computer [respectively, the Internet], either privately, on your job, in your training/education? (by computer include the personal computer (PC) or the main-frame but not purely a game machine).' The answers are coded separately for 'private' and 'job, training or educational' use of a computer or the Internet. In the 2003 wave of the GSOEP the bivariate (yes/no) coding of the variables for computer and Internet use are substituted by a six item scale (no comment, daily, once a week, once a month, more seldom, never). To make the results of this wave comparable to the former ones, two of these items (no comment, never) received the value '0', whereas the rest of the item scale received a '1'.
9. For example, it takes about 13 years to get an *Abitur* in Germany so the educational year-proxy is 13 here. A university degree takes on average six years and therefore a university diploma equals 19 years (13 years for the *Abitur* plus six years of studying time).
10. Usually the average educational level in Western industrialized societies increases over time. The figure found here can be explained by looking at the educational background of the Turkish population. Within our six-year time window we observe a decrease in average education for Turkish men and women. On average, a Turkish man loses an entire year and a Turkish woman more than a half of a year of schooling between 1997 and 2003 (table available from the first author).
11. In order to extend our analyses into 2003, we retrieve the variable 'computer use at work' from the 2001 wave, since it was not surveyed in 2003. Therefore, the corresponding figure in Table 1 is not interpreted.
12. Official statistics show percentages of single households in Germany to be around 30 per cent. Statistical offices include all possible household affiliations of persons, whereas the GSOEP considers the composition of the current household only (personal communication with Jürgen Schupp, DIW). The GSOEP household weights render the correct figures, but due to our research questions we use person weights.
13. The significance level is chosen at $P < 0.01$ per cent due to the large number of cases in the data. All other outcomes are rejected as chance findings. Odds ratios (or) are calculated by $or = exp^{(log)}$ and interpreted as relative probabilities (a table comparing the single and multivariate effects is available from the first author). Contrary to the conventional estimators of variance, the cluster adjusted estimator of variance corrects for the fact that on the level of the household some variables have the same value (e.g. household income). Thus, here we need to relax the assumption of independence of observations. Processing a cluster adjusted analysis requires only that the observations be independent across observations (Huber, 1967).
14. As mentioned above, in 2003 this effect is estimated prospectively. Therefore, the interpretation here is that if people use a computer at work in 2001, they are four times more likely to use a computer for private ends in 2003. Note for all three waves that people who use computers for their private ends are perhaps more likely to get a job which acquires computer expertise.
15. Computer programs can be bought for very small children between two and three years.
16. In 2003, the variable measures the effect of net equivalence income in Euros (€). Computing those effects in D-Mark (with € 1≈1.96 DM) renders coefficients between 1.016 (computer use) and 1.018 (Internet use).
17. Results are taken from Table 3. Household income is measured in D-Mark in 1997 and 2001 and in € in 2003. All numbers are divided by 100. The 1997 figure, for example, is calculated as follows: 3500 = (1.7–1)/(1.02–1) × 100.
18. Note that the odds ratio does not capture effects of older siblings. What is more, additional analysis reveals tentative hints towards differences of children's effects for various status groups. Interactions between

education and living with children showed the influence of children to be more important for respondents with lower educational levels (< 13 years).

19. Additionally, note that the coding of the dependent variable changed between 2001 and 2003 (see footnote 8).
20. To rank the effects of the metric variables in Table 3 we based their scores on the averages values in Table 1.

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