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Empirical Analyses of the Digital Divide in Germany

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Age-specific and Regional Aspects

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Mannheim, April 16, 2008 *Katrin Schleife*

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List of Abbreviations

b2b	business to business
b2c	business to consumer
BBR	Bundesamt für Bauwesen und Raumordnung (German Federal Office for Building and Regional Planning)
betw.	between
BITKOM	Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V. (German Association for Information Technology, Telecommunications and New Media)
bspw.	beispielsweise
bzw.	beziehungsweise
char.	characteristics
DIW	Deutsches Institut für Wirtschaftsforschung (German Institute for Economic Research)
DSTI	Directorate for Science, Technology, and Industry
E	expected value
ebd.	ebenda
e.g.	for example
EU	European Union / Europäische Union
e.V.	eingetragener Verein (registered association)
FRM	fractional response model
GDP	gross domestic product
H	hypothesis
ibid.	ibidem
ICT	information and communication technologies
IG	Industriegewerkschaft (union)
IKT	Informations- und Kommunikationstechnologien
INKAR	Indikatoren und Karten zur Raumentwicklung (indicators and maps on land development)
INQA	Initiative Neue Qualität der Arbeit (initiative new quality of work)

ISCED	International Standard Classification of Education
IT	information technologies / Informationstechnologien
IV	instrumental variables
log	logarithm
low-l.	low-level
Min	minimum
Max	maximum
N	number of observations
occup.	occupational
OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least squares
p.	page
pp.	pages
Prob	probability
Prop., prop.	proportion
QMLE	quasi-maximum likelihood estimation
R&D	research and development
ref.	reference group
S.	Seite
serv.	services
SOEP	Socio-Economic Panel / Sozio-ökonomisches Panel
STD	standardized
Std. Dev.	standard deviation
train.	training
TSLS	two-stage least squares
UK	United Kingdom
UNESCO	United Nations Educational, Scientific, and Cultural Organization
U.S.	United States
w.	workers
z.B.	zum Beispiel
ZEW	Zentrum für Europäische Wirtschaftsforschung (Centre for European Economic Research)

1 Introduction

> *"In today's society, access to information by all citizens is a right as well as a condition for prosperity. It is neither morally acceptable nor economically sustainable to leave millions of people behind, unable to use Information and Communications Technologies to their advantage."*[a]
>
> Viviane Reding
> EU Commissioner for Information Society and Media
>
> [a]Statement made during the presentation of the European Commission's *e-Inclusion* initiative to Council on November 29th, 2007 (European Commission, 2007b).

The use of information technologies and telecommunication networks, especially the Internet, has boomed spectacularly over the last decade. Information and communication technologies (ICT) thereby have a strong impact on the German economy as a whole but also on the economic conditions of firms and on the private life of individuals. The ICT sector has created a multitude of new employment opportunities.[1] By 2007, the number of employees in the German ICT sector had risen to about 800,000 (TNS Infratest, 2007b).

[1]The definition of the ICT sector slightly varies over different studies. Following the common OECD definition, "the production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display." (OECD, 2007a, p. 15). The ICT sector thereby includes manufacturers of ICT, ICT trade industries, and ICT service industries, such as telecommunications, data processing, web portals, and repair of computers and communication equipment (ibid.).

Another 650,000 qualified ICT employees worked in other industries (ibid.).[2] The value added of the German ICT sector increased by 50 percent between 1995 and 2005 and reached a value of 74 billion Euro, which was more than the value added of the traditional German industries, such as machine construction, automotive industry, and metal industry (BITKOM, 2007a). Data recently published by the German Federal Statistical Office shows that it further increased to 92 billion Euro by the end of 2007 (Statistisches Bundesamt, 2008). The transition from industrial to information society therefore steadily proceeds.

Further developments confirm this trend: an increasing number of employees in Germany use a computer in their workplace. The proportion of computer users was 44 percent in 2003 and rose to 61 percent by 2007 (Eurostat, 2007).[3] More and more firms also make use of e-business and digitally link their internal and external business processes. In 2007, more than half (52 percent) of the firms in Germany purchased online over the last year, 24 percent received their orders this way (ibid.).

Furthermore, the number of individuals who use the Internet for their communication via email, for their job search, and for shopping activities strongly increases. In 2007, more than 1.2 billion people used the Internet worldwide, be it at home or at work (BITKOM, 2007a). In Germany the number of Internet users was nearly 40 million, which corresponds to a proportion of about 60 percent of the German population aged 14 or above (TNS Infratest, 2007a). In comparison, the proportion of Internet users in Germany was only 37 percent in 2001 (ibid.). Already 38 percent of individuals between 16 and 74 years used the Internet for purchasing goods online in 2006, which is nearly double the value of 2003 (BITKOM, 2007a).

Given these figures, it is virtually impossible to imagine modern economic and private life without ICT. However, large disparities exist between different population groups with regard to their use of new technologies. Individual characteristics, such as education, age, and income can generate large access barriers. Recent data from the EU25 countries shows that individuals who are less educated, older, and economically inactive have lower levels of computer and Internet skills, as can be seen by Table 1.1 (European Commission, 2007a).

[2] Taken together, these 1.45 million ICT employees correspond approximately to a proportion of 3.4 percent of all employees in Germany.

[3] These are proportions of computer users in all firms in Germany with 10 or more employees.

Table 1.1: Internet and computer skills of particular population groups

Internet use						
Experience with the Internet	EU25 average	Low educated[i]	Aged 55-64	Aged 65-74	Retired/ inactive	Unem-ployed
Never used	43	67	65	85	76	48
Low	31	17	26	12	17	27
Medium	20	12	8	3	6	19
High	6	4	1	0	1	6
Computer use						
Experience with computers	EU25 average	Low educated[i]	Aged 55-64	Aged 65-74	Retired/ inactive	Unem-ployed
Never used	41	65	61	83	73	44
Low	13	10	13	7	11	14
Medium	24	15	16	7	11	23
High	22	10	10	3	5	19

Notes: Figures are the percentage of the population in the particular group in 2006.
[i]) Low educational level applies to those with no formal education, primary, or lower secondary education (corresponding to UNESCOs ISCED classification levels 0, 1, or 2).
Source: European Commission (2007a, p. 48).

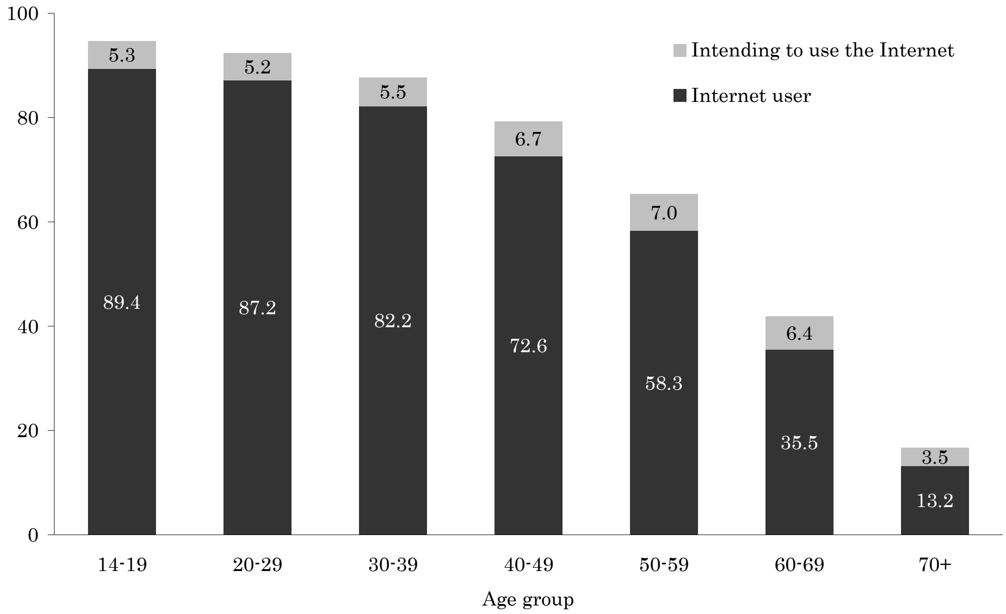
Those disparities in the use of ICT can also be observed for Germany. Statistics published by the German Federal Statistical Office show that while in 2004 82 percent of the 25 to 34 years old individuals used a computer and even 95 percent of the 10 to 24 year olds, the proportion of users was only 31 percent for individuals aged 55 or above (Statistisches Bundesamt, 2005).[4] The (N)onliner-Atlas studies disparities in the use of the Internet within Germany and also shows that Internet use is higher for people who are younger, more highly educated, and earn a higher income (TNS Infratest, 2007a). Various research studies show that these differences in the use of information technologies (IT)[5] persist in multivariate analyses.[6] Figure 1.1 illustrates the different Internet use rates by age groups in Germany.

[4]No differentiation is made here between usage at home and usage at work.

[5]The abbreviations IT and ICT are used synonymously in this dissertation.

[6]See Korupp, Künemund, and Schupp (2006), Korupp and Szydlik (2005), Haisken-DeNew, Pischner, and Wagner (2000), and Prince (2008), for example, as well as the results of my own analyses in sections 2.3.2 and 4.4.2.

Figure 1.1: Internet use by age groups in Germany 2007 (in percent)

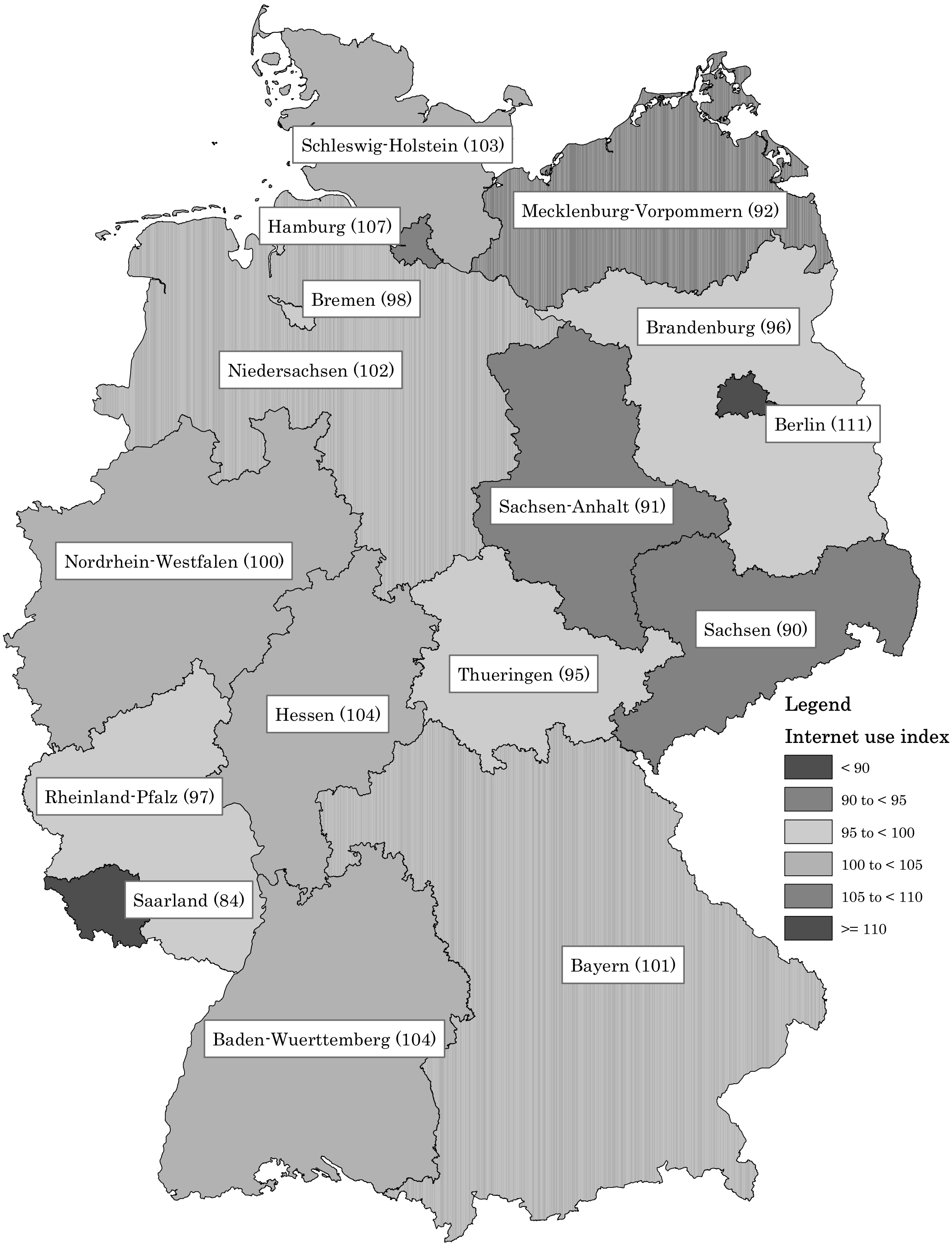


Source: TNS Infratest (2007a), author's illustration.

Regional characteristics, such as the existing ICT infrastructure and the price structure of ICT goods, can additionally influence the individual access probability. In Germany, Internet use is not evenly spread over the country. Regional differences in the rates of Internet use exist between East and West Germany, between federal states, and between rural and urban areas. As can be seen by Figure 1.2, the rates of Internet users are below the German average in the federal states of East Germany, except for Berlin (TNS Infratest, 2006). In addition, there is a difference of 11 percentage points between the user rates of small communities (51 percent) and large cities (62 percent) in 2006, a discrepancy that has even been growing in recent years (ibid.).[7]

[7] Small communities are those with a population of less than 5,000 inhabitants, large cities have a population of more than 500,000 inhabitants.

Figure 1.2: Internet use by German federal states in 2006



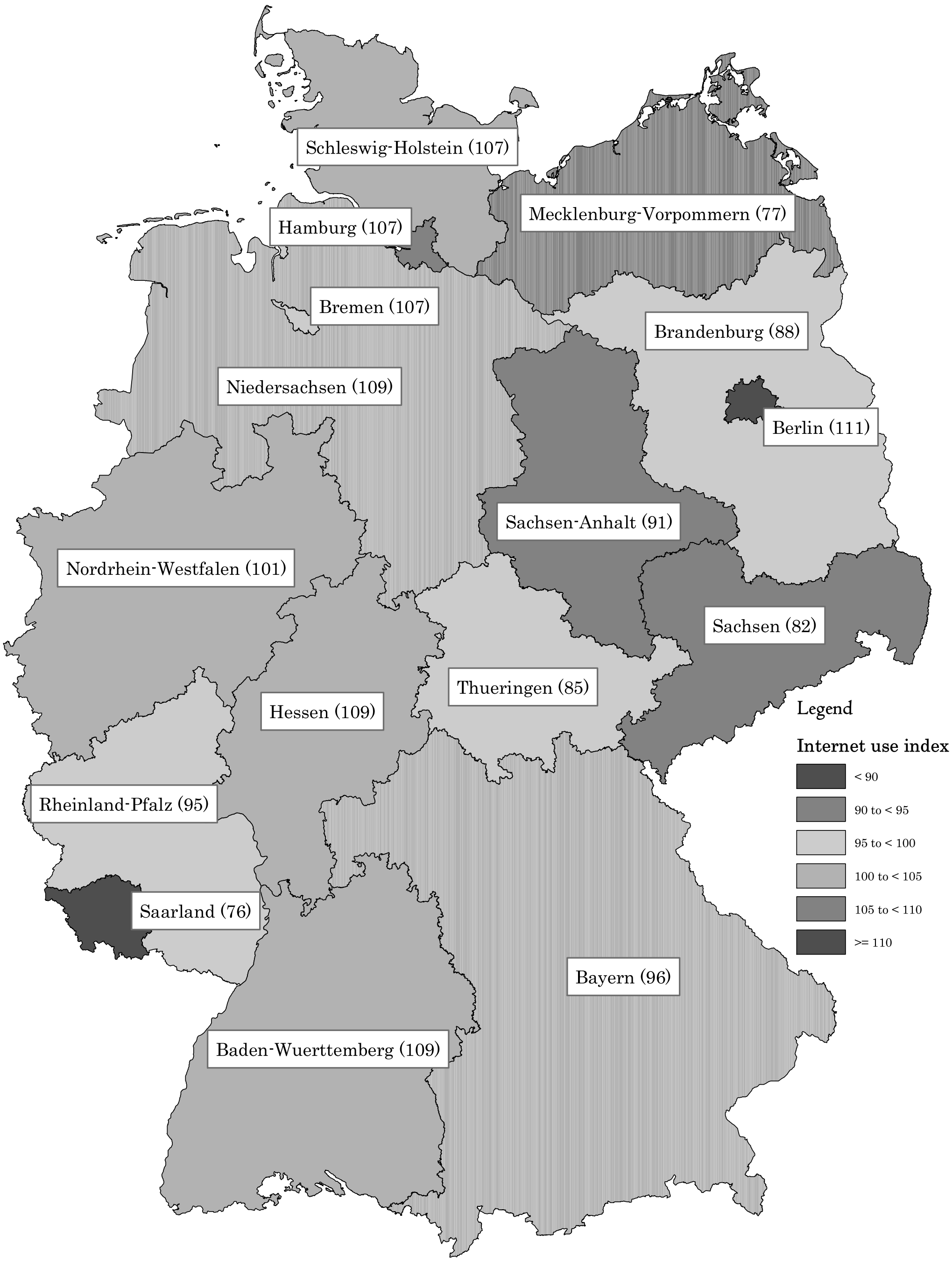
Note: Deviation from German average. The indices are calculated by $Index = \frac{percentage\ of\ federal\ state}{percentage\ of\ Germany} \times 100$, where $Index = 100$ corresponds to the German average of 58.2 percent.

Source: TNS Infratest (2006), GfK Macon.

Figures 1.3 and 1.4 provide further information about regional differences in the proportions of Internet use of younger and older people in Germany, thereby combining age-specific and regional differences in Internet use. Comparing the rates of Internet use of people aged 50 or above with the German average of this age group shows that the federal states of East Germany again evince rates of Internet use below the average, except for Berlin (Figure 1.3). The index value of the West German federal state of Saarland is the lowest in Germany, while Berlin has the highest index of older Internet users. Comparing the index values of the older age group with the index values of all Internet users by federal states shows that for the former their variation is much higher. Particularly in the East German states Mecklenburg-Vorpommern, Sachsen, and Brandenburg the indices of the older age group are far below the total index of the federal state. The same can be found for Saarland. Thus, in these states older people further lag behind in their Internet use.

Figure 1.4 compares the rates of Internet use of people aged between 14 and 49 and those of people aged 50 or above by federal state. It thereby again illustrates the large differences between young and old. While the values of the younger age group lie between 73 and 86 percent, only 26 to 37 percent of the older age group use the Internet. For both age groups Berlin again shows the highest rates of Internet users and Saarland the lowest.

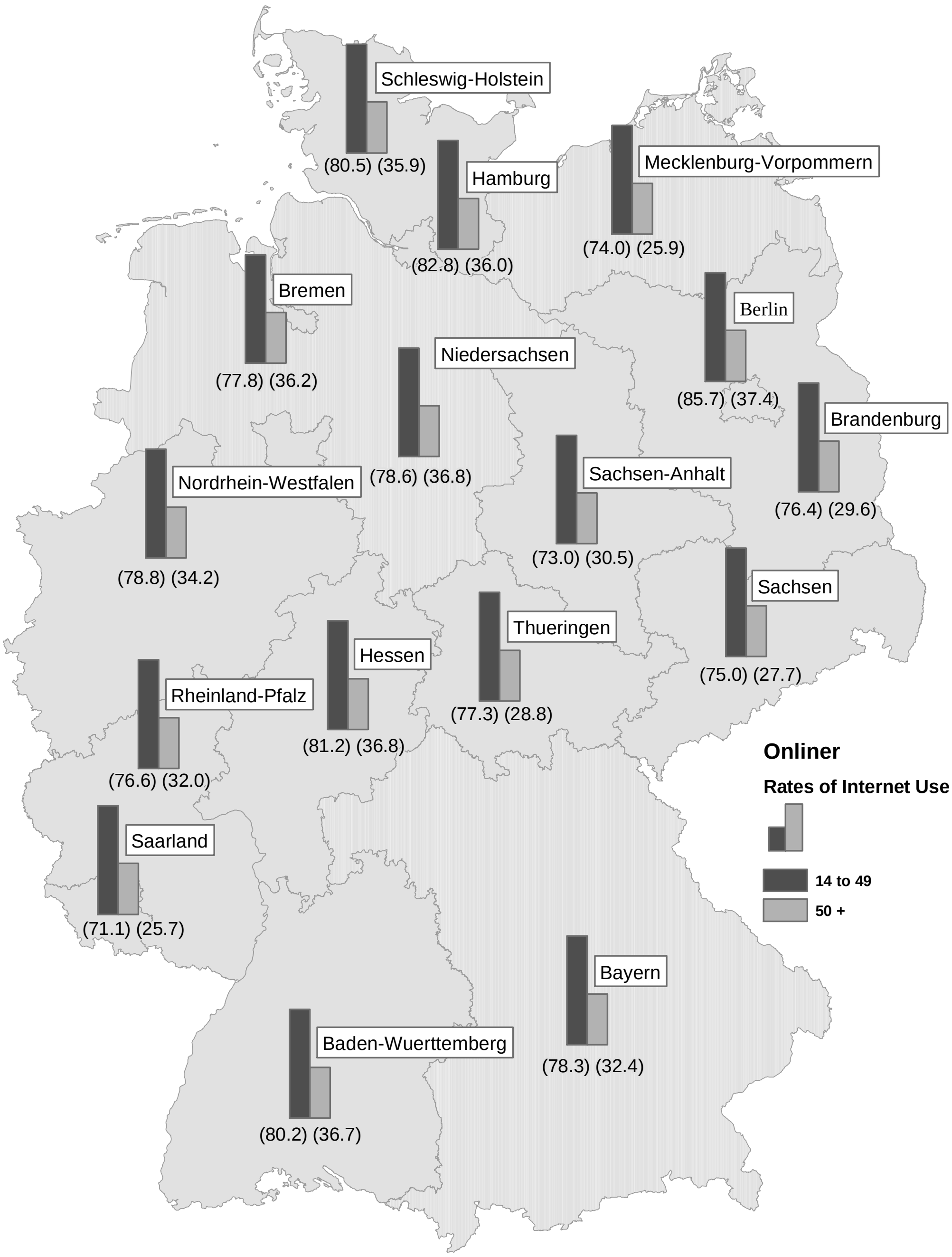
Figure 1.3: Internet use of persons aged 50 or above by German federal states in 2006



Note: Deviation from German average. The indices are calculated by $Index = \frac{percentage\ of\ federal\ state}{percentage\ of\ Germany} \times 100$, where $Index = 100$ corresponds to the German average of 33.7 percent.

Source: TNS Infratest (2006), GfK Macon.

Figure 1.4: Internet use by age groups and federal states in Germany 2006 (in percent)



Note: Rates of Internet use of people aged between 14 and 49 and those with an age of 50 or above.

Source: TNS Infratest (2006), GfK Macon, author's illustration.

The above-mentioned differences in using new technologies are facets of the so-called *digital divide*. The OECD defines it as "the gap between individuals, households, business 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/DSTI, 2001, p. 5). Since the Internet facilitates the availability of information and services as well as the exchange of knowledge, people who are not involved in ICT use can easily fall behind in social and economic participation. Employees and firms that use ICT are likely to gain exceedingly from increases in efficiency.

Closing the digital divide within and between countries is therefore one of the current political challenges and it is crucial to identify the dimensions and origins of the disparity in ICT use. This dissertation focuses on two main facets of the digital divide: age-specific and regional aspects. Firstly, I analyze how the computer use of older workers and their attendance at firm-provided IT training activities are related to their employment chances. Secondly, I study regional differences in the use of ICT in Germany by examining the individual probability of becoming an Internet user, while taking individual and regional factors into account.

In the light of the ongoing demographic changes in Germany, age-specific aspects of the digital divide have become an important political topic. As a result of increasing life expectancy, declining fertility rates, and the aging of the baby boom generation, the German population is constantly aging. Figure 1.5 shows the rise of the median age of the German population in the period between 1950 and 2035. This aging trend is also expected to appear in the German employment structure. For many years this has not been the case, however. To a large extent older workers have used the generous early retirement schemes provided by the German pension system. In West Germany the average age of retirement for men has decreased from 62.2 years in 1973 to 59.8 years in 2000 (Clemens, Künemund, and Parey, 2003).[8] This has been accompanied by a sharp decline in the labor force participation rate[9] by 37 percentage points for men aged 60 to 64 and by 10 percentage points for men aged 55 to 59 between 1970 and 2000 (ibid.).[10] In Germany as a whole, the labor force participation rate of men aged 55 to 64 then amounted to only 52

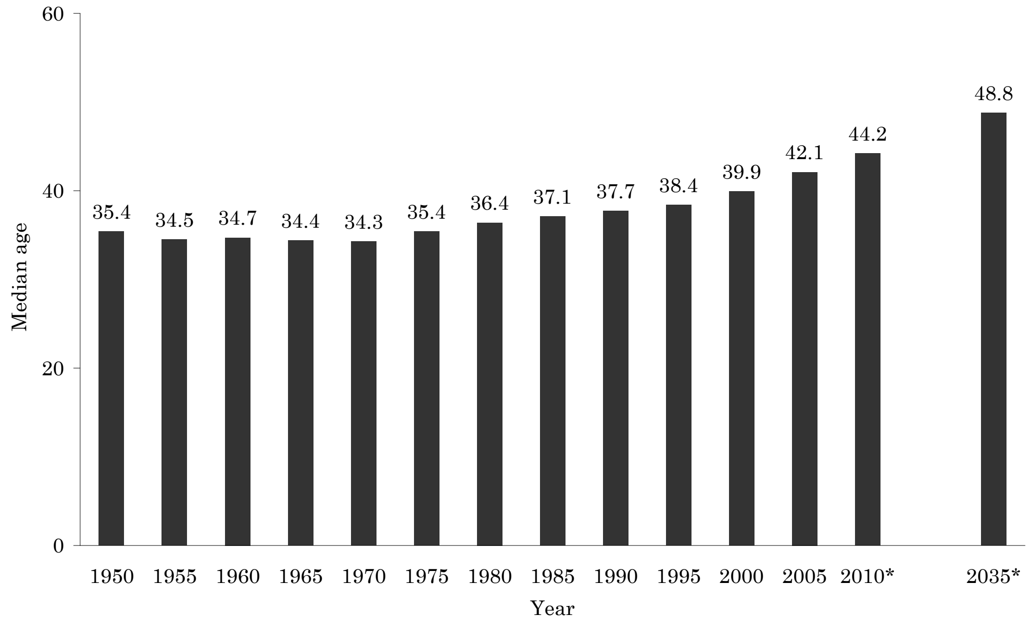
[8]After 2001 the values increased slowly and reached the level of 1973 in the year 2006 (Eurostat, 2007).

[9]The labor force participation rate is the percentage of working-age persons (15 to 64 years) in an economy who are employed or are unemployed but looking for a job.

[10]The participation rate of men aged 60 to 64 has decreased from 70 to 33 percent and the rate of men aged 55 to 59 from 88 to 78 percent.

percent in the year 2000 (Eurostat, 2007).[11] At the same time, the participation rate of males with an age between 30 and 45 years has remained relatively stable and amounted to more than 90 percent by the year 2000 (Statistisches Bundesamt, 2001). Hence, the average age of the German labor force stagnated during the last three decades of the previous century. In West Germany, it has remained at about 38 to 39 years between 1970 and 1990 and reached a value of still no more than 40 years by the year 2002 (Statistisches Bundesamt, 2001).

Figure 1.5: Median age of the German population between 1950 and 2035



Note: * indicates that the values are forecasts.

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2006), author's illustration.

One explanation for this trend is the many reforms of the German pension system in the 1970s and 1990s, which have opened up various possibilities regarding early retirement.[12] However, since the rise in the financial burden on the German public pension system accelerates due to the rapidly increasing number of retirees, the political debate focuses on a re-enhancement of the labor force participation of people over fifty. Furthermore, due to

[11] In 2006 it reached a value of 64 percent. But only 56 percent of men aged 55 to 64 were actually in employment (Eurostat, 2007).

[12] See Berkel and Börsch-Supan (2003) and Arnds and Bonin (2003b) for a description.

the decreased labor supply of highly qualified young individuals provoked by demographic shifts, firms will increasingly need their experienced older employees to maintain their economic position. In addition, it is generally assumed that a large part of the economically inactive older workers would have preferred to continue participating in the labor market (Gelderblom and de Koning, 2002). Pushing individuals between 55 and 64 out of employment can then be regarded as social exclusion. Increasing the labor market participation of older individuals is therefore important from an economic and a social point of view (ibid.). In 2001 and 2002, the European Council emphasized the importance of higher employment participation of older men and women. Firstly the Stockholm European Council of March 2001 agreed on the target for increasing the average EU employment rate of those aged between 55 and 64 to 50 percent by the year 2010 (European Commission, 2003). The Barcelona European Council of March 2002 then concluded that the average age of withdrawing from the labor force should be increased by about five years on EU average by 2010.[13]

The rapid diffusion of information and communication technologies throughout German firms is often cited as another important reason for the low labor market participation of people aged over fifty. ICT have become essential in nearly every economic area and have led to changes in production processes and required skills. However, older workers fall behind in using new technologies: data from the ICT survey carried out by the Centre for European Economic Research (ZEW) shows that in firms belonging to the manufacturing sector or to selected service industries, 48 percent of the younger employees aged less than 50 years used a computer at work in 2003, but only 34 percent of those aged 50 years or above did.

For older workers who are near retirement the time to capture the returns to training investment is short. Thus, their incentive to invest in computer skills may be lower compared with younger workers. Since IT skills are needed in an increasing number of jobs, the resulting lack of these skills of older workers may increase their incentive to make use of early retirement opportunities. On the other hand, acquiring computer skills and working with a computer on the job may give older workers an incentive to delay retirement. Therefore, the decision to invest in IT skills is not least influenced by the legal opportunities to retire early and is itself one of the factors that affects the labor supply decision of older workers.

[13] In 2001, the average exit age from the labor force for the EU was 59.9 years, the employment rate of those aged 55 to 64 was about 39 percent (European Commission, 2003).

In chapter 2 of my dissertation, I study empirically the relationship between the computer use of workers with an age between 50 and 60 years in 1997 and their employment status in the following years. In this context, I examine the characteristics of computer users and whether or not older computer users have a higher probability of remaining employed full-time compared with non-users. For this purpose, I analyze individual data on male workers taken from the German Socio-Economic Panel (SOEP) waves 1997, 1999, and 2001. The results of the multivariate estimation approach show that older workers are less likely to use a computer on the job compared with younger workers, thereby confirming the findings of earlier research studies. However, taking into account a possible endogeneity bias, further results do not provide clear evidence that computer use on the job induces older workers to delay retirement.

It is likely that only considering the use of computers is not enough to explain the impact of new technologies on the employment participation of older workers. In addition, the decision to invest in IT skills is often not only made by the older worker himself, but is also determined by the training opportunities offered by his employer. Thus, in chapter 3 of this dissertation, I focus on the relationship between firm-provided IT training for workers aged 50 or above and their proportion in the firm. I thereby turn to the labor demand side and use firm data to further analyze age-specific aspects of the digital divide in Germany. The data used in chapter 3 stems from the waves 2004 and 2007 of the ZEW ICT survey.

The supply of employer-provided training aims at increasing a worker's firm-specific skills, thereby increasing his productivity and employability. Several studies for Germany find a positive impact of job-related training on the stability of individual employment.[14] Since younger cohorts are getting smaller and provide an insufficient amount of highly qualified young workers, employer-provided training for older workers is particularly important. In addition, technological change is often supposed to generate or even accelerate skills obsolescence (Bartel and Sicherman, 1993). Thus, if new technologies are increasingly used within firms, continuous training is required. As the original education is less recent for older workers and they tend to participate less in training activities due to impending retirement, the firms' adoption of new technologies can lead to a decreasing demand for older workers. Technological change is then supposed to be age-biased (Aubert, Caroli, and Roger, 2006). My analyses of chapter 3 confirm a negative relationship between the firms' intensity of using information technologies and their proportion of older workers. The extent of IT use within firms is measured by an indicator of the firms' IT intensity.

[14] For example, see the Christensen (2001), Fitzenberger and Prey (1999), and Hübler (1998).

This indicator is developed by combining various IT items, such as several IT applications executed by the firm, its proportion of computer users, and its IT costs.

Providing older workers with IT training could be an appropriate means to reduce the negative impact of a high IT intensity, because older workers can get to know how to use these new technologies and can become more productive and valuable to their employer. The results of my multivariate analyses show that a higher participation rate of older workers in IT training provided by a firm is positively correlated with the proportion of older workers within the firm. Further estimation analyses are made for two subgroups of the sample of firms to study whether the impact of training differs between IT-intensive and less IT-intensive firms. It turns out that while a higher IT training participation of older workers is positively related to the proportion of older workers in IT-intensive firms, this relationship cannot be found for the less IT-intensive subgroup. Thus, it can be concluded that providing older workers with IT training is particularly important in firms that extensively use IT.

While chapter 2 and 3 concentrate on age-specific aspects of the digital divide and their impact on the labor market participation of older workers, the focus of chapter 4 is on regional differences in ICT use at home. In particular for people living in rural areas, the Internet provides many advantages as it can neutralize two major barriers to rural economic growth: large distances and the lack of economies of scale due to smaller market size (Hudson and Parker, 1990). However, for the same reasons – large distances and small markets – the incentive of Internet service providers to invest in Internet infrastructure and services is lower in rural areas. Due to the resulting lack in the supply of fast, efficient, and inexpensive Internet infrastructure, the possibilities of accessing and using the Internet for inhabitants of remote areas are limited and they often cannot benefit from the possibilities the Internet offers.

Important regional factors that have attracted attention in previous research studies which analyze differences in ICT use between rural and urban regions are the so-called *network effects*. Positive network effects arise if the individual probability of participating in a network is positively affected by the size of the network (Goolsbee and Klenow, 2002). Accordingly, a higher local proportion of Internet users not only increases communication opportunities, for example if family members and friends also use the Internet. It additionally increases the content provided online which may be interesting for potential users, as websites often comprise information with regard to economic, political, or cultural local activities. Furthermore, learning from others is an important network effect as experienced users can teach a current non-user how to use the Internet and what its benefits are. Moreover, the higher the local number of Internet users the more public rooms with Internet use, such as Internet cafés, exist. They make Internet use observable and increase the probability of learning spillovers.

In chapter 4, I study the determinants of home Internet use in Germany on the level of counties as well as on the level of individuals by merging two large data sets: the SOEP, which provides detailed information on individuals, and INKAR (indicators and maps on land development), which comprises a wide range of official regional figures for Germany. At county level, regional characteristics that may be correlated with the local rate of Internet use are considered. The results of the corresponding multivariate empirical analyses do not support the hypothesis that a higher local proportion of people living in rural communities is accompanied with a lower Internet use rate. Other regional characteristics, such as the proportion of foreigners and the regional rate of unemployment, turn out to be more important. At individual level, I particularly consider the role of network effects, that is the impact of the local proportion of experienced Internet users, on the access probability of individuals. My estimation results confirm the findings of previous studies: the individual probability is influenced by individual characteristics such as age, education, and income. In addition, strong and positive network effects are observable, particularly in the western part of Germany. Moreover, even after taking network effects into account, living in a rural region remains important, in particular in East Germany. This is likely to be caused by differences in Internet infrastructure between rural and urban areas.

In addition to the description of my own empirical analyses, chapters 2 to 4 each comprise a literature survey that discusses the respective theoretical and empirical background. Chapter 5 summarizes the main findings of the previous chapters. In addition, it includes an overview of current political programs in Germany and the European Union designed to reduce the discrepancies in ICT use between different population groups. Moreover, I provide further suggestions about what should be done with regard to the diminishment of the digital divide and give some final remarks about future research regarding this important topic.

2 Computer Use and Employment Status of Older Workers

This part of the dissertation focuses on age-specific aspects of the digital divide by analyzing data on individuals. It studies the determinants of computer use of male employees and estimates the relationship between computer use and the employment status of older workers. Thus, it contributes to the research on age-biased as well as skill-biased technological change. The main hypotheses to be analyzed are: firstly, older workers have a lower probability of using a computer at work than younger workers. Secondly, those older workers who use a computer are more likely than non-users to continue to work full-time until the statutory retirement age.

The empirical analysis is based on individual data taken from the German Socio-Economic Panel and shows that: i) the probability of using a computer on the job is lower for workers with an age of 55 or above compared to younger workers. ii) The probability of using a computer at work is significantly and positively influenced by the use of a computer at home, the educational level, and the occupational status. iii) In the subsample of older workers (aged 50 to 60 years), there is a positive partial correlation between computer use at work and the probability of continuing to work full-time within a two-year period. However, using an instrumental variables approach and controlling for various other factors, the impact of computer use on employment status becomes insignificant. Thus, for the analyzed age group, the use of a computer at work does not seem to be correlated with the probability of changing the employment status. iv) The occupational status of older workers is more important for the probability of changing employment status: self-employed men have a significantly lower probability of switching to another employment status than others. v) The educational level, the firm size, and the industry show a significant correlation with the probability of older workers changing employment status.

This chapter proceeds as follows: the next section discusses the labor supply decision of older workers and provides a literature survey regarding factors that may influence this decision. The survey concentrates on institutional regulations, the use of new technologies, and labor demand determinants. Section 2.2 describes the data set used in the empirical analyses. In section 2.3 the determinants of using a computer at work are empirically studied. The following section 2.4 empirically analyzes changes in the employment status of older workers within a two-year as well as within a four-year period depending on their computer use. Section 2.5 concludes this chapter.

2.1 The Labor Supply Decision of Older Workers

In the economic literature, alternative hypotheses are discussed in order to explain why the labor force participation rate of older workers is lower compared to younger workers and why some workers retire earlier than others. First of all, institutional factors, such as the pension system or the rigidity of the wage structure, play a crucial role as they determine the possibilities and incentives for older workers to retire early. Secondly, the labor supply decision is affected by the individual health status as well as by personal preferences which can be assumed to change when people grow older. Thirdly, the labor supply decision of older workers is strongly related to labor demand as it determines whether older workers are needed by firms and under which circumstances they are employed. With regard to labor demand, the literature discusses particularly the effects of the introduction of new technologies at work on the productivity and employability of older workers. Changing skill requirements and the restructuring of work processes within firms are also important in this context.

Below, the labor supply decision of older workers is presented. In addition, this section provides an overview of the literature that discusses some of the factors which influence the retirement decision of older workers.

2.1.1 Modelling the Individual Retirement Decision

The concept that from the time a transition to retirement is possible, the worker compares the present value of his future incomes when retiring immediately with the present value of his future incomes when postponing retirement is an important part of the model which describes the retirement decision of older workers (Arnds and Bonin, 2003b). On the one hand, a transition to retirement at an early age reduces a worker's old-age pension, as the benefit largely depends on the years of contribution. On the other hand, the worker saves pension contributions that would reduce his wage. In addition, as many older workers are employed part-time in their remaining years of work, early retirement could prevent the person from a potentially lower wage due to this reduction in working hours. Moreover, as the old-age pension also depends on prior earnings, part-time employment would lessen the increase in pension benefits due to additional working years. The difference between the present value of postponing retirement and the present value of immediate retirement can be modeled by computing the *option value* of continued work as Stock and Wise did in 1990:

$$V_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} U_w(Y_s) + \sum_{s=r}^{S} \beta^{s-t} U_r(B_s(r)). \tag{2.1}$$

At the beginning of year t the individual has not yet retired. In every year s he continues to work, he receives the wage Y_s. If he is retired in year s, he receives real retirement benefits B_s. The age at which the individual retires is denoted by r. Thus, the value function $V_t(r)$ depends on the individual's utility from the real income earned while working $U_w(Y_s)$ and the utility from real pension benefits he received while retired $U_r(B_s(r))$, assuming a discount factor of β.

The expectations regarding future income change over time, as more and more information becomes available to the individual with increasing age (Stock and Wise, 1990). If $E_t(\cdot)$ denotes the expectations about future circumstances at the beginning of year t, the expected gain from postponing retirement to age r can be derived as

$$G_t(r) = E_t[V_t(r)] - E_t[V_t(t)]. \tag{2.2}$$

As long as the option value $G_t(r)$ is positive, it is profitable for a worker to remain in employment. The optimal time of retirement is the time when the option value becomes zero or negative.

As described by Arnds and Bonin (2003b), the empirical adoption of the option value model considers more than monetary factors. The impact of various socio-economic characteristics on the decision to retire is also assessed. Arnds and Bonin (2003b) add that the actual retirement age is thereby affected by a combination of *push* and *pull factors*. Push factors are, for example, the deterioration of the labor market situation of older workers due to technological or organizational changes. These factors push older workers out of the labor market. Pull factors increase the incentives for early retirement, such as generous retirement regulations and an increased marginal utility of spare time when individuals grow older. I will discuss some of these factors in the following sections. Which factors finally become most important is largely determined by the institutional framework (ibid.). In this context, the pension system as well as possible wage rigidities play a crucial role and are therefore described in detail below. The labor supply decision of individual i at a particular time can therefore be modelled as:

$$L_i^S = F[Y_i, R, A, L^D, X_i, H_i, \vartheta], \tag{2.3}$$

where Y_i is the individual's wage and R reflects the retirement regulations which determine early retirement possibilities as well as the amount of retirement benefits. A is the status of technology adoption in firms. L^D describes the labor demand for older workers, which is influenced by their productivity. Socio-economic factors of the individual i, such as age, gender, and education, are covered by X_i. H_i indicates the individual health status and ϑ covers unobserved abilities and preferences with regard to spare time and consumption, for example. If L_i^S equals zero, the individual retires.

2.1.2 Institutional Factors

2.1.2.1 The Impact of Retirement Regulations

An international comparative analysis based on OECD data of 1998 indicates that the average age of retirement is lower in countries with a higher implicit tax rate on continued employment, that is, where the ratio of additional retirement benefits and additional pension contributions is lower (Arnds and Bonin, 2003b). Thus, the study provides evidence that the design of the pension scheme yields decisive incentives for the labor supply decision of older workers.

Below, I provide a description of the pension system in Germany because it forms the basis of my empirical analyses with regard to older workers. In Germany, the retirement age has become more flexible since the middle of the 1970s. This has been mainly due to reforms of the German pension system, most notably the reform of 1972. Since then, older workers have had different legitimate options to work part-time and to retire before the regular retirement age (65 for men and women). As the replacement rates, which are defined as the current pension of a retiree with a 45-year average earnings history divided by the current average earnings of all dependently employed workers, were high and no actuarial adjustments were made, the ratio of additional retirement benefits and additional pension contributions was very low. Thus, the incentive to use the given early retirement possibilities was great for older individuals. In the following years these regulations led to a reduction in the average age of retirement of men (women) from 62.2 (61.6) years in 1973 to 59.8 (60.5) years in 2000 (Clemens et al., 2003).

In East Germany, a new temporary retirement regulation came into force between 1990 and 1992, after the German reunification. It had a strong impact on the East German labor market for many years and caused a massive decline in the employment participation of workers aged 55 and above.[1]

In 1992 and 1999 reforms were launched to simplify the German old age pension system. Especially the reform of 1992 aimed at stopping the early retirement trend. The intention was to increase the average retirement age to 65 years by abolishing exceptions for unemployed persons, part-time employees and women, as well as by introducing explicit adjustment cost for retirement before the age of 65 (Berkel and Börsch-Supan, 2003).[2] Due to a change of government in Germany in 1998, the reform of 1999 was revoked. Nevertheless, part of it has become accepted: a gradual change of eligibility ages for pensions for women and unemployed will be fully implemented by 2012 (Börsch-Supan and Wilke, 2004).

For the older workers of the year 1997, who are analyzed in this chapter of my dissertation, the 1972 legislation was largely relevant since the reform of 1992 was not fully phased in. However, their retirement decision up to the year 2001 could have been already influenced by the reduction in opportunities to retire early.

Early retirement is facilitated by institutional regulations allowing employers to lay off older workers years before they reach the regular retirement age.[3] This early retirement strategy can be executed without great financial losses for the firms, because the German social security systems bears a considerable part of the dismissal expenses (such as unemployment and retirement benefits) (Beckmann, 2007).

2.1.2.2 Wage Rigidities

In principle, even if older workers are very unproductive, it should be possible to employ them at a relatively low wage. However, even if an older individual is willing to supply his labor at a low wage, there may be institutional barriers to employ him at this wage. There may be a minimum wage or a negotiated wage agreed upon between union and employer which exceeds the low wage. It could even be forbidden by anti-discrimination law that wages for older individuals fall below a certain value.

[1] See Ernst (1996) for a detailed description.

[2] Before 1992 the adjustment of pension benefits occurred only implicit due to less years of contribution (Berkel and Börsch-Supan, 2003).

[3] See Börsch-Supan and Wilke (2004) for details.

In addition, productivity can be assumed to be positively affected by wages.[4] Thus, there may be efficiency wage arguments that prevent wages from falling. Lazear (1979) shows that in imperfect labor markets it is optimal for employers to pay older workers above their marginal productivity (and younger workers below theirs) to bind them more closely to the firm, to increase their work motivation, and to reduce their incentives to shirk. However, if the wage of older workers exceeds their productivity, their employment represents current losses for the firm. This gives employers an incentive to send older workers into early retirement and to avoid reemploying older workers because they are too expensive.

There is much literature on wage rigidities.[5] But only a few studies focus on older workers.[6] However, as older workers' opportunity costs of continued employment at a low wage are high due to relatively generous unemployment and retirement benefits in Germany, it can be expected that older workers refuse to be employed at a low wage. They decide instead to leave the workforce.

2.1.3 Investment in IT Skills

Another factor that determines the labor supply decision of older workers is their ability to use information technologies. Older individuals have completed their original training less recently than younger ones. Without further training this results in a lower actual skill level, in particular with regard to IT skills. Moreover, as human capital theory predicts, older workers will participate less in training activities as for them less time remains to amortize the effort.[7] Therefore, older workers often have difficulties in using new technologies and their IT adoption rates are low. This provides older workers an incentive to leave the labor market earlier if new technologies are increasingly used.

The reduction in the labor force participation of older workers due to technological progress is analyzed by Ahituv and Zeira (2000). Using U.S. data, they conclude that the labor supply of older workers is negatively correlated with the average rate of technological progress across industries, due to an *erosion effect*. Older workers tend to reduce training efforts because their career horizon is short. Hence technological change leads to an erosion of their human capital, younger workers gain a relative advantage in knowledge and become more productive. In the end, this leads to a fall in the relative income of older workers.

[4] See, for example, Franz (2006).

[5] See, for example, Blinder and Choi (1990), and Altonji and Devereux (2000). Pfeiffer (2003) as well as Franz and Pfeiffer (2006) focus on reasons for wage rigidities in Germany.

[6] See, for example, Kawaguchi and Ohtake (2007).

[7] The participation of older workers in training activities is analyzed in detail in chapter 3.

They tend to reduce their labor supply and to take advantage of the option of retiring early.

Friedberg (2003) also studies the relationship between computer use and early retirement using U.S. data. She supports the hypothesis that not age alone, but also impending retirement affects the decision to use a computer on the job. Friedberg (2003) additionally states that computer users retire later than non-users. She concludes that the relationship between computer use and retirement is mutual. Workers who choose to invest in computer training retire later, and workers who decide to retire later are more likely to invest in further training and acquire computer skills. By analyzing cohorts, Friedberg (2003) shows that the rate of computer use was essentially stable over most ages up to an age of 53. Only for people in their late fifties and sixties the proportions of computer users decreased when they approached retirement, although they had previously kept pace with the younger workers. The analysis implies that computer use leads to later retirement as it considerably raises the likelihood of continuing to work. The strongest effects are found for workers in their late fifties (ibid.).

Aubert et al. (2006) point out that there may be selectivities that lead to an underestimation of the effect of IT use on the employment of older workers. It is possible that only those older workers who are used to working with computers are still employed by the firm. As mentioned above, this suggestion is supported by Friedberg (2003) who finds a mutual relationship between the decision of older workers to invest in computer skills and their decision to retire early.

2.1.4 Individual Preferences and Health Status

The individual decision to retire early is also influenced by personal preferences, in particular with regard to spare time, consumption, and family time, which change with increasing age. On the one hand, a higher wage increases the opportunity costs for free time, thereby reducing the incentive to retire early. On the other hand, a higher wage enhances the financial conditions of an older person, which allows him to enjoy expensive travelling or other recreational activities. By taking his spare time preferences as well as present and future health conditions into account, an older worker may therefore decide to retire early although he earns a high wage.

The average preferences with regard to spare time could also change over generations, that is later cohorts may have a stronger desire for spare time. Besides changes in ethical values regarding work and spare time, one reason may be that people are living longer and many individuals stay healthy until a very high age. This increases the possibilities of enjoying activities during the retirement years.

However, older workers are more likely to be confronted with health problems. If working hours and workplaces cannot be adjusted to the changing health conditions of older workers, their retirement age is likely to be brought forward.

2.1.5 Labor Demand for Older Workers

The labor demand for older workers plays an important role in their decision to enter early retirement. In the literature, a multitude of reasons for a lower labor demand for older workers compared to younger workers is discussed. This section provides an overview of studies that analyze the relationship between productivity, technological change, discrimination, and labor demand for older workers.

2.1.5.1 Productivity of Older Workers

As described by Boockmann and Zwick (2004), the groups of younger and older workers can be regarded as different production factors. The employers' incentive to employ workers of one of the two age groups depends on the relative wages and the relative productivities. The age-specific elasticity of substitution is additionally related to the amount of complementarity or substitutability with other production factors (ibid.). For example, younger workers are supposed to be complementary to ICT use at work since they often have a better and more recent education than older workers. I will come back to this argument later.

The productivity of (older) workers is determined by several individual factors, such as educational level, work experience, abilities, physical and mental health, and moreover by firm-specific factors, such as firm size, industry, and the applied technology. Due to biological or labor market reasons, the labor productivity does not remain constant during working life (Skirbekk, 2004). While some of the individual skills even increase throughout the working life, for example work experience or communication skills, others may decline, for example physical strength or the interest in receiving training.

The so-called *deficit model of aging* states that older workers automatically become less productive, less able to work under pressure, less flexible, and less innovative with increasing age (Lehr, 2007). Physical abilities and muscular strength are assumed to decrease as workers grow older. Older workers' probability of retiring early increases if it is not possible to adjust their work conditions or to employ them in another part of the firm (Pack et al., 1999).

However, it is not only the productivity of older workers in a particular job that changes, the job requirements have also been shifting. While physical strength was more important in the past due to physically demanding work, knowledge as well as the ability to grasp information and to use IT have become necessary for many jobs, as a result of the immense technological changes in recent years. Thus, the physical limitations of older workers have become less important for jobs over time (Skirbekk, 2004). In addition, the trend that people are living longer while staying quite healthy and productive up to a very high age has been observed for many years. Recent studies therefore contradict the *deficit model of aging*. They present evidence that older workers are not necessarily less but rather differently qualified than younger workers (Clemens et al., 2003). Pack et al. (1999) suppose that not age itself makes older workers less productive, but the fact that job requirements and individual ability do not balance each other out. Especially constant physically hard work can lead to a rapid decline in physical strength and employability as workers grow older. Thus, physical wear and tear are not predetermined by a worker's age; they are rather a result of his working conditions in the past.

Skirbekk (2004) compares several approaches used to measure productivity differences of workers of different age groups and particularly stresses the measurement problems.[8] For example, productivity could be measured indirectly by the proportion of workers of different age groups employed by the firms, as applied by Arnds and Bonin (2003a). This method is justified by the assumption that employers tend to lay off in particular those workers with a low productivity. The great number of older workers who are laid off therefore leads to the conclusion that older workers are less productive than younger workers. However, Arnds and Bonin (2003a) suppose that this relation is biased in Germany, due to the institutional regulations that facilitate the transition into early retirement.

2.1.5.2 Technological Change and Rising Demand for Computer Skills

Modern business processes have undergone many changes at the end of the 20th century and afterwards. There have been major technological and organizational advances in production processes and working conditions. There is a huge amount of literature on skill-biased technological change, organizational changes, and globalization and on their effects

[8] A description of these measurement problems goes beyond the scope of my study. See Skirbekk (2004) for details.

on the demand for different skills and skill groups.[9] Since there have been major impacts on the relative demand for different skill groups as well as on wages and employment, the demand for older workers has clearly been affected by these developments as well.

Using data on older male workers in the U.S. between 1966 and 1983, Bartel and Sicherman (1993) distinguish between high rates of technological change in particular industries on the one hand, and technological shocks on the other hand. They conclude that workers in industries with high rates of technological change remain longer with the firm because they are obliged to perform permanent on-the-job training, which keeps their skills up-to-date. However, an unexpected technological shock leads to an abrupt depreciation of human capital and thus to a drop in the retirement age of workers. Bartel and Sicherman (1993) conclude that permanently high rates of technological change cause a postponement of retirement, whereas technological shocks lead to earlier retirement.

Recent papers concentrate on the reasons why the type of skills demanded in the labor market has shifted. These shifts could be a result of changing skill compositions within jobs. Autor et al. (2002, 2003) analyze the impact of technological changes on the design and skill requirements of jobs, using data from the U.S. They find that computers are introduced in particular "to automate tasks that can be described in terms of rules-based logic" (Autor, Levy, and Murnane, 2002, p. 445). At the same time, this technological change leads to a reorganization of those tasks that are not computerized. The authors support the widespread theory that computers and education are complementary, and that computerization therefore leads to an increase in the relative demand for highly skilled labor. Spitz-Oener (2006) describes the changes in the occupational structure of employment due to the diffusion of IT and analyzes the changes in skill requirements among occupations, using data on German employees. Her findings support the hypothesis that IT capital substitutes repetitive tasks, and complements analytical, interactive and computational skills. Therefore, a shift in the task composition of occupations due to IT capital leads to an increase in the demand for more highly educated labor.

The relationship between changes in the skill requirements of jobs and the age structure of the workforce is not completely obvious. Aubert et al. (2006) point out that as older workers are more experienced and have a higher level of accumulated knowledge they should benefit from the increasing demand for highly skilled labor. The results of Weinberg

[9]These include the papers of Chennells and van Reenen (2002), Acemoglu (2002) and Bresnahan, Brynjolfsson, and Hitt (2002) on skill-biased technological change. Organizational changes are identified in the literature as a determinant of labor demand by Lindbeck and Snower (1996) and Caroli and van Reenen (2001), for example. The globalization of goods and labor markets are influencing developments described by Feenstra and Hanson (1996), and Wood (1998).

(2002) suggest that the positive impact of experience particularly holds for less educated workers. For them, new technologies complement existing skills. Thus, experience matters and new technologies are adopted first by experienced (older) workers. On the other hand, the impact of technological progress on older workers may be negative if it leads to a depreciation of a given stock of human capital (*economic skills obsolescence*)[10].

Bertschek (2004) uses data from the ZEW ICT survey of 2002 and empirically analyzes the impact of IT use on the proportion of older workers employed by the firm. She finds a significantly negative correlation of a firm's proportion of employees predominantly working with a computer and the proportion of older workers. However, Bertschek (2004) recognizes that there might be a problem of simultaneity: firms may decide to have less computer workplaces because their workforce is older.

The negative relationship between computer use and the age of the workforce is also a result reached by Hirsch, Macpherson, and Hardy (2000). They base their analyses on several U.S. data sets and find that older workers face substantial entry barriers in occupations characterized by intensive computer use.

My own analyses provided in chapter 3 of this dissertation support the view that firms which intensively use information technologies employ fewer older workers. Based on firm data from the ZEW ICT survey from the years 2004 and 2007, I also show that IT training for older workers is positively related to the proportion of older workers employed by the firm. This effect can particularly be found in IT-intensive firms.

2.1.5.3 Skills Obsolescence

The longer workers participate in the labor market, the higher their probability of facing skills obsolescence. Thus, older workers are particularly affected. Skills obsolescence reduces older workers' productivity and increases their probability of leaving the labor market.

The use of new information technologies within firms increases the average amount of skill requirements in the labor market and often changes the composition of skills required for jobs. Rosen (1975) refers to the resulting reduction in the market value of a worker's human capital as *economic skills obsolescence*. De Grip and Van Loo (2002) distinguish three types of economic skills obsolescence: firstly, *job-specific skills obsolescence* arises from changes in job-specific skill requirements as a result of technological and organizational

[10] See the next section.

developments in the production process. Secondly, shifts in the industry structure of employment due to changes in consumption or in international trade patterns may result in changes in the demand for specific occupations. Thus, a worker may still exhibit the right skills for his specific occupation, but *skills obsolescence due to sectoral shifts* occurs because his occupation is less in demand. And thirdly, *firm-specific skill obsolescence* arises if the value of firm-specific skills is lost when workers are laid off due to reorganization processes or firm closure.

Pack et al. (1999) refers to the second category of economic skills obsolescence when he states that in firms with an age-segmented workforce older workers are often employed in those areas of firms where they have to produce out-dated and out-phasing product lines. This renders the exchange of information and know-how between younger and older workers unnecessary. In addition, older workers are often not involved in innovation processes, and their work even becomes useless if the product line actually phases out. Therefore, they run the risk of reduced work motivation and early exit from the workforce.

Contrary to this externally caused skill obsolescence, the *technical skills obsolescence* describes the depreciation of human capital stock due to changes that originate in workers themselves (De Grip and Van Loo, 2002). This concept parallels to a great extent the considerations with regard to the *deficit model of aging* described above. De Grip and Van Loo (2002) differentiate between the *wear of skills*, that is technical skills obsolescence due to natural aging processes or health problems, and the *atrophy of skills* caused by an insufficient use of skills, for example as a result of unemployment, career interruptions, or of being underchallenged in the present job. Koller and Plath (2000) support the view that technological skills obsolescence is often caused by an inadequate use of qualifications, the so-called *disuse effect*, as well as by a lack of training possibilities to adjust or increase skills.

2.1.5.4 Discrimination

Finally, the low labor demand for older workers could simply be a result of discrimination. In many cases, the employer's subjective assessment of older workers' labor productivity as well as prejudice against older workers influence the decision to lay them off. The analyses of Strotmann and Hess (2003), Boockmann and Zwick (2004) as well as Koller and Gruber (2001) deal with this topic. They are based on interviews of personnel managers of firms. The respondents assess age-specific strengths and weaknesses of workers and state their employment preferences with regard to the age of workers. Strotmann and Hess (2003) as well as Boockmann and Zwick (2004) use data from the German state of

Baden-Württemberg. Their findings are quite similar to those provided by Koller and Gruber (2001) who used data from the whole country. They show that experience, mental strength, working discipline, loyalty, and basic knowledge are regarded as the strengths of older workers. Physical strength, creativity and flexibility, learning ability, and the ability to work in a team turn out to be the advantages of younger workers. This valuation implicates disadvantages for older workers in the course of ongoing technological change, as older workers seem less flexible, less creative and less willing to learn how to use new technologies.

In order to estimate the relation between the age-specific assessments of personnel managers and the proportion of older workers within firms, Boockmann and Zwick (2004) develop an indicator which comprises the direction as well as the importance of the evaluated categories. The authors find that the assessments of personnel managers only have a significant impact on the proportion of older workers for small firms. Thus, in larger firms a negative evaluation of older workers is usually not accompanied by reduced employment of older workers. This could be a result of stronger dismissal protection rules for larger firms.

Strotmann and Hess (2003) show that employers in Baden-Württemberg see the age of workers as a relevant decision criterion when hiring new workers. The authors additionally find that the evaluation of older workers is worse in firms that have no older workers at all. Their results further indicate large differences in the age-specific employment preferences by size and industry of the firm. Especially small firms and firms of the 'building', 'retail', 'other services', and 'craft' sectors view older workers much more critically and often refuse to employ them. Moreover, those firms who refused to employ older workers are on average in a worse economic situation than other firms.

After having provided the theoretical and empirical background, I now focus on my own empirical analyses. The next section describes the data used.

2.2 Data

The analysis of the change in employment status of older workers in Germany is based on the Socio-Economic Panel (SOEP) data.[11] The SOEP is a representative longitudinal survey of private households collected by the German Institute for Economic Research (DIW). Annually, since 1984, the same individuals have been asked about the develop-

[11]See Haisken-DeNew and Frick (2005) for a detailed description of the SOEP.

ment of their living and working conditions. Since the German reunification in 1990, East German households have been added to the survey.

The data analyzed in this chapter is taken from the waves conducted in 1997, 1999, and 2001. These years are three of the four years (1997, 1999, 2000, 2001) in which questions concerning computer use at work were asked. The questions in 1997 were: "Do you use a computer, either privately, on your job, in your training/education? And if yes, since when?"[12] This information is used in a first step to find out who uses a computer in the workplace. I analyze the determinants of computer use of men employed full-time in 1997. In addition to the age of workers, this multivariate analysis includes several demographic, job-related, and firm-related characteristics.

In a second step, the relationship between computer use at work and a change in employment status of older workers between 1997 and 2001 is studied. This four-year period is chosen in order to observe a sufficiently large group of individuals undergoing a change in their employment status. However, in order to detect short term computer use effects on employment status, the changes between 1997 and 1999 are examined as well. The employment status of the individuals analyzed is 'employed full-time' in 1997. In 2001 (and 1999 respectively) either it can be still 'employed full-time', or it can be changed and the people are 'employed part-time', 'retired' or 'unemployed'.[13] Men who declared themselves as unemployed but had no hope of finding a new job and were not looking for one are defined as 'retired'.[14] In addition, there is one person in the analyzed sample who declared himself retired but was still looking for a job. This person is defined as 'unemployed'.

The SOEP wave of the year 1997 covers more than 13,000 individuals aged 16 years and above. For my analyses the sample is restricted to males who are working full-time in 1997. Only males are considered because only a very small proportion of women of the older age groups works full-time. The analyses of the determinants of computer use are made for workers of all age groups. The analyses regarding employment status change

[12]The exact questions were: "Benutzen Sie privat oder beruflich (bzw. in Ihrer Ausbildung) einen Computer? Falls 'ja': seit welchem Jahr?" In 2001, questions concerning Internet use were additionally asked. The ICT questions from the years 1999 and 2000 were less precise. In this chapter, the information about Internet use is ignored. Any computer use data is taken from the 1997 SOEP wave.

[13]This division was chosen under the assumption that for the analyzed older age group part-time employment is a form of smooth transition into retirement. In Germany, older employees have the opportunity to reduce their working hours by applying for *partial retirement*, for example.

[14]The receipt of pension or social security income was not considered when defining retirement.

is only made for workers with an age between 50 and 60 years in 1997.[15] With the lower threshold of 50, the analyzed data set also comprises male workers in their fifties who are in certain circumstances allowed to reduce their working time in accordance with various early retirement regulations in Germany. The maximum age of 60 in the year 1997 implies that the workers had not yet reached the statutory retirement age of 65 in 2001. Moreover, only individuals who responded to the survey questions about their computer use in 1997 are included in the analyses. Thus, according to the group of workers to be analyzed, the sample was cut to 3,638 individuals in the first part of the study analyzing the determinants of computer use. The analysis of an employment status change is only made for older workers, which reduces the sample to 581 men for whom the relevant criteria are met.

2.3 Determinants of Computer Use

2.3.1 Hypotheses and Estimation Strategy

Table A.1 in the appendix shows the proportions of computer users and non-users of the analyzed group of full-time employees in 1997 according to various individual and firm-related characteristics.[16] There are large differences in the proportions of computer use between workers aged 55 years and above and those who are younger than 55. Whether this is a result of age itself or, for example, of the educational or occupational composition of the workforce in the respective age group is studied in the following. Thus, the determinants of computer use of full-time workers are analyzed, particularly considering the oldest age group. The hypotheses are: i) older workers have a lower probability of using a computer than younger age groups. ii) Education has a positive impact on the probability of computer use. iii) The hourly wage is positively related to the propensity to use a computer.

Computer use is measured by a binary variable taking the value one if the employee uses a computer and the value zero otherwise. I use a PROBIT model to estimate the coefficients. The relationship between different individual and job-related characteristics

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[15]Hence, they become 52 to 62 years old when observed in 1999, and 54 to 64 years old in 2001.

[16]Additionally, Table A.1 contains the total proportion in the sample for every characteristic.

and the probability of using a computer is analyzed in four steps.[17] At first, only age group dummies are included in the regression. In a second step, education and occupational status categories are added. Hourly wage, computer use at home, region, and nationality are additionally analyzed in a further specification. The last specification also contains firm-specific determinants (firm size, industries).

Assuming that the latent propensity to use a computer at work y_i^*, representing the utility of using a computer, depends on individual and job-related characteristics X_i and on normally distributed unobserved factors ε_i in the form

$$y_i^* = X_i\beta + \varepsilon_i, \tag{2.4}$$

the observed computer use y_i is

$$y_i = \begin{cases} 1 & if \quad y_i^* > 0 \\ 0 & if \quad y_i^* \leq 0 \end{cases}$$

and the probability of computer use can be modelled as

$$Pr(y_i = 1|X_i) = Pr(y_i^* > 0|X_i) = \Phi(X_i\beta), \tag{2.5}$$

where Φ is the cumulative normal distribution function.

2.3.2 Empirical Results

The results of the four PROBIT estimations are presented in Table 2.1.[18] Specification (1) which includes only age group dummies shows that the probability of using a computer at work is lowest for the youngest and the oldest age group of full-time workers compared with those who are 25 to 34 years old.

As age differences may exist between educational levels and occupational status categories, these factors have to be controlled for when analyzing the effect of age on computer use.

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[17] As the use of a computer at work can only be observed for employed persons, the analyzed sample is supposed to be a non-random sample. This may cause a sample selection bias in the estimations. The attempt to use a Heckman correction for being employed had to be abandoned as no adequate instrumental variables were found. Thus, the possibility of a sample selection bias has to be kept in mind when interpreting the results.

[18] The sample size differs between the specifications in order to have a larger sample in the first specifications. However, estimating specification (1) to (4) with a constant sample size provides coefficients which are very similar.

Considering education and occupation in a regression additionally shows their impact on the probability of using a computer at work. Various economic studies confirm a positive relationship between the highest achieved educational level of workers and their use of new technologies.[19] Eight education variables are therefore considered in specification (2) to test this presumption on the basis of the SOEP data. Furthermore, seven occupational status categories are included. As can be seen in Table 2.1, education and occupation show the expected and significant relation to the probability of using a computer at work: for higher levels of education and occupational status the probability of using a computer is significantly higher. If education and occupation are included, the negative average marginal effect of the oldest age group regarding computer use increases from 10 percent to 17 percent (the effect of the youngest age group is no longer significant). Since the consideration of education increases the negative correlation between age and computer use, the hypothesis is confirmed that older workers who still work are more qualified than the average.

Borghans and ter Weel (2002) as well as Entorf and Kramarz (1997) find a positive correlation between computer use and wage. Moreover, using a computer at home is expected to be highly correlated with using a computer at work, as people who use a computer at home already have some computer skills.[20] Thus, the effort required to use a computer at work should be lower. Table A.1 in the appendix also shows that the use of computers differs by nationality (German, Non-German) and by region (East Germany, West Germany). In order to find out whether the differences are significant in a multivariate setting, these variables are additionally included in specification (3).

The results of the regressions provided in Table 2.1 confirm that there is a significantly positive correlation between hourly wages and computer use at work.[21] As expected, using a computer at home is highly correlated with using a computer at work. It increases the probability of using a computer at work by 36 percent on average. To a large extent using a computer at home explains the observed age effect. As older workers are less likely to use a computer at home, this factor reduces the average marginal effect of age on computer use at work. The probability of older workers using a computer at work turns out to be 11 percent less than the probability of workers aged 25 to 34.

[19] This result is obtained, for example, by Borghans and ter Weel (2002) using data of Germany, Great Britain and the United States, and by Entorf, Gollac, and Kramarz (1999) analyzing French data.

[20] The positive correlation is found, for example, by Haisken-DeNew and Schmidt, 1999. See also Table A.1 in the appendix for the bivariate relation.

[21] The results of specification (3) show an increase of the negative average marginal effect of the oldest workers to 19 percent if 'computer use at home' is not considered (not shown in the table).

Table 2.1: Computer use at work of full-time workers in 1997 – Probit results

dependent variable: computer use at work				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
age (ref.: age 25-34)				
19-24	-.156 (.035)***	-.024 (.029)	.021 (.027)	.006 (.027)
35-44	.034 (.021)	-.011 (.016)	-.016 (.015)	-.014 (.015)
45-54	.040 (.023)*	-.028 (.018)	-.011 (.017)	-.014 (.017)
55-64	-.100 (.027)***	-.168 (.021)***	-.111 (.021)***	-.101 (.021)***
education (ref.: university degree)				
lower secondary education or less		-.212 (.030)***	-.099 (.031)***	-.113 (.032)***
other vocational education		-.230 (.033)***	-.123 (.035)***	-.134 (.035)***
apprenticeship		-.154 (.027)***	-.061 (.026)**	-.081 (.028)***
specialized vocational school		-.132 (.033)***	-.083 (.032)**	-.094 (.032)***
technical/commercial college		-.065 (.030)**	-.015 (.030)	-.019 (.031)
civil servant college		-.049 (.045)	.033 (.045)	-.007 (.044)
polytechnic or college abroad[i]		-.031 (.030)	.015 (.030)	.006 (.031)
occup. status (ref.: blue collar low-l.)				
blue collar high-level		.067 (.019)***	.013 (.020)	.022 (.019)
clerical worker low-level		.229 (.028)***	.124 (.030)***	.121 (.030)***
clerical worker high-level		.577 (.019)***	.396 (.031)***	.371 (.032)***
civil servant low-level		.371 (.033)***	.245 (.044)***	.206 (.049)***
civil servant high-level		.430 (.027)***	.300 (.043)***	.279 (.047)***
self-employed		.337 (.022)***	.217 (.031)***	.249 (.039)***
nationality (ref.: foreign)				
German			.024 (.020)	.028 (.020)
region (ref.: west)				
east			-.025 (.017)	-.014 (.017)
log hourly wage			.083 (.018)***	.058 (.019)***
computer use at home			.363 (.021)***	.335 (.020)***

continued on next page

Table 2.1 – continued from previous page

dependent variable: computer use at work				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
firm size (ref.: 20 to 199 employees)				
less than 5				-.008 (.029)
5 to 19				-.005 (.021)
200 to 1,999				.029 (.018)
2,000 or more				.061 (.019)***
industry (ref.: public sector)				
agriculture, forestry, fisheries				-.105 (.050)**
mining, utilities				-.048 (.043)
building industry				-.107 (.032)***
manufacturing				-.002 (.029)
wholesale, retail trade				.023 (.033)
hotels & restaurants				-.029 (.057)
transport, communications				-.063 (.031)**
credit, insurance, real estate				.101 (.051)**
data processing, R&D, business serv.				.077 (.046)*
other services				-.073 (.028)**
other sectors				-.040 (.047)
pseudo-R^2	.010	.331	.459	.480
number of observations	3,638	3,595	3,133	3,046

Notes: The table shows the average marginal effects. Standard errors in parentheses.

***, **, * indicate significance at the 1%, 5% and 10% level.

[i]) College abroad: In the data it is not clear what kind of degree is meant.

Source: Author's calculations based on SOEP 1997.

Specification (4) in Table 2.1 adds firm-related variables to the analysis. For those determinants already included in specification (3), this leads to very similar results regarding the direction and the significance of the effects. Compared with workers aged 25 to 34 years, workers of the oldest age group again show a significantly smaller probability of using a computer at work. Having an age of 55 to 64 years reduces the probability of using a computer by about 10 percent. This finding again supports the hypothesis that computer use is age-dependent and that computer use is lower for workers who are near retirement.

Table 2.2: Impact of levels and changes in average computer use – Probit results

dependent variable: computer use at work				
	(1)		**(2)**	
	age 26-45	age 55-64	age 26-45	age 55-64
average occupational computer use	.824 (.087)***	.989 (.223)***	.875 (.090)***	1.035 (.225)***
change, 1994-1997			-.115 (.052)**	-.272 (.117)**
average industry computer use	.581 (.116)***	.457 (.338)	.706 (.176)***	.150 (.618)
change, 1994-1997			-.134 (.143)	.267 (.505)
occupation × industry average	-.273 (.182)	-.481 (.461)	-.279 (.182)	-.410 (.467)
number of observations	2,229	427	2,229	427

Notes: The table shows average marginal effects. Standard errors in parentheses.
***, ** indicate significance at the 1% and 5% level.
All workers analyzed are employed full-time in 1997. Levels and changes in average computer use are based on seven occupational status categories and twelve industries of workers aged 26 to 45. The estimation results of the workers aged 46 to 54 form a logical transition between the other two age groups, but are not additionally shown in the table.
Source: Author's calculations based on SOEP 1994 and 1997.

Specification (4) additionally shows that the probability of using a computer is significantly higher in large firms with 2,000 or more employees and in the 'credit, insurance, real estate' as well as 'data processing, R&D, business services' industries, as compared to public sector firms. The effects of region and nationality remain insignificant.

As pointed out by Bartel and Sicherman (1993), older workers tend to retire sooner if technological shocks occur in the sector they are working in. These shocks lead to a sudden depreciation of knowledge, and investments in training become less attractive for older workers as they near retirement. In order to find out how the computer use of older workers responds to the pace of computerization, the relationship between individual computer use and the levels and changes in average computer use in the person's occupation and industry are tested based on the SOEP data using regression analysis. Following Friedberg (2003), specification (1) includes the levels of average computer use by occupation and industry as well as their interaction. Specification (2) additionally considers the changes in average computer use between 1994 and 1997. The results for older workers (55 to 64 years) are compared to those for prime age workers (26 to 45 years). Table 2.2 depicts the average marginal effects of the PROBIT estimations.

As expected, a higher level of average computer use in an occupation highly increases the probability of using a computer for older and younger persons working in that occupation. However, recent increases in the average computer use in an occupation make older workers significantly less likely to use a computer at work. This indicates an explanation for the relationship between technological change and impending retirement. A sudden increase in the average computer use leads older workers to fall behind in using new technologies. As skills depreciate quickly the incentive for older workers to invest in training decreases, and the incentive for early retirement increases. The negative effect of changes in the average computer use in the own occupation on the probability of using a computer at work is observable for workers younger than 46 as well, but it is less than half the effect observed for older workers. The level of average computer use in an industry is only influential for the probability of younger workers using a computer. Contrary to the work by Bartel and Sicherman (1993) the effect of recent changes in the average computer use in the own industry turns out to be insignificant for older workers when occupational and industry averages are considered together.

2.4 Employment Status Change

2.4.1 Hypotheses and Estimation Strategy

The main hypothesis to be tested in this section is that older workers who use a computer at work are more likely to remain employed full-time than non-users in the same age group. Therefore, the relationship between computer use and the change in employment status of male workers from 1997 to 1999 and from 1997 to 2001 is analyzed. The 581 workers in the applied data set were all between 50 and 60 years old and employed full-time in 1997. In 1999 and 2001 they were either still full-time workers or had changed their status and become employed part-time, retired or unemployed. Table 2.3 shows the expected decline in the proportion of full-time employment and the expected rise in the proportions of part-time employment and retirement as the workers grow older. The focus of the following analyses lies on the transition of older workers to early retirement, part-time employment or unemployment, especially if they do not adopt new technologies. The change of older workers from full-time into part-time employment is assumed to be a decision for a transitional status before finally going into retirement. This assumption is supported by the finding that especially the oldest age group uses options of part-time employment.

Table 2.3: Employment status of older workers^{i} in 1999 and 2001 by age group (in percent)

age in 1997	**50-55**		**56-60**	
	1999	**2001**	**1999**	**2001**
employed full-time	90	79	70	44
employed part-time	0	1	2	7
not employed (retired)	7	15	25	47
not employed (looking for a job)^{ii}	3	4	3	2
number of observations	338		243	

Notes: ^{i}) All men were employed full-time and between 50 and 60 years old in 1997.
^{ii}) Including one man who declared to be retired.
Source: Author's calculations based on SOEP 1997, 1999 and 2001.
Example: 47 percent (115 men) of the male workers who were 60 to 64 years old in 2001 and who were employed full-time in 1997 are retired in 2001.

A first idea of employment status differences between older computer users and non-users is given by the following observation: among the 336 non-users 24 percent (39 percent) changed status between 1997 and 1999 (between 1997 and 2001); among the 245 users only 10 percent (31 percent) did. Thus, the probability of computer users leaving full-time employment in the two-year period is 14 percentage points (in the four-year period 8 percentage points) less than the probability of non-users, if no further covariates are considered. These results also indicate a declining impact of computer use over the years for the same cohort.

2.4.1.1 Ordinary Least Squares Estimates

In the following, the relationship between computer use at work and the development of the employment status of older workers from 1997 to 1999 and from 1997 to 2001 will be examined in a multivariate analysis. Here, the development of the employment status of older workers is measured by a dummy variable z. It takes the value zero if workers kept the full-time status by 1999 (or by 2001, respectively). For workers who changed their employment status to being employed part-time, retired or unemployed in 1999 (2001, respectively), z is given the value one. Besides the computer use characteristic of workers (x_c), their employment status decision depends on various individual and firm-related variables (x_j). This can be regarded as a *linear probability model* (ordinary least squares – OLS):

$$z = \beta_0 + \beta_j x_j + \beta_c x_c + u \qquad \text{with} \quad j = 1, 2, ..., c-1, \tag{2.6}$$

where β_c measures the impact of using a computer at work, and u is the error term.[22]

2.4.1.2 Two-Stage Least Squares Estimates

Two possible directions of causality have to be borne in mind when analyzing the relationship between computer use and changes in employment status. Computer training and usage may provide older employees the prospect of improved work opportunities. As a result, investments in computer skills may induce older workers to delay retirement. However, the decision to delay retirement may have other causes. The postponement may give older workers an incentive to invest in training as they still have enough time to amortize the effort. Thus, the decision to invest in computer skills and to retire early is made simultaneously.

As x_c might then be correlated with u, computer use is to be regarded as endogenous in equation (2.6) and the OLS approach results in inconsistent estimators.[23] An approach to consistently estimate the model with computer use at work being endogenous is the *two-stage least squares* (TSLS) approach using instrumental variables. The idea is to find an observable variable h_1 (the instrument) that has an impact on the decision to use a computer but is otherwise uncorrelated with the decision to change employment status. The instrument has to satisfy two main conditions (Wooldridge, 2002). Firstly, it must be uncorrelated with u: $Cov(h_1, u) = 0$, secondly, modelling computer use as

$$x_c = \delta_0 + \delta_1 x_1 + \delta_2 x_2 + ... + \delta_{c-1} x_{c-1} + \theta_1 h_1 + r_c, \tag{2.7}$$

the coefficient on h_1 is assumed to be nonzero: $\theta_1 \neq 0$. Including this reduced form equation for x_c in (2.6) gives

$$z = \alpha_0 + \alpha_j x_j + \lambda_1 h_1 + v \tag{2.8}$$

[22]For better comparison with the results presented by Friedberg (2003) the linear probability model is used instead of the PROBIT approach.

[23]Following Wooldridge (2002), one might think of u as comprising an omitted variable which is uncorrelated with all explanatory variables except for x_c.

with $j = 1, ..., c-1$, the coefficients $\alpha_j = \beta_j + \beta_c \delta_j$ and $\lambda_1 = \beta_c \theta_1$, and the reduced form error $v = u + \beta_c r_c$. The instrumental variable used here is computer use at home. Workers who use a computer at home already have some computer skills. Thus, for these workers the costs of on-the-job computer training will be lower than for workers without these skills. For older workers nearing retirement age this also positively affects their decision to invest in on-the-job computer skills.

Moreover, starting to use a computer at home can be assumed to be less based on the intention to invest in skills and to increase labor market prospects. Rather it is often an individual decision based on personal interests and on network effects, for example due to learning spillovers from children in the same household who use a computer themselves.[24]

When added along with the other covariates in a linear regression of employment status change, computer use at home is statistically insignificant. Thus, computer use at home is uncorrelated with the outcome variable of the second stage regression. In addition, the Durbin-Wu-Hausman test was used to test for endogeneity of computer use at work. Given the instrument 'computer use at home' the test shows significant evidence of endogeneity (t-values: 8.82 in 1999, 4.47 in 2001). Thus, OLS provides inconsistent estimates and TSLS proves out to be a better estimation strategy.

2.4.2 Empirical Results

2.4.2.1 Ordinary Least Squares Estimates

For comparison, Table 2.4 shows the results of four OLS specifications that analyze the impact of computer use at work on the employment status of older workers, controlling for various other characteristics.[25] In the first specification only computer use at work is included to estimate the bivariate correlation. The expected negative correlation between computer use and the probability of changing employment status is significant in 1999 as well as in 2001. Thus, as seen before, computer users are more likely to remain employed full-time than non-users, especially in the short term. Including age in the second OLS specification reduces the effect of computer use. However, it is still significant in the short term, but it becomes insignificant in the long run.

[24]See chapter 4 for a detailed description of network effects.

[25]The full versions of the Tables 2.4 to 2.6 are shown in the appendix.

Table 2.4: Employment status change of older workers[i] from 1997 to 1999 and from 1997 to 2001 – OLS results

dependent variable: change in employment status 1997 → 1999				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.142 (.030)***	-.127 (.029)***	-.093 (.041)**	-.117 (.043)***
age (ref.: age 50-54)				
age 55-60		.214 (.030)***	.213 (.033)***	.225 (.034)***
self-employed			-.105 (.048)**	-.196 (.098)**
further covariates[ii]			demographic and job-related characteristics	demographic, job-related and firm-related characteristics
dependent variable: change in employment status 1997 → 2001				
computer use at work	-.080 (.040)**	-.052 (.037)	-.058 (.050)	-.068 (.053)
age (ref.: age 50-54)				
age 55-60		.390 (.036)***	.388 (.040)***	.411 (.041)***
self-employed			-.173 (.062)***	-.343 (.110)***
further covariates[ii]			demographic and job-related characteristics	demographic, job-related and firm-related characteristics
number of observations	581	581	527	515

Notes: ***, ** indicate significance at the 1% and 5% level. Robust standard errors in parentheses.
[i]) Men who were between 50 and 60 years old in 1997.
[ii]) Demographic characteristics: education, region, nationality; job-related char.: log hourly wage, tenure, tenure^2; firm-related char.: firm size, industry. See Tables A.2 and A.3 in the appendix for all coefficients.
Source: Author's calculations based on SOEP 1997, 1999 and 2001.

The correlation between computer use and the change in employment status of older workers becomes smaller if additional demographic and job-related characteristics, such as nationality (German, foreigner), region (east, west), education, self-employment status, and log hourly wages, are considered in specification (3). The correlation is still significant for the two-year period and remains insignificant for the four-year period.

Controlling for firm-related variables in specification (4), such as firm size and industry, increases the correlation between computer use and the change in employment status in the short term. The results indicate that part of the correlation is captured by differences in *both* variables between industries, that is there are industries that have many computer users and many workers who change their employment status. Additionally, the results show that the impact of computer use declines over the years. By 1999, using a computer makes workers 11.8 percentage points less likely to change their employment status, a high correlation. After four years, the observed effect is much smaller and no longer significant.

Self-employed workers are significantly less likely to change their employment status than workers in the other occupational groups. This result is not surprising as self-employed men are not eligible for a retirement pension the way employees are. They have a large incentive to work longer as well as to work full-time in order to finance their life. Moreover, they cannot be dismissed.

The results of the OLS estimations differ from those given by Friedberg (2003). She finds a significant effect of computer use on the retirement decision for a period of four years (1992 to 1996) even after including various covariates. Thus, people who work with a computer choose to retire later. However, Friedberg uses a slightly different definition of the change in employment status and analyzes male *and* female workers. In addition, the difference can also be the result of my relatively small sample.

Bartel and Sicherman (1993) also discuss the effects of various variables on the decision to retire. They find that self-employed workers retire later. This result is similar to the one given above. On the other hand, they find that schooling has a negative effect on the likelihood of retirement and tenure has a positive one. In contrast, the effects of education and tenure are insignificant in specification (4) of the OLS regression of my analyses.

2.4.2.2 Two-Stage Least Squares Estimates

As can be seen by the results of the first stage of the TSLS regression (Table 2.5) the instrument 'computer use at home' is highly significantly correlated with computer use at work. As expected, workers who use a computer at home are much more likely to use a computer at work than the non-users at home.[26] This result does not change when demographic, job-related, and firm-related characteristics are additionally considered in the regression. Thus, together with the thoughts and tests provided in section 2.4.1.2, it can be assumed that the instrument is not weak.

[26] This correlation was also observed when younger age groups of full-time employed men were additionally considered (see Table 2.1).

Table 2.5: Employment status change of older workers^{i} – TSLS results, first-stage regressions

dependent variable: computer use at work				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at home	.671 (.034)***	.668 (.034)***	.462 (.049)***	.462 (.048)***
age (ref.: age 50-54)				
age 55-60		-.031 (.034)	-.060 (.033)*	-.045 (.033)
further covariates^{ii}			demographic and job-related characteristics	demographic, job-related, and firm-related characteristics
R^2	.349	.350	.488	.519
number of observations	544	544	492	481

Notes: ***, * indicate significance at the 1% and 10% level. Robust standard errors in parentheses.
^{i}) Men who were between 50 and 60 years old in 1997.
^{ii}) Demographic characteristics: education, region, nationality; job-related char.: log hourly wage, tenure, tenure^2; firm-related char.: firm size, industry. See Table A.4 in the appendix for all coefficients.
Source: Author's calculations based on SOEP 1997, 1999 and 2001.

The second-stage results of the TSLS approach are reported in Table 2.6.[27] The significance of the computer use effect observed in the short term OLS regressions (Table 2.4) vanishes when further characteristics are included. Thus, together with the insignificant effects in the four-year period, the multivariate TSLS approach does not provide evidence that differences in the probability of changing employment status between older workers result from their computer use at work.

The result of insignificant effects of computer use at work on the employment status of older workers fundamentally differs from the one given by Friedberg (2003) as she finds a significant correlation. However, she uses different instruments[28] and, as already mentioned, she uses a slightly different definition of a change in employment status. In addition, the relatively small size of the sample I use could make it difficult to identify the effect.

[27] Applying a PROBIT instrumental variables approach instead of the TSLS approach provides very similar results. See Wooldridge (2002) for a description of the model.

[28] The instruments used by Friedberg (2003) are the average computer use by prime-age workers in the same occupation and industry, and their changes over time. They could not be used in my analyses because contrary to Friedberg's findings occupational dummies (and thus the mean of occupational computer use of prime age workers) show a significant effect on the probability of changing employment status (the second stage). In addition, the average computer use by industry shows no significant impact on the probability of older workers using a computer at work (the first stage) (see Table 2.2). One reason could be that Friedberg includes covariates in the regressions that result in insignificant coefficients of occupational status variables in her analyses.

Table 2.6: Employment status change of older workers[i] from 1997 to 1999 and from 1997 to 2001 – TSLS results, second-stage regressions

dependent variable: change in employment status 1997 → 1999				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.172 (.049)***	-.140 (.048)***	-.114 (.086)	-.110 (.085)
age (ref.: age 50-54)				
age 55-60		.219 (.031)***	.212 (.033)***	.222 (.034)***
self-employed			-.098 (.052)*	-.193 (.098)**
further covariates[ii]			demographic and job-related characteristics	demographic, job-related, and firm-related characteristics
dependent variable: change in employment status 1997 → 2001				
computer use at work	-.117 (.069)*	-.060 (.062)	-.009 (.109)	-.024 (.107)
age (ref.: age 50-54)				
age 55-60		.393 (.038)***	.393 (.041)***	.410 (.042)***
self-employed			-.169 (.069)**	-.365 (.109)***
further covariates[ii]			demographic and job-related characteristics	demographic, job-related, and firm-related characteristics
number of observations	544	544	492	481

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses. Instrument for computer use at work: computer use at home.

[i]) Men who were between 50 and 60 years old in 1997.

[ii]) Demographic characteristics: education, region, nationality; job-related char.: log hourly wage, tenure, tenure^2; firm-related char.: firm size, industry. See Tables A.5 and A.6 in the appendix for all coefficients.

Source: Author's calculations based on SOEP 1997, 1999 and 2001.

However, the TSLS and the OLS approaches lead to similar results regarding self-employed men. For both the two-year and the four-year period, self-employed men are significantly less likely to change their full-time employment status than workers with a different occupational status, presumably for the reasons discussed in the previous section. The effect is even stronger in the longer period. In addition, in the long run, educational level, firm size, and industry show a significant correlation with the probability of older workers changing their employment status. Older men who work in firms with less than five employees as well as those who completed an apprenticeship are less likely to remain employed full-time than men who work in larger firms or achieved a higher educational level. The effect of age is highly significant and positive, as expected. Older workers have a higher probability of changing employment status and becoming retired or part-time employed as they near the compulsory retirement age.

2.5 Concluding Remarks

For older workers who are near retirement the time to capture the returns to training investment is short. Thus, their incentive to invest in computer skills may be lower compared with younger workers. The resulting lack of IT skills may increase the incentive to take advantage of early retirement opportunities. On the other hand, acquiring computer skills and working with a computer on the job may give older workers an incentive to delay retirement.

In this chapter of my dissertation, I analyze the relationship between computer use and employment status of older workers. I study the characteristics of computer users, and whether or not older computer users have a higher probability of remaining employed full-time than non-users. For this purpose individual data on male workers is taken from the German SOEP waves 1997, 1999, and 2001.

As expected, older workers aged between 55 and 64 are less likely to use a computer at work compared with younger workers, even after controlling for various other variables. Consistent with the results of other studies, educational level, occupational status, hourly wage, and computer use at home are significantly positively correlated with the probability of using a computer at work.

Further analyses focus on the question whether computer use of older workers has a significant causal effect on their employment status. In the subsample of workers aged 50 to 60 years, the results of the OLS approach show a positive partial correlation between computer use at work and the probability of continuing to work full-time within a two-year period. However, taking endogeneity of computer use at work into account, the instrumental variables approach leads to insignificant coefficients of computer use at work for the two-year as well as the four-year period when several individual and firm-related characteristics are included. Being self-employed is one of the main determinants of an employment status change. For self-employed men the probability of remaining employed full-time is much higher than for workers in other kinds of occupations.

The analyses based on the SOEP data thus support the negative relationship between the age of employees and the probability of working with a computer. This result provides evidence of an age-specific digital divide in Germany. However, the results regarding the hypothesis that computer use on the job increases the probability of older workers remaining in full-time employment until the statutory retirement age are ambiguous. But it seems that computer skills themselves cannot prevent older workers from entering early retirement.

However, since a small sample size makes it difficult to identify causal effects, future analyses should be based on a larger sample. Moreover, future research should take into account which tasks are performed with the computer at work. Coping with different computer tasks and thus having different IT skills may have an unequal impact on the decision of older workers to retire. The level of IT skills of older workers is assumed to be strongly influenced by participation in IT training activities. In the next chapter I will follow up on the question of whether firm-provided IT training for older workers is accompanied by a higher proportion of this group of workers within firms.

3 IT Training and Employment of Older Workers Within Firms

The empirical analyses of the previous chapter show that the probability of using a computer at work is lower for the oldest age group of full-time workers compared to those who are 25 to 34 years old. However, further results do not provide evidence that there is a difference in the probability of remaining employed full-time between older computer users and nonusers. Maybe it is not just the use of computers itself that is important. The employment effect of using a computer at work may depend on the total extent of IT use within the firm. That has not been considered in the analyses so far, as there is no information on this available in the SOEP data.

This chapter makes an empirical analysis of the relationship between the participation of older workers in firm-provided IT training and the proportion of older workers employed by the firm, while taking into account the IT intensity of firms. Thus, this chapter studies age-specific aspects of the digital divide at firm level. It thereby sheds some light on an important part of training activities of firms as IT skills have become essential in so many workplaces. IT training could narrow the digital divide between younger and older workers regarding their use of new technologies. However, it can itself be part of the digital divide if younger workers receive employer-provided IT training more often or at a higher level than older workers. The analyses are made on the basis of firm data from the ZEW ICT survey.

The extent of IT use within firms is shown by an indicator of the firms' IT intensity. This indicator comprises various IT items, such as several IT applications executed by the firm as well as its IT costs. It plays a crucial role in the following analyses as it is closely related to the firms' propensity to provide IT training and its propensity to employ older workers.

Various studies deal with the relationship between IT use within firms and the age structure of their workforce, for example Bartel and Sicherman (1993), Bellmann and Leber (2004), and Beckmann (2007). Other authors study the impact of on-the-job training activities on the individual job stability, for example Büchel and Pannenberg (2004) as well as Fitzenberger and Prey (1999). However, to my knowledge none of these or further studies specifically concentrate on firm-provided *IT training*, particularly with regard to older workers, and its relationship with the firms' proportion of older workers. This is the contribution of this chapter's study.

The results of my analyses show that: i) firms with a larger IT intensity employ a smaller proportion of older workers than those firms that are less IT-intensive. ii) Firms with a higher participation rate of older workers in employer-provided IT training employ a larger proportion of older workers three years after the training program, compared to firms with a lower IT training participation of older workers. iii) However, the marginal employment gain of increasing the proportion of trained older workers declines with the rate of IT training participation of older workers. iv) The positive impact of a larger proportion of older workers participating in IT training activities on the firms' proportion of older workers is higher in firms that intensively use IT compared to firms with a lower IT intensity.

This chapter proceeds as follows: the next section provides an overview of some theoretical and empirical literature regarding the decision of firms to provide training as well as regarding the impact of job-related training on the job stability of trained workers. Section 3.2 describes the data used for the analyses and specifies the composition of the IT intensity variable. The focus of section 3.3 is on the derivation of the hypotheses. Having described the estimation strategy in section 3.4, section 3.5 presents the empirical results regarding the relationship between the proportion of older workers receiving IT training and the proportion of older workers employed by the firms. It additionally analyzes the determinants of a firm's decision to provide IT training at all. Section 3.6 gives a short summary of chapter 3.

3.1 Theoretical and Empirical Background

Generally, firms want to provide training and further qualification if their employees either do not have the appropriate skills or a skill level that is too low, or if they cannot get the human capital they need by hiring new workers. However, following the human capital approach of Becker (1962) where the decision to provide training is made by calculating and comparing the overall costs and benefits of the training investment, firms will invest in *firm specific* training only. The main reason is that *general* training could be used in other firms too, and there is a risk that the trained workers will move to another firm. If this happens the firm that provides training cannot get all of the benefits from the training investment, but has to bear all of the costs. That possibility reduces the incentive for a firm to invest in its employees' general skills. The investment for general training has to be borne by the workers themselves.

However, as is stated for example by Stevens (1996) and by Gerlach and Jirjahn (1998) this result holds in perfect labor markets only, where there is full information regarding the skill level of workers and the wages paid by different firms, and where workers can move without restrictions between firms. In general, however, labor markets are not perfect. These imperfections can make general skills specific. For example, certain skills could be useful in many firms, but only a small number of these firms may be located in a certain region (Stevens, 1996). In such a case firms have an incentive to invest in general human capital as the probability that a trained worker stays with the firm is non-zero and firms do not only bear the costs of training but can also expect positive benefits (Stevens, 1996). A positive probability of remaining with the firm arises, for example, from mobility restrictions and from workers' uncertainties regarding the outcome of their prospective labor search process as well as regarding additional transaction costs (Hashimoto, 1981). Moreover, Acemoglu and Pischke (1999) show that the possibility of compressing the wage structure, that is reducing the wages of skilled workers relative to wages of unskilled workers, encourages firms to provide general training and to pay for it. The reason is that due to the compressed wage structure, highly qualified workers are paid below their marginal product and therefore bear part of the training costs. Thus, imperfections could indeed lead to firms' investments in general training.

In light of these thoughts, Stevens (1996) defines a supplemental form of training – *transferable training* – because not all kinds of training can be described by the theoretical tools of *general* or *specific*. *Transferable* training is defined as "training for skills which are of potential value to at least one other firm in addition to the training firm, without any assumption about the nature of the labor market" (Stevens, 1996, p. 26). Purely general and purely specific training then are the extreme cases. If the training a worker receives is transferable but not completely general, the training firm and the worker will share the investment costs. Both have an incentive to bear part of the costs as they expect positive benefits from the training activity.[1] Thus, the wage profile of the worker rises after the training but remains below his value of the marginal product in his firm (Stevens, 1996). Applying the Coase Theorem, Hashimoto (1981) concludes that the optimal cost share largely depends on the post-training transaction costs that both parties face. However, as Stevens (1996) elaborates, part of the expected economies of training are obtained by

[1]This result can be assumed for older workers too, as the training decision may induce older workers to postpone retirement.

an alternative firm as there is the possibility that the worker will move to that firm after the training. This uncertainty at the time the investment decision is made, the so-called *poaching externality*, may result in under-investment of transferable skills.[2]

The participation in employer-provided training aims at increasing a worker's firm-specific skills, thereby increasing his productivity and employability. The positive effect of training activities on the probability of staying with the firm is demonstrated, for example, by Christensen (2001) using the German SOEP data for the years 1984 to 1999. For West German employees the author not only detects a significant reduction in the risk of being laid off after participation in occupational training, he also shows that training reduces the individual probability of resigning from a job. A significantly positive impact of job-related training on the stability of individual employment is also discovered by Fitzenberger and Prey (1999), using data from the West German SOEP of the period 1984 to 1997. In addition, they find that the positive effect seems to increase with the duration of the training program. Hübler (1998) also shows positive effects of firm-provided training on the job stability of trained workers for East Germany. He uses eight waves from the specific East German data set "Arbeitsmarkt-Monitor" for the years 1990 to 1994. However, Büchel and Pannenberg (2004) say that for East Germany the empirical findings regarding the relationship between training and employment stability vary between the data sets used and the econometric specifications applied by the different studies.

Several studies find that older workers participate less in training activities than their younger colleagues. Using German data, Büchel and Pannenberg (2004) estimate a significantly lower probability of participating in firm-provided training for workers aged between 45 and 64 years compared to younger workers. According to Larwood, Ruben, Popoff, and Judson (1997) older workers represent a quadruple challenge regarding their retraining activities: firstly, older workers are in greater need of retraining because their original training is less recent compared to their younger colleagues. Secondly, older workers are often believed by their employers to have a lower performance and to be less flexible, less adaptable, and less interested in learning how to handle and work with new technologies. Thirdly, older workers differ in their ability to learn and to use new technologies.

[2]In the limiting cases of general and specific training the externality disappears. Purely *specific* training has no value to other firms. In the case of completely *general* training the trained worker gets a wage equal to his marginal product which reduces the expected return to the alternative firm to zero. See Stevens (1996).

Finally, older workers differ in their individual time horizon that remains until retirement, and therefore in the time where the benefits of the training can be achieved.[3]

As described in section 2.1.5.1, the *deficit model of aging* states that with increasing age older workers automatically become less productive, less able to work under pressure, less flexible, and less innovative. However, recent studies find evidence that older workers are not necessarily less but rather differently qualified than younger workers (Clemens et al., 2003). Pack et al. (1999) suppose that not age itself makes older workers less productive, but inappropriate working conditions. The use of computers in the workplace can facilitate work tasks and can therefore help to maintain the physical strength of older workers.[4] This may reduce older workers' tendency to make use of options to retire early.

New technologies change very rapidly and as a result IT skills quickly become obsolete today. Therefore, the remaining time horizon until the statutory retirement age becomes less important (Bellmann and Leber, 2004). Older *and* younger workers need to be trained consistently. Provided that a certain basic level of IT skills exists, older workers are able to keep up with the young if they are involved in training activities early enough.

As in my analyses, Burgert (2006) focuses on the proportion of older workers in firms when studying the employment effects of on-the-job training. By using German data from the IAB establishment panel, the author was unable to find any evidence of a positive link between the decision of firms to finance training activities and the firms' proportion of older workers. The result remains unchanged for different observation periods and for different forms of training, such as internal or external training courses, attending lectures, performing self-determined learning, and so on. He even finds slightly significantly negative effects in some specifications. However, Burgert (2006) does not consider the *number* of employees participating in training activities. In addition, as he does not know who is participating, he cannot observe whether older workers receive training. In contrast to his study, my analysis specifically looks at the participation rate of *older workers* in

[3] Actually, Larwood et al. (1997) speak of a triple challenge by pooling together point three and four. However, I think each of both points is important and does not imply the same. They should therefore be examined separately.

[4] It can be argued that older workers do not need physical strength any longer when working with computers. However, there are workplaces where the computer cannot replace all tasks carried out manually, for example in the field of manufacturing or logistics. Secondly, a decrease of a worker's physical strength is in most cases accompanied by a productivity loss and frequent absence from work due to illness. Thus, employer and employee should aim at maintaining the physical strength of workers even when they work with computers.

firm-provided training and estimates its correlation with the proportion of older workers employed by the firm. Moreover it is *IT training* my study concentrates on.

The impact of IT training on the employment of older workers may depend on the intensity of IT use within the firm. Therefore, a multitude of IT applications as well as other IT-related variables indicating a firm's intensity of IT use will be considered in an indicator which is developed in the next section. Focusing on firms, several authors conclude that the introduction and usage of new technologies is biased against older workers. Empirically analyzing data from the ZEW ICT survey of the year 2002, Bertschek (2004) finds a negative correlation between the firm's proportion of employees predominantly working with a computer and the firm's percentage of older workers. Beckmann (2007) concludes that the technological change in German firms is age-biased as it noticeably leads to a reduction of the relative size of the older workforce, causing a shift in the age-structure within firms. His findings are in line with those of Aubert et al. (2006) who analyze French manufacturing firms. Concentrating on firms of the German state of Baden-Württemberg, Boockmann and Zwick (2004) find that the proportion of older workers is smaller in firms with an state-of-the-art technology compared to firms with prior technology. In addition, Wagner (2000) and Pack et al. (1999) state that older workers are often employed in those firm areas where they produce out-dated and out-phasing product lines. As a result, they are often not involved in the firm's innovation processes. This may also have a negative impact on the proportion of older workers because this kind of age separation reduces older workers' work motivation and increases their incentive to retire early.

The existence of a works council in the firm is expected to be positively related to the proportion of older workers. Firstly, works councils can help to impose restrictions on employers to lay off older workers (and substitute them with younger workers, for example). In addition, they can improve working conditions by requesting training activities. They have the right to influence the decision on the kind of training that is provided by the employer and on the recipients of training, especially if there is a risk that specific groups of workers, for example the older ones, are excluded from those activities (Bellmann and Ellguth, 2006). The dismissal restrictions and the improved training possibilities are assumed to improve the work motivation of older employees and to provide incentives to postpone retirement. Bertschek (2004) finds that having a works council is positively associated with a firm's proportion of older workers. This result is supported by the findings of Boockmann and Zwick (2004). The empirical study of the relationship between the existence of a works council and the employment of older workers is also part of my analyses.

3.2 Data

3.2.1 ZEW ICT Survey

The data used for the empirical analyses stems from two waves of the ZEW ICT survey, a representative business survey carried out by the Centre for European Economic Research (ZEW) in Mannheim. In the years 2004 and 2007 (waves three and four of the survey) around 4,400 firms belonging to the manufacturing sector or to selected service industries were interviewed. The aim of the ICT survey is to analyze the diffusion of information and communication technologies on the level of firms, as well as to study the effects of ICT adoption on employment, productivity, and the success of businesses in Germany.

In addition to the large number of IT questions included in every wave of the ICT survey, the wave of 2004 also includes several questions regarding older workers, that is workers aged 50 years or above. The data generates information on the proportion of older workers employed by the firm (based on the previous year 2003), for example, or the participation of older workers in IT training (in 2003). This provides the possibility of analyzing the factors that affect the employment of older workers in detail.

Table 3.1 provides an overview of the employment of older workers and the participation of workers in IT training in Germany and within the sample. Projecting the ICT survey data onto all firms in Germany belonging to the analyzed sectors reveals that only slightly more than 80 percent of all firms employ workers aged 50 years or above in 2006. The proportion of older workers within the firms is 20 percent on average. The proportions are larger in East Germany than in West Germany: in the eastern part 86 percent of all firms employ at least one older worker in 2006. The proportion of older workers is 24 percent on average. In the western part of Germany 79 percent of the firms employ older workers in 2006, and the overall proportion of older workers within firms is 20 percent. In 2003, older workers participate in IT training in only 15 percent of the German firms, while younger workers did in 41 percent of the firms. On average, a proportion of 9 percent of the older workers participate in IT training, while the proportion is 12 percent for workers aged less than 50 years.

The following analyses are limited to those firms that participated in the ICT survey in both years, 2004 and 2007. In addition, only firms that provided information about their use of ICT, about the proportion of older workers, and about the participation rate of older workers in within-firm IT training are kept in the data set. The net sample used for the empirical analyses then consists of 1,035 firms.

Table 3.1: Older workers and IT training in firms

	Germany	**sample**
proportion of firms employing older workers in 2006	.81	.90
East Germany	.86	.91
West Germany	.79	.89
proportion of older workers within firms in 2006	.20	.21
East Germany	.24	.25
West Germany	.20	.20
proportion of firms providing IT training for older workers in 2003	.15	.29
participation rate of older workers in IT training in 2003	.09	.10
prop. of firms providing IT training for younger workers in 2003	.41	.59
participation rate of younger workers in IT training in 2003	.12	.13

Notes: Figures for Germany are projected values. The sample is taken from the ZEW ICT survey. Sample size: 1,035 firms. Older workers are those aged 50 years or above. Younger workers are those who are less than 50 years old.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

Within the sample, 90 percent of the firms employ at least one older worker in 2006. Thus, compared to the projected values, the sample includes relatively more firms that employ older workers. While the projected values indicate a difference in the proportion of firms employing older workers between East and West Germany, the values in the sample are almost the same. The firms' proportion of workers aged 50 years or above is on average 21 percent in 2006. The value is higher in East Germany (25 percent) than in West Germany (20 percent). These percentages are close to the projected values. In 2003, the proportion of firms with older workers is 88 percent in the sample. 7 percent of the sample firms do not employ older workers either in 2003 or in 2006 (not shown in the table).

Table 3.1 also shows that in 29 percent of all firms belonging to the sample older workers participate in IT training activities in the year 2003. The proportion of older workers who receive firm-provided training is 10 percent. If only those firms that provide IT training for older workers are considered, 34 percent of the workers aged 50 years or above receive IT training on average in 2003 (not shown in the table).

The proportion of firms that train their younger workers (those who are less than 50 years old) in IT use is 59 percent and is therefore much larger than the proportion of firms providing training for older employees. All in all, the firms train 13 percent of their younger workers. However, if only those firms that provide IT training for the young are considered, a proportion of 22 percent of younger workers takes part in IT training activities (not shown in the table).

The data suggests that the higher total participation rate of young workers is a result of more firms providing training for them. While nearly 90 percent of the firms in the sample employ older workers, less than a third provide training for older workers at all. But those firms that train their older workers evince a participation rate of older workers in the training courses of more than a third.

Compared to the projected values, there are more firms in the sample that provide training to their younger and older workers at all. However, the proportions of workers that participate in IT training are almost the same.

3.2.2 Measuring IT Intensity

One determinant that is expected to influence the proportion of older workers is the extent of IT use within the firm. In the empirical part I use an IT intensity indicator which consists of several IT variables contained in the data set:[5]

- IT applications,
- proportion of employees predominantly working with a computer,
- IT costs per employee,
- open source software for the operating system of computers,
- proportion of computers connected to a network,
- own homepage,
- process innovation.

Before I explain the strategy I use to aggregate these variables, I specify the variables in detail. The first category comprises several IT applications that could be executed by the firm, such as buying and selling products and services via the Internet (e-commerce), performing online marketing, or using customer relationship management software.[6] The

[5] The IT intensity indicator is created according to Beckmann (2007) who generates an indicator representing technological change. Beckmann (2007) thereby refers to Bresnahan et al. (2002) who construct a workplace organization measure consisting of several variables.

[6] The nine applications taken into account are in detail: selling products and services via the Internet (b2b or b2c e-commerce), buying products and services from suppliers via the Internet, performing online marketing, using an electronic data interchange system, using engineering and controlling software, customer relationship management software, supply chain management software, and performing e-learning.

IT application variables are measured by three dummy variables for each application. The first dummy gets the value one if the specific application is 'not used' by the firm, the second dummy represents 'sporadic use', and the third 'wide use'.

Secondly, the IT intensity indicator includes a quantitative measure of IT use: the proportion of employees predominantly working with a computer. A larger proportion of computer users indicates a higher IT intensity.

IT-intensive firms are assumed to face higher IT costs because they use state-of-the-art and advanced hard- and software which often require higher investment costs.[7] Furthermore these firms need specialized personnel in order to administrate and service their IT equipment. Thus, the IT indicator additionally contains the firms' IT costs per employee including all expenditures related to IT components (hard- and software) and IT specialized staff. As IT expenditures also include costs for IT services that are sourced out, firms are also defined to be IT-intensive if they procure a lot of their IT services externally. It is assumed that IT use is nevertheless high within the firm and is supported by the outsourced services. IT costs per employee are grouped into six categories and are included in the IT intensity indicator.[8]

Some of the advanced IT technologies themselves can be considered when generating the IT intensity variable. As, for example, the use of open source software for the operating system of computers requires specific and advanced IT skills, it indicates a greater IT intensity.[9] The proportion of computers connected to a network as well as whether the firm maintains its own homepage are additionally included in the IT intensity variable. A firm is assumed to be a more advanced IT adopter if it maintains its own homepage and more of its computers are connected to a network. While the latter is measured in percent, maintaining a homepage as well as using open source software are represented by dummy variables taking the value one if this is done by the firm, and the value zero otherwise.

The IT intensity indicator also comprises a dummy variable that is given the value one if the firm underwent some process innovation activities in the year 2003. Process innovations

[7] Although IT prices have been declining in previous years on average, advanced technologies are still expensive, especially when they are adopted very early.

[8] The categories of IT costs per employee (in Euro) are: less than 200; 200 to < 555; 555 to $< 1,621$; 1,621 to $< 4,000$; 4,000 to $< 10,000$; 10,000 or more (corresponding to the 10th, 25th, 50th, 75th, and 90th percentile).

[9] In the case of open source software the skill aspect is more important than the cost aspect with regard to IT intensity. Open source software can often be used free of charge.

are used in order to restructure business processes and improve business performance. They are largely based on the use of information technologies. Thus, process innovations indicate a higher IT intensity.

As these aforementioned IT variables are highly correlated, considering them separately as explanatory variables in one estimation could lead to a collinearity bias in the estimation results. Therefore, these variables are pooled in an IT intensity indicator. The indicator variable is generated according to Bresnahan et al. (2002). As the considered IT variables are not equally scaled, each IT variable is standardized in a first step by calculating

$$STD(x_k) = \frac{x_k - \bar{x_k}}{\sigma_{x_k}}, \tag{3.1}$$

where $\bar{x_k}$ is the sample mean and σ_{x_k} the sample standard deviation of the k-th IT variable x. The IT intensity indicator is then calculated by adding up the standardized IT variables and standardizing the result once again:

$$\text{IT intensity} = STD(\sum(STD(x_k))). \tag{3.2}$$

The result is a variable that has zero mean and unity variance. It is independent of the scale level of the original IT variables.

Further variables included in the estimations as controls are described in section 3.4, where the estimation strategy is explained. An overview of the variables is given in the descriptive Tables B.1 and B.2 in the appendix B.

3.3 Hypotheses

The focus of this part of my dissertation is on the propensity of firms to employ older workers depending on the amount of firm-provided IT training available to older workers. The analyses regarding that relationship can be described by a two-period model. In period one, firms decide whether to provide IT training for older workers at all, and, if yes, how many workers may participate. From the data of the ZEW ICT survey it is not clear whether the participation in IT training is voluntary.[10] It is assumed here that

[10] One might argue that the participation is voluntary if the proportion of older workers participating in IT training is not hundred percent. However, those workers who do not participate in the year of observation could have been forced to participate in that training course the year before. In addition, if the firms know the skill level of their employees they will not provide those older workers with a training for the skills they already have.

older workers themselves can choose whether or not to participate in the training activity provided by their employer in period one.

Given the number of older workers participating in IT training in period one, firms decide by period two whether to keep their older workers, to lay off some or all of them, or to employ more older workers. Of course, this decision depends not only on the skill level of the older workers but is also related to many other worker- and firm-related factors as well as to the labor market situation. Furthermore, it is not only the firm that determines its own proportion of older workers. It is also older workers employed by the firm in period one that choose whether to stay with the firm. And those older workers who were not employed by the firm in period one can decide by period two whether to apply for a job there. The decision the workers then have to make is related to many individual or firm-related factors and of course also to their labor market situation. But their decision depends not least on the prospect of receiving IT training within the firm. Especially if a firm is IT-intensive one can assume that older workers will have a higher incentive to apply for a job if the firm provides IT training for all or at least for their older employees.

Using data from the ZEW ICT survey of the year 2002, Bertschek (2004) finds a negative correlation between the firm's proportion of employees predominantly working with a computer and the firm's percentage of older workers. Having an intranet is also negatively correlated with the percentage of older workers. The other IT tasks examined, such as using engineering and controlling software or using databases, have insignificant coefficients.[11] However, this could be the result of multicollinearity between the IT task variables which increases the variance of the estimators.[12] In order to take the multicollinearity into account it is econometrically advantageous to develop an IT intensity indicator that comprises several IT tasks as described in the previous section. Given the results of Bertschek (2004) as well as the empirical considerations of Beckmann (2007) and Aubert et al. (2006) regarding the age-biased technological change, my first hypothesis is:

H1: Firms with a larger IT intensity employ a smaller proportion of older workers.

[11] The IT variables included in the ZEW ICT survey data vary slightly over the waves. For example in 2002, no questions were asked about the use of open source software. Moreover, in 2002 questions concerning the proportion of trained workers are only asked with regard to all workers, not specifically with regard to older workers.

[12] By estimating additional specifications, each with only one of the IT task variables, Bertschek (2004) indeed finds a negative and significant relationship between the IT task variables and the proportion of older workers.

Trained workers are of higher value to the employer and therefore face a lower probability of being laid off. In addition, training participation can increase older workers' motivation to work hard and to postpone retirement. This is especially assumed for IT training as new technologies are extensively used in nearly every economic area today. Older workers trained in IT use have more employment possibilities within the firm and are less likely to become segregated. Moreover, a firm offering IT training for workers of all age groups, not only for the young, becomes attractive for skilled workers of every age group.[13] All these factors can increase a firm's probability of employing older workers. My second hypothesis therefore is:

H2: Firms with a larger proportion of older workers participating in employer-provided IT training in 2003 exhibit a larger proportion of older workers three years later compared to firms with little or no IT training for older workers.

Larwood et al. (1997) state that although it might readily be agreed that especially those workers with a low skill level need retraining, they do not have the highest probability of participating in training activities. Training requires an effort, and this effort is higher for workers with a lower base level of skills. Thus, the incentive to participate in further training is highest for those who have already obtained a certain skill level. Older workers receiving IT training become familiar with using new technologies and have a higher probability of participating in further IT training. Thus, a higher IT intensity is less harmful for people who participate in training. Therefore, hypothesis three is:

H3: The participation of older workers in firm-provided IT training reduces the negative impact of a firm's IT intensity on the proportion of older workers employed by the firm.

Conceivably, the effect of IT training on the proportion of older workers might differ between IT-intensive firms and less IT-intensive firms, because in IT-intensive firms it is much more important to receive IT skills and to keep these skills up-to-date. This provides the fourth hypothesis to be analyzed:

H4: The positive impact of the participation rate of older workers in IT training activities on the proportion of older workers employed by the firm is higher in firms that intensively use IT compared to firms with a lower IT intensity.

[13] A firm which provides training may of course also become attractive for *un*skilled workers who are interested in training activities, but these workers are of less interest to the firm.

3.4 Estimation Strategy

Following Bertschek (2004), the determinants of the proportion of older workers employed by the firm are analyzed econometrically by using the *fractional response model*. This quasi-maximum likelihood estimation method was developed by Papke and Wooldridge (1996) for analyzing fractional response variables bounded between zero and one. Papke and Wooldridge (1996) as well as Wagner (2001) describe the shortcomings of several alternative estimation approaches when analyzing such variables, especially for data where there is the possibility of observing the boundary values. A short overview of that is given in the following in order to motivate the adoption of the fractional response approach for my analyses.

3.4.1 Alternative Estimation Approaches

Papke and Wooldridge (1996) analyze employee participation rates in voluntary pension plans in the U.S., Wagner (2001) studies the relationship between firm size and the export/sales ratio in German manufacturing establishments. In both studies, the boundary values of zero and one hundred percent can possibly be observed for the dependent variable. Thus, given that the dependent variable y varies between zero and one and X denotes a vector of all explanatory variables, the authors state that modelling the standard linear model

$$E(y|X) = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k = X\beta \tag{3.3}$$

rarely exhibits a good description of $E(y|X)$. Since the true model is in general non-linear, estimating the linear model (3.3) by OLS is inconsistent in the presence of boundary values. Papke and Wooldridge (1996) point out that the linear model could be augmented with non-linear functions of the explanatory variables. However, that modification will not eliminate the risk that the predicted values of the dependent variable lie outside the zero/one interval.

An alternative to the OLS approach is modelling the log-odds ratio as a linear function, described by

$$E(log\left[\frac{y}{1-y}\right]|X) = X\beta, \tag{3.4}$$

where again the dependent variable y varies between zero and one and X describes a vector of explanatory variables. However, a large problem with using log-odds ratios is that if y

takes the value zero or one, the equation (3.4) is mathematically not well-defined. Thus, adjustments must be made before computing the log-odds ratio, for example by adding an arbitrary small constant to all observations. However, this will arbitrarily change the distribution of the dependent variable (Wagner, 2001).

Another possible solution is the so-called TOBIT approach which is a censored regression model widely used for bounded outcome variables. However, in the literature it is a controversial issue whether this approach is appropriate for a situation where the endogenous variable is bounded to zero as a result of individual choice and not because of non-observability. Maddala (1991) states that one should differentiate between these two possibilities. In the TOBIT model, the latent outcome variable y^* can be less than the boundary value c, but these values cannot be observed because of censoring. Then, negative values of y^* are substituted by zero (if $c = 0$). In contrast, following Maddala (1991) the zero values often arise simply by individual choice, not because of censoring and substituting negative values. In Maddala's opinion the TOBIT approach is not appropriate in these cases. On the other hand, Wooldridge (2002) describes the application of the TOBIT approach also in the case of corner solution outcomes, where y can be zero with positive probability but is a continuous random variable over strictly positive values.

Assuming a particular distribution for y given X and estimating the parameters of the conditional distribution by maximum likelihood is another possible approach for analyzing a bounded outcome variable (Papke and Wooldridge, 1996). Initially Papke and Wooldridge (1996) suggest the beta distribution where the data is limited to the interval between zero and one. However, this approach also faces limitations as it is a continuous distribution and assumes that the probability of the dependent variable taking a certain value is zero. This means that the extreme values zero and one cannot be justified by the beta distribution. Thus, in data sets where there are many observations of y with a value of zero or a value of one, this approach is inappropriate.

3.4.2 Fractional Response Model

The data set I use in this part of my dissertation comprises firms which do not have older workers and firms with a positive proportion of older workers, with a maximum value of one hundred percent. Thus, the outcome variable is a fractional response variable, defined on a closed interval [0,1]. Given the shortcomings of the alternative models described above, I use the quasi-maximum likelihood estimation procedure (QMLE), the so-called *fractional response model*, for my analyses, which was developed by Papke and Wooldridge (1996). The authors use a non-linear function $G(.)$ for estimating the expected values of the dependent variable y_i conditional on a vector of covariates X_i. The model can be written as

$$E(y_i|X_i) = G(X_i\beta), \tag{3.5}$$

where in my case y_i is the proportion of older workers employed by the firm i in 2006. The chosen $G(.)$ is a cumulative distribution function satisfying $0 < G(.) < 1$. This ensures that the predicted values of y_i lie in the interval between zero and one (ibid.).

Following Papke and Wooldridge (1996) the multinomial logistic function

$$E(y_i|X_i) = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}} \tag{3.6}$$

is applied for $G(.)$. As suggested by the authors I assume a Bernoulli distribution for y_i and maximize the following binary choice log-likelihood function using QMLE:

$$l_i(\beta) = y_i log[G(X_i\beta)] + (1 - y_i) log[1 - G(X_i\beta)]. \tag{3.7}$$

Papke and Wooldridge (1996) show that the obtained quasi-maximum likelihood estimator, $\hat{\beta}$, is consistent and $\sqrt{N}$-asymptotically normal distributed regardless of the distribution of y_i conditional on X_i.

The parameter vector β measures the impact of the considered covariates X_i on the proportion of older workers. While the dependent variable stems from the ICT survey wave 2007, the covariates come from the data set of 2004. The most important covariates in my analyses are the firm's IT intensity and the proportion of older workers who receive IT training within the firm. The composition of the IT intensity variable is explained in detail in section 3.2.2. The participation rate of older workers in IT training is measured in percent (and divided by 100).

Further determinants considered in the estimations are size, age, and industry of the firm, the existence of a works council, the firm's expectations regarding the development of turnover between 2003 and 2004, the proportion of employees with a university degree, the proportion of employees working part-time, and the region (East or West Germany). The firm size is measured by five categories of the number of employees in 2003. The age of the firm is considered as a dummy variable having the value one if the firm is less than seven years old and having the value zero if the firm age is seven years or more. This threshold is chosen in order to differentiate between young and old firms. As done by Bertschek (2004), I make the assumption that firms having survived for seven years can be regarded as established. Long-established firms should be shown to have larger proportions of older workers, as start-up firms probably tend to employ younger workers rather than older ones (Boockmann and Zwick, 2004). The existence of a works council is presented by a dummy variable that has the value one if the firm has a works council and the value zero otherwise.

The expectation regarding the turnover development between 2003 and 2004 is measured by three dummy variables. The first takes the value one if a decline in turnover is expected. The second becomes one if the turnover is expected to remain unchanged. And the third dummy variable takes the value one if the employer expects an increase in turnover. The industry the firm belongs to is measured by 14 industry dummies.

To complete this section, some remarks address the problem of endogeneity. According to Zwick (2005), an 'unobserved heterogeneity bias' can occur if firms which provide IT training for their older workers structurally differ from those that do not provide it, due to firm-specific unobserved factors such as the firm's management quality, the activity of the personnel department, or the motivation of the workforce. Zwick (2005) uses panel estimation techniques to correct for this kind of endogeneity problem. A 'selectivity bias' could be the result of random transitory shocks that affect the proportion of older workers employed by the firm *and* the decision of employers to provide IT training (ibid.). Such external shocks can be, for example, a deterioration of market conditions, changes in retirement regulations, or the introduction of unspecific subsidies for employers with regard to older workers. In addition, the possibility of 'reversed causality' has to be kept in mind. In general, an instrumental variables approach is applied in order to deal with such problems. Unfortunately, as the IV approach has not yet been implemented within the fractional response model framework I had to abandon this procedure.

Part of the endogeneity problem is taken into account in my analyses by measuring the employment effect of IT training after three years. In addition to this time lag, the assumption that a worker's decision to participate in IT training is voluntary helps to identify the causal effect. However, some endogeneity issues remain. Thus, the estimated parameters should be cautiously interpreted.

3.5 Empirical Results

3.5.1 Determinants of IT Training

Before empirically analyzing the differences in the proportion of older workers I provide some insight into what factors drive a firm's probability of offering IT training. In the ZEW ICT survey, the kind of IT training provided by the firm is not specified. Thus it is assumed that the skills acquired by participating in firm-provided IT training are transferable as defined by Stevens (1996).[14] This gives older workers the possibility of using their IT skills when they move to another employer. Following the thoughts provided above, at least part of the costs would be borne by the firm if it decides to invest in training. Several firm characteristics affect the (potential) training costs of firms and therefore their decision whether to invest in training or not.

Using the ZEW ICT survey 2004, a firm's probability of providing IT training is measured by a binary variable that has the value one if a firm provides IT training to its employees and zero otherwise. I use a PROBIT model to estimate the coefficients.[15] The resulting marginal effects from the PROBIT estimations are presented in Table 3.2. Besides the factors considered in specification (1), such as firm size, firm age, and proportion of highly qualified employees, specification (2) additionally includes the IT intensity indicator.

The results largely support the expectations. They show that the size of the firm is highly correlated with the probability of providing IT training. Larger firms are significantly more likely to offer IT training compared to small firms with less than ten employees. One reason could be that larger firms are more likely to benefit from economies of scale (Gerlach and Jirjahn, 1998). They have the possibility of providing various training courses, as there are many workers who can participate. The costs per employee participating in a course can be expected to decline with an increasing number of participants. In addition, large firms often provide internal labor markets that can be assumed to have a positive effect on tenure (ibid.). Thus, Gerlach and Jirjahn (1998) state that it is useful to evaluate and adapt the skill level of the employees, as finding the optimal match of workers and positions within the firm should reduce the probability of workers leaving the firm after participating in training.

Firms in the 'banks and insurances', 'electronic processing/telecommunication', 'technical services', 'electrical engineering', and 'precision instruments' industries are significantly

[14] See section 3.1.

[15] A description of the PROBIT model is provided in section 2.3.1.

positively related to IT training compared to firms of the 'metal and machine construction' industry. They can be assumed to be IT-intensive industries where IT training is particularly needed.

Looking at specification (1), the proportion of employees with a university degree turns out to be significantly and positively correlated with a firm's decision to provide IT training. Although less qualified workers are in more need of training than highly qualified workers, the latter have a higher probability of participating in training activities, because their expected increase in productivity after training is higher than for the less skilled (Larwood et al., 1997). Wooden, Cully, and Curtain (2001) state that a higher education indicates that the individual possesses an aptitude for learning, thereby making training more cost effective. In addition, the adoption of new technologies as well as considerable innovation activities demand both highly skilled employees and training. Especially highly-developed IT equipment and IT tasks (factors that increase the IT intensity) make training necessary as they are often newly installed. Thus, a larger proportion of university graduates turns out to be positively correlated with the training supply of firms. However, the proportion of employees with a university degree becomes insignificant once IT intensity is examined (specification (2)). These two variables have a highly positive correlation.

As mentioned above, works councils are allowed to request training activities for the firm's workforce.[16] Moreover, they have the right to influence what kind of training is provided by the firm and who receives training (Bellmann and Ellguth, 2006). Thus, works councils may positively affect the decision of firms to provide IT training. However, this is not observable in the estimation results, as the coefficients do not significantly differ from zero.

Firms that are anticipating a positive development of their turnover are expected to have a higher probability of training their employees than firms with pessimistic turnover expectations. The former will need qualified employees in order to satisfy the increasing demand of their customers in the near future. The latter are more likely to save costs and thus to postpone or even cancel training. The estimation results do not support these expectations. The effects are not of significant size. The age of the firm and its regional affiliation do not show significant relations to the probability of providing IT training, either.

[16] See section 3.1.

Table 3.2: IT training of firms in 2003 – Probit results

dependent variable: probability of providing IT training		
variable (reference group)	**(1)**	**(2)**
firm size (ref.: less than 10 employees)		
10-49	.225 (.027)***	.189 (.028)***
50-249	.408 (.028)***	.356 (.033)***
250-499	.395 (.020)***	.370 (.026)***
500 or more	.417 (.016)***	.400 (.020)***
firm age <7 years (ref: 7 or more years)	-.041 (.042)	-.063 (.041)
proportion of employees with a university degree	.215 (.064)***	.054 (.064)
proportion of part-time employees	-.001 (.091)	.016 (.089)
expected turnover development^{i} (ref.: increase)		
reduction	-.029 (.036)	-.000 (.035)
unchanged	-.059 (.030)*	-.031 (.029)
east	-.030 (.031)	.014 (.030)
works council	.020 (.040)	.000 (.038)
industry (ref.: metal and machine construction)		
consumer goods	.014 (.056)	-.008 (.056)
chemical industry	.047 (.064)	.020 (.067)
other raw materials	-.014 (.059)	-.024 (.057)
electrical engineering	.132 (.059)**	.104 (.060)*
precision instruments	.107 (.050)**	.085 (.050)*
automobile manufacturing	.009 (.067)	.018 (.062)
wholesale trade	-.028 (.069)	-.084 (.068)
retail trade	.041 (.057)	.015 (.059)
transportation and postal services	.064 (.059)	.061 (.059)
banks and insurances	.242 (.047)***	.172 (.054)***
electronic processing/telecommunication	.263 (.044)***	.131 (.060)**
technical services	.176 (.052)***	.124 (.055)**
other business-related services	.085 (.056)	.035 (.056)
IT intensity^{ii}		.124 (.015)***
pseudo-R^2	.213	.257
number of observations	1,035	1,035

Notes: The table shows the average marginal effects. Robust standard errors in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.

^{i}) Expectation concerning the development of turnover in 2004 compared to 2003.

^{ii}) IT intensity is an indicator comprising several IT variables. See section 3.2.2 for details.

Source: Author's calculations based on ZEW ICT survey 2004.

As expected, IT intensity turns out to be a driving force regarding a firm's probability of providing IT training (specification (2)). However, the firm size and the above-mentioned industries show again significant coefficients. The correlation of these variables with the probability of providing IT training cannot be explained by IT intensity.

3.5.2 IT Training and Employment of Older Workers

The hypotheses developed in section 3.3 are econometrically analyzed in this section. The fractional response model is applied for the analyses and the results are shown in Table 3.3.

In accordance with hypothesis H1 the results clearly indicate a negative relationship between a firm's IT intensity and its proportion of older workers. This result holds while controlling for many other firm-related characteristics, such as firm size, firm age, or industry. As discussed before, these findings are in line with those of Beckmann (2007) and Bertschek (2004).

Providing older workers with IT training could be an appropriate means to reduce the negative impact of a high IT intensity because older workers can get to know how to use these new technolologies, and can become more productive and valuable to their employer. Indeed, the results of specification (2) and (3), where IT training variables are considered, show a positive effect of older workers' IT training on the propensity of firms to employ older workers. The results support hypothesis H2: the higher the participation rate of older workers in IT training the larger the proportion of older workers working in that firm three years later. However, as the quadratic term of IT training shows a significantly negative coefficient, the positive correlation between older workers' participation in IT training and the proportion of older workers declines with the rate of IT training participation of older workers. One possible explanation is that firms tend to train those workers first for which the highest productivity gain is expected. The marginal increase in productivity therefore declines with the proportion of trained older workers. Thus, a higher participation rate of older workers in IT training enhances the propensity of firms to employ older workers. But the employment gain of increasing the IT training participation rate by a small unit is higher in firms with a relatively small proportion of trained older workers compared to firms with a large proportion.

Considering older workers' IT training in specification (2) increases the absolute value of the IT intensity coefficient. Thus, in line with hypothesis H3, IT training helps to alleviate the negative effect of IT intensity.

Looking at the other control variables, the estimation results show that compared to firms with less than ten employees a higher firm size is accompanied by a significantly lower proportion of older workers. A negative relationship between the size of the firm and the proportion of older workers is also described by Bertschek (2004).

The results also show that firms which have a works council exhibit a larger proportion of older workers. This result is in line with the findings of Bertschek (2004) and Boockmann and Zwick (2004).

Firms expecting a reduction in turnover compared to the previous year employ a larger proportion of older workers three years later than firms expecting a rise in turnover. One explanation could be that in economically difficult times firms try to save costs and do not have the financial means to hire additional young workers. In addition, in his study regarding West Germany, Beckmann (2001) finds that firms that are forced to reduce staff tend to lay off younger workers rather than their older colleagues. This could be explained, for example, by higher protection from dismissal of older workers. Moreover, Beckmann (2001) states that the exchange of information could be another reason. Younger workers observe the unreliable behavior of the firm with regard to its older workers and may expect the same for themselves in the future. Possible consequences are a lack of motivation, a decreasing willingness to undergo training, and a higher fluctuation of employees (ibid.). In addition, the wage costs of the firm could increase if new workers call for higher wages as a kind of risk compensation (ibid.). Beckmann (2001) concludes that the anticipated damage to the firm's reputation may therefore lead to a higher incidence of laying off younger workers instead of older ones. This leads to a larger proportion of older workers if the staff is reduced as a consequence of expecting a decline in turnover.

A larger proportion of part-time workers accompanies a larger proportion of older workers. According to Beckmann (2001), this could be due to internal strategies of making working hours more flexible and thereby avoiding staff reduction.

Several studies show that in the eastern part of Germany the firms' proportion of older workers is significantly larger. This positive relationship can also be found in the results provided here.

Consistent with the findings of Bertschek (2004), the effect of the firm age dummy is not significantly different from zero. It therefore makes no difference to the proportion of older workers whether the firm has existed for less than seven years or is already long-established.

Table 3.3: Proportion of older workers employed by firms in 2006 – FRM results

dependent variable: proportion of older workers within firms			
variable (reference group)	**(1)**	**(2)**	**(3)**
firm size (ref.: less than 10 employees)			
10-49	-.134 (.100)	-.151 (.099)	-.152 (.100)
50-249	-.303 (.119)**	-.352 (.119)***	-.351 (.119)***
250-499	-.330 (.176)*	-.398 (.177)**	-.390 (.177)**
500 or more	-.222 (.162)	-.306 (.162)*	-.302 (.162)*
firm age <7 years (ref: 7 or more years)	-.162 (.105)	-.160 (.104)	-.164 (.104)
proportion of employees with a university degree	-.085 (.208)	-.117 (.208)	-.120 (.207)
proportion of part-time employees	.616 (.214)***	.619 (.212)***	.620 (.212)***
expected turnover development[i] **(ref.: increase)**			
reduction	.220 (.085)***	.224 (.085)***	.224 (.085)***
unchanged	.059 (.074)	.066 (.074)	.066 (.074)
east	.309 (.077)***	.296 (.077)***	.297 (.077)***
works council	.377 (.089)***	.369 (.088)***	.366 (.088)***
industry (ref.: metal and machine construction)			
consumer goods	-.262 (.145)*	-.271 (.144)*	-.277 (.144)*
chemical industry	-.161 (.167)	-.171 (.167)	-.169 (.167)
other raw materials	-.018 (.128)	-.029 (.128)	-.027 (.129)
electrical engineering	-.016 (.152)	-.040 (.151)	-.038 (.151)
precision instruments	-.273 (.124)**	-.281 (.124)**	-.283 (.125)**
automobile manufacturing	-.441 (.170)***	-.443 (.171)***	-.445 (.170)***
wholesale trade	-.172 (.146)	-.199 (.148)	-.199 (.148)
retail trade	-.218 (.153)	-.241 (.152)	-.247 (.152)
transportation and postal services	.320 (.138)**	.302 (.138)**	.296 (.138)**
banks and insurances	-.212 (.179)	-.256 (.182)	-.262 (.182)
electronic processing/telecommunication	-.209 (.187)	-.227 (.185)	-.247 (.185)
technical services	-.125 (.181)	-.135 (.178)	-.137 (.178)
other business-related services	-.110 (.161)	-.105 (.161)	-.108 (.160)
IT intensity[ii]	-.212 (.041)***	-.226 (.041)***	-.235 (.043)***
prop. of older workers participating in IT training		1.647 (.405)***	1.651 (.402)***
(prop. of older w. participating in IT training)^2		-1.669 (.463)***	-1.794 (.488)***
(IT intensity) x (prop. of older w. with IT training)			.170 (.147)
constant	-1.365 (.135)***	-1.372 (.134)***	-1.371 (.135)***
log pseudolikelihood	-382.742	-381.728	-381.650
number of observations	1,035	1,035	1,035

Notes: Fractional response model (FRM). Robust standard errors in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
[i]) Expectation concerning the development of turnover in 2004 compared to 2003.
[ii]) IT intensity is an indicator comprising several IT variables. See section 3.2.2 for details.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

The results of further specifications that include the participation rate of *all* workers in IT training show that it is not significantly related to the proportion of older workers (not shown in the table). This provides evidence that it is not IT training for all workers that is important for a firm's employment of older workers; instead, the crucial factor is the firm's supply of IT training for older workers in particular.

Specification (3) shown in Table 3.3 additionally includes an interaction term of IT intensity and the proportion of older workers receiving IT training. It captures whether the effect of older workers' IT training on the proportion of older workers is different for increasing values of IT intensity. The coefficient of the interaction term is positive but not significantly different from zero. To enhance the analysis of the differences between IT-intensive and less IT-intensive firms, however, I estimate the coefficients for two subsamples. The first group includes those firms intensively using IT with a value of IT intensity above zero (that is, above the mean). The second group consists of firms with a relatively low IT intensity (values less than or equal to zero).[17] 552 firms belong to the first subgroup, 483 to the second. The two subgroups are described in Tables B.3 to B.5 in the appendix. Among other things, the tables confirm that the mean proportion of older workers is lower in the IT-intensive subgroup (17 percent versus 25 percent).[18]

The estimation results for the two subgroups are provided in Table 3.4. The *fractional response model* is again applied. The results show that the IT intensity is significantly negatively correlated with the proportion of older workers only for IT-intensive firms. In addition, there are differences between the two subsamples regarding the correlations between older workers' IT training participation and the proportion of older workers. Within the group of IT-intensive firms, providing IT training for older workers in 2003 is crucial as it is associated with a significantly larger proportion of older workers in 2006. Again, the quadratic term of IT training for older workers has a significantly negative coefficient. Thus, the employment gain from increasing the trained proportion of older workers by one unit declines with the training intensity.

Contrary to the IT-intensive subgroup the IT training intensity of older workers does not have a significant influence on the proportion of older workers for those firms that use IT less intensively. This result supports hypothesis H4 stating that the positive impact of IT training participation of older workers on the firm's proportion of older workers is higher in firms that intensively use IT compared to firms with a lower IT intensity. Although

[17] The values of the IT intensity variable range between -2.74 and 3.01 with a mean of zero, see Table B.2 in the appendix as well as the description of the variable in section 3.2.2.

[18] The t-test on the equality of means shows that the difference is significant.

firms of the less IT-intensive subgroup employ larger proportions of older workers few of them provide these workers with IT training. In the data set there are only 76 in 483 (16 percent) less IT-intensive firms that arrange IT training for their older workers.[19]

Within both subgroups firms with a works council as well as firms that are located in East Germany exhibit a significantly larger proportion of older workers. While for the less IT-intensive firms the proportion of part-time employees is another significantly positive factor, this relation cannot be found for the IT-intensive firms. For the latter however, firm size and firm age are further important factors. This cannot be observed in the less IT-intensive subgroup.

When applying the logistic function to be the link function of the dependent variable within the fractional response model, it is assumed that this is the correct distribution function. In addition, it is assumed that all relevant variables are considered on the right hand side of the equation, and no variables are included that should not be in the model. I use Tukey's one-degree-of-freedom test for non-additivity, also known as *link test*, to find out whether these assumptions apply to my model (Tukey, 1949). Since the test turns out to be not significant for specification (2) and (3) shown in Table 3.3, I cannot reject the null hypothesis that the model is specified correctly.

[19]The proportion of IT-intensive firms that provide their older workers with IT training is 40 percent.

Table 3.4: Proportion of older workers employed by firms in 2006 – IT-intensive versus less IT-intensive firms, FRM results

dependent variable: proportion of older workers within firms		
variable (reference group)	**IT-intensive firms**^{ii}	**less IT-intensive firms**^{ii}
firm size (ref.: less than 10 employees)		
10-49	-.273 (.157)*	-.101 (.126)
50-249	-.583 (.172)***	-.242 (.172)
250-499	-.460 (.220)**	-.516 (.328)
500 or more	-.397 (.213)*	-.417 (.249)*
firm age <7 years (ref: 7 or more years)	-.387 (.130)***	-.034 (.153)
proportion of employees with a university degree	-.371 (.229)	.462 (.354)
proportion of part-time employees	.227 (.366)	.897 (.276)***
expected turnover development^{i} **(ref.: increase)**		
reduction	.277 (.111)**	.208 (.126)*
unchanged	.107 (.094)	.008 (.111)
east	.252 (.111)**	.293 (.107)***
works council	.342 (.108)***	.342 (.140)**
industry (ref.: metal and machine construction)		
consumer goods	-.092 (.198)	-.311 (.197)
chemical industry	-.086 (.257)	-.257 (.215)
other raw materials	-.094 (.191)	-.045 (.164)
electrical engineering	-.184 (.206)	.047 (.201)
precision instruments	-.229 (.192)	-.354 (.151)**
automobile manufacturing	-.297 (.218)	-.542 (.241)**
wholesale trade	-.166 (.216)	-.281 (.210)
retail trade	-.074 (.235)	-.293 (.192)
transportation and postal services	.037 (.207)	.480 (.173)***
banks and insurances	-.148 (.205)	-.552 (.426)
electronic processing/telecommunication	-.044 (.215)	-.840 (.303)***
technical services	.124 (.203)	-.707 (.319)**
other business-related services	-.283 (.231)	.098 (.202)
IT intensity^{ii}	-.332 (.098)***	-.059 (.083)
prop. of older workers participating in IT training	2.427 (.473)***	.381 (.777)
(prop. of older workers participating in IT train.)^2	-2.397 (.511)***	-.467 (1.046)
constant	-1.178 (.218)***	-1.271 (.182)***
log pseudolikelihood	-183.316	-194.916
number of observations	552	483

Notes: Fractional response model (FRM). Robust standard errors in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
^{i}) Expectation concerning the development of turnover in 2004 compared to 2003.
^{ii}) IT intensity is an indicator comprising several IT variables. IT-intensive firms are those firms with IT intensity greater than zero, less IT-intensive firms have an IT intensity of less than or equal to zero. See section 3.2.2 for details.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

3.6 Concluding Remarks

This chapter focuses on the relationship between firm-provided IT training and the firm's proportion of older workers. In Germany, the relative labor supply of older workers is increasing due to the shift in demographics. At the same time, the ongoing technological change is often supposed to be age-biased, thereby leading to a decreasing demand for older workers. Thus, labor supply and labor demand developments are moving in opposite directions (Beckmann, 2007). Providing older workers with IT training could be an appropriate means of reducing the negative impact of an extensive use of new information technologies in the workplace.

My empirical analyses are based on firm data from the ZEW ICT survey of the years 2004 and 2007. Applying the *fractional response model*, the estimation results clearly indicate that a higher IT intensity of firms accompanies a lower proportion of older workers. However, a higher participation rate of older workers in IT training is related to a larger proportion of older workers employed by the firm and alleviates the negative impact of IT intensity.

Further analyses of two subgroups of the sample show that while a higher IT training participation of older workers is positively related to the proportion of older workers in IT-intensive firms, this relationship is not observable for the less IT-intensive subgroup. Thus, providing older workers with IT training turns out to be particularly important in firms that extensively use IT.

Some final notes concern a few shortcomings of the data set used as well as some ideas for future research. Unfortunately, the data of the ZEW ICT survey does not provide more detailed information about the IT training activities. It does not indicate, for example, whether there are training courses specifically provided for older employees. Information about the content as well as the level of training would be useful. There may be a high training participation rate of older workers, but these workers are only given basic IT training, while the younger participants receive advanced IT courses. In addition, the frequency and the duration of the training program are not addressed in the survey. Such data could help to identify causal effects.

Future research should comprise in-depth analyses of endogeneity questions, such as 'unobserved firm-related heterogeneity' and 'selectivity bias' (see section 3.3). Part of the endogeneity problem is taken into account in my analyses due to the temporal structure of the data used. However, some endogeneity issues remain. Using panel data or linked employer-employee data could help to mitigate possible distortions.

4 Regional Aspects of the Digital Divide

While the focus of the previous two chapters was on age-specific differences in ICT use and the respective effects on employment, this part of my dissertation will concentrate on the additional differences in ICT use that are created by regional factors. The study thereby focuses on Internet adoption by individuals and regional proportions of users, but it does not consider patterns of use.[1] Whereas the previous two chapters deal with job-related ICT use, this chapter focuses on ICT use at home.

The Internet is an information and communication technology which has diffused rapidly in households throughout Germany in recent years. It has led to considerable changes in the living and working conditions of an increasing part of the population. However, not all population groups participate similarly in the diffusion process. In the year 2001, which will be one of the years of observation within this chapter's empirical analyses, 37 percent of the population in Germany (aged 14 years and above) was online (at home or at work) (TNS Infratest, 2007a). Thus, the majority had not yet adopted the Internet. Although the proportion of Internet users increased to 60 percent by 2007, the diffusion of this technology has by no means reached all parts of the population (ibid.). Individual characteristics, such as education, age, and income can create large Internet access barriers. In addition, regional characteristics, such as the existing ICT infrastructure and price structure can determine the individual access probability. These differences in accessing and using the Internet are facets of the digital divide.

Rural regions tend to be economically lagging behind urban areas as industrial and labor markets are concentrated in densely populated regions (Malecki, 2003). People living in rural areas have to overcome long distances to most markets and face limited access to consumer goods, labor, information and other resources. Against the background of this *rural penalty* the use of information and communication technologies, especially the Internet, provides various possibilities to reduce the associated disadvantages (Hudson and Parker, 1990). The Internet can encourage rural development by reducing or even eliminating the difficulties of distance. Besides providing various opportunities for firms that are located

[1] Analyses with regard to patterns of use include, for example, what the Internet is used for or how often and for how many hours per week it is used.

in rural areas, the Internet offers, for instance, convenient shopping opportunities and a broader product mix to consumers. It provides the possibility of distance learning and it can facilitate job search activities by providing access to information, advice services, and job search networks, as described by McQuaid, Lindsay, and Greig (2004). Communication with family members and friends is an additional important motive of using the Internet. However, in spite of these possibilities and advantages the diffusion of the Internet is much slower in rural regions than in city areas, which potentially hampers economic development in rural areas and increases the gap in economic well-being between rural and urban areas.

In order to reduce the existing divides it is crucial to identify the driving forces behind that development. The analyses of this part of my dissertation contribute to the empirical research on the various dimensions of the digital divide. They study the determinants of home Internet use in Germany on the level of counties as well as on the level of individuals by merging two large data sets. At individual level the study focuses on *network effects*, that is the impact of the local proportion of experienced Internet users on the access probability of individuals, as many empirical studies underline the importance of such effects.

The results at regional level show that regions with higher rates of highly educated employees and students exhibit a higher proportion of Internet users, which again provides evidence for the important role of education with regard to the use of new technologies.[2] A higher unemployment rate and a higher proportion of foreigners is accompanied by a lower proportion of local Internet use. At individual level, the decision to become a new Internet user is strongly influenced by individual characteristics. In line with previous research results, individuals who are more highly educated, younger, and wealthier are more likely to access the Internet. On the other hand, being female or being a foreigner is accompanied by a lower access probability. The results regarding the positive impact of the local proportion of experienced Internet users who live around hitherto non-users underline the importance of network effects for the individual adoption decision. This could be a result of learning spillovers, for example. The population density turns out to play a minor role. However, if East and West Germany are studied separately, the results show that living in a rural area in East Germany strongly reduces the probability of accessing the Internet compared to individuals living in East German city regions. This effect cannot be found for West Germany. Large differences in the Internet infrastructure between rural and urban areas in East Germany are likely to be a reason for this result.

[2] The particular importance of education was also found in the previous chapters.

This chapter proceeds as follows: the next section provides firstly a theoretical description of the Internet diffusion process. Secondly, it provides an overview of some theoretical and empirical literature regarding the individual and regional differences in ICT adoption as well as the role of network effects. In addition, studies that deal with the consequences of the digital divide are presented. Section 4.2 describes the two data sets used for the analyses and specifies how the sample is created. The derived hypotheses, the estimation strategy as well as the results of the empirical analyses at regional level are provided in section 4.3. The focus of section 4.4 is on the individual level. This section also comprises the hypotheses, the estimation strategy, and the empirical results. Section 4.5 gives a short summary of chapter 4.

4.1 Background Discussion

4.1.1 The Process of Internet Adoption

The diffusion process of the Internet technology can be analyzed by applying general diffusion models of innovations. The adoption rate of an innovation can be defined as "the relative speed with which an innovation is adopted by members of a social system" (Rogers, 2003, p. 221). Focusing on Internet technology, it can be measured as the number of individuals who become new Internet users within a specific period. Rogers (2003) elaborates on five important perceived attributes of innovations that determine the speed of technology adoption: relative advantage, compatibility, complexity, trialability, and observability.[3]

The first attribute, *relative advantage*, measures the extent to which the new technology is of greater value to adopters than the previous technology. The advantage could be expressed in an economic, social, or technical dimension. Which dimension is most significant and how great the relative advantage is, is not only determined by the innovation itself but also depends on individual characteristics of the potential adopter. The greater the relative advantage of the new technology, the higher the probability of adoption. As described by Greenstein and Prince (2006), the Internet exhibits a multitude of relative advantages, for example in communication, purchasing, and information gathering: emails are written and sent faster than postal mail, purchases can be made without driving to every single store, and nearly unlimited information is just a few clicks away.

[3] The following descriptions of the attributes are largely based on Rogers (2003).

The aspect of *compatibility* considers the experiences of a potential adopter with a previous technology as well as the degree to which the new technology is able to meet his needs. As described by Rogers (2003), the previous practice with the old technology helps to reduce uncertainty as it facilitates the evaluation of the new technology. For example, experience in using a typewriter can facilitate using a computer keyboard. In addition, the Internet has been adopted relatively quickly since it meets the needs for faster communication and easier consumption opportunities. It is also possible that a potential adopter may not recognize his need for a specific new technology unless he becomes aware of this innovation and realizes its usefulness. Internet content has been increasing sharply in recent years. This has created new consumer demands, but the new content has also provided new possibilities which are compatible with the existing needs. The adoption rate of a new technology is positively related to the perceived compatibility.

Although *complexity* is supposed to be less important than relative advantages or compatibility, it can work as a barrier to adoption in some cases. In particular for the use of home computers or the Internet, complexity plays a crucial role. Computers have become much more user-friendly in recent years, which leads to a speed up of computer adoption in private households. As Internet use is largely based on the existence of a computer as well as on computer skills, the acceleration of computer adoption laid the foundations with regard to prospective Internet use.

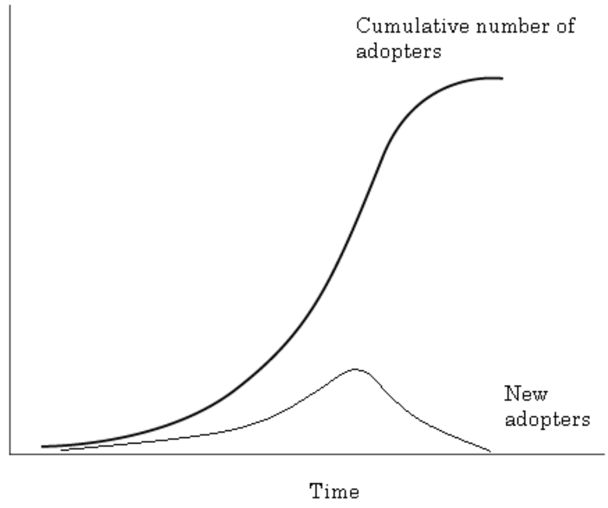
Especially for relatively early adopters of a new technology, *trialability* is important. Trialability measures the degree to which new users have the ability of experimenting with (parts of) the new technology. This possibility reduces uncertainty regarding its final implementation. Later adopters are often surrounded by peers who have already adopted the new technology. These peers can provide a kind of indirect personal trial when they share their experience with others. Thus, trialability is expected to play a minor role for late adopters as compared to early adopters.

Moreover, the speed of the adoption process is positively related to the *observability* of the innovation. Regarding Internet technology, the degree to which the use and its results are observable to others has been increasing in recent years, for example due to family members who are able to use the Internet or due to public rooms with Internet use, such as Internet cafés.

Rogers (2003) describes the typical distribution pattern for the general process of innovation adoption. When plotted over time the adoption rate can be expected to follow a normal, bell-shaped curve, which is accompanied by an S-shaped curve of the cumulative number of adopters, as shown in Figure 4.1. Greenstein and Prince (2006) state that the

Internet diffusion process follows similar patterns to those which can be observed for the adoption rate of other innovations.

Figure 4.1: Technology diffusion process



Source: Based on Rogers (2003).

As demonstrated by Rogers (2003), technology adopters can be categorized in five groups: innovators, early adopters, early majority, late majority, and laggards.[4] The distribution curve of Internet adoption rises gently first, when the small number of innovators and early adopters start using the Internet at the beginning of the diffusion process. These people can be characterized as "enthusiastic first users" (Greenstein and Prince, 2006, p. 2), being open-minded about new ideas and technically oriented. They have to cope with a high degree of uncertainty regarding the new technology.

The adoption rate increases when the early majority starts using the new technology. Their Internet adoption is more deliberate and the process of adoption takes more time than that of the early adopters. However, members of the early majority adopt the new technology just before the average member of the system. The early majority plays an important role in the diffusion process as it sharply increases the user network. It thereby provides interconnectedness and helps to further reduce uncertainty regarding the new technology.

[4]The following description of the categories is largely based on the specifications of Rogers (2003).

The distribution of Internet adoption reaches its peak when half of the individuals have adopted the new technology. After the peak the adoption rate decelerates as fewer and fewer of the remaining individuals become new Internet users. The members of the so-called late majority do not adopt until most other individuals are already using the new technology. They are more sceptical and cautious when approaching new technologies. But, as a result of economic necessities and increasing peer pressure they slowly begin to join the Internet diffusion process.

The last adopters of a new technology are characterized as being very traditional and nearly isolated in a social system. They tend to interact primarily with those other individuals who have similar traditional and sceptical attitudes towards new ideas. As their resources are scarce they need a lot of certainty that a new technology will not fail before they decide to adopt it. Moreover, as the price of most innovations decreases during the diffusion process, late adopters can benefit from lower prices.

A lot of individual characteristics are related to the innovativeness of individuals and determine to which adoption category a person belongs. The following section describes several socio-economic factors that influence the probability of Internet adoption.

4.1.2 Heterogeneity of Potential Internet Adopters

The demand for Internet connectivity depends on the individual utility of using this new technology. Thus, individual preferences as well as perceptions regarding the possibilities of the Internet play an important role in the decision to become an Internet user. In addition, technical and financial resources determine the individual start-up costs and price sensitivity. All these factors interact with several demographic and social characteristics, such as age, education, skill level, occupation, and income.

Research in various countries confirms that individual characteristics can generate differences in the timing of adoption. An international comparative analysis of the OECD in 2001 based on national statistics of OECD countries shows that Internet access and use is more frequent for individuals and households with a higher income and a higher level of education (OECD/DSTI, 2001). The authors conclude that policies should aim at improving Internet literacy by expanding the related skill base in educational institutions and vocational training programs. Analyzing the online population in the U.S., Lenhart (2003) reaches similar conclusions with survey data from 2002.

Research results obtained for Germany resemble those mentioned above. Using German SOEP data from the years 1997, 2001, and 2003, the empirical analyses of Korupp and

Szydlik (2005) indicate a positive impact of educational background and income on home Internet use. Additionally they show that being a young adult as well as being male significantly increases the Internet use probability. A recent study of Korupp et al. (2006) based on a special SOEP ICT survey supports the negative impact of age and the positive impact of education on the probability of using ICT.

The results of Jäckel, Lenz, and Zillien (2005) confirm the crucial role of education analyzing German data from 2003. An important reason for this finding may be that as computers and the Internet were introduced first in academic and research institutions, highly educated people grew accustomed to these new technologies earlier than others. The important role of universities in the process of Internet diffusion is analyzed by Goldfarb (2006). He provides evidence that in the mid-1990s universities in the U.S. intensely taught students how to use the Internet and that "these students then brought the technology into their homes" (ibid., p. 203).

As connecting to the Internet depends heavily on using a computer, factors influencing computer adoption also affect Internet adoption to a large extent. Several studies analyze the determinants of computer use. Most of them find that a higher education and a higher income are positively related to computer adoption.[5]

4.1.3 Regional Differences in the Use of New Technologies

The geographical diffusion of the Internet is primarily determined by both the decision of individuals to adopt the Internet and the decision of firms to supply Internet connectivity in a specific region. On the demand side, the individual adoption decision largely depends on the individual willingness to pay for the new technology. On the supply side, firms will only enter a market if it is profitable.

The innovation attributes mentioned above, which influence the demand for the new technology to a great extent, can be assumed not to be equally distributed geographically. In particular, differences between rural and urban areas are observable. For example, the Internet can provide a higher *relative advantage* for people living in rural areas than for those in cities, as better and faster communication channels or easier consumption possibilities are of higher value for those living in remote areas (Greenstein and Prince, 2006). Thus, the demand for Internet access is large in remote areas.

However, although it could provide a substantial return on investment to the economy as a whole, as stated by Parker (2000), there is little supply of Internet infrastructure in

[5]See, for example, Prince (2008), Borghans and ter Weel (2002), and Haisken-DeNew et al. (2000).

rural regions because the return on investment for each potential supplying firm is often too small to justify the investment. In addition to the barriers created by large distances and the low density of markets, *complexity* and *observability* may be big problems for people in rural regions, as these people do not have the variety of learning and observation possibilities which exist in cities. Moreover, higher unemployment rates in rural areas lead to lower income levels and less financial resources compared to cities.[6] This further reduces the incentives of firms to invest in Internet infrastructure and services in rural areas and thus further decreases the possibilities of adopting the Internet for the people living in these regions.

Providing related considerations, Sinai and Waldfogel (2004) state that the Internet may act as both a substitute and a complement for cities. The substitute function originates from individuals using the Internet to overcome local isolation regarding communication and product availability. Local product variety is expected to be higher in larger markets. If the substitute function prevails, Internet use should be higher in rural areas. On the other hand, the Internet complements cities as it offers local websites containing local news and information. The amount of these sites grows with size and population density of the region. Besides, local sellers may provide special services or may offer additional products via the Internet. This is also part of the complement function as the density of sellers is much higher in city areas. Using data for the U.S., Sinai and Waldfogel (2004) conclude that both the substitute and the complement function are observable.

Sinai and Waldfogel (2004) additionally explain that the strength of these functions varies between population groups. For example, foreigners tend to use the Internet to overcome local isolation. In areas where many foreigners live, face-to-face communication as well as the exchange of information is much easier for them to perform. In addition, as the group of foreigners may have its own preferences, its size determines the amount of preferred products available on the local offline market. The larger the local foreign minority group the more foreign newspapers and shops exist, and the smaller are the benefits of using the Internet to get some information and to buy preferred products. Thus, for foreigners the substitution function prevails: the larger the foreigners' proportion, the less the Internet is needed for their online communication or shopping activities.

However, Sinai and Waldfogel (2004) provide evidence that the tendency to connect to the Internet is not affected by the size of the market. It seems that the complement and the

[6] In East Germany, rural regions exhibit the highest unemployment rates. In contrast, in West Germany rural areas have lower unemployment rates compared with city regions (OECD, 2007b).

substitute function offset each other. However, the authors do not account for regional variations in the supply of Internet connectivity.

Gaspar and Glaeser (1998) find that new information technologies and cities are rather complements than substitutes by stating that face-to-face contacts and electronic contacts are positively correlated. The authors suggest that new information technologies increase the number of contacts, as even long-distance collaboration involves occasional face-to-face activities. Thus, cities attract the Internet because a higher population density enables more and easier face-to-face contacts. However, the authors do not take a possible selection bias into account that is due to people with specific characteristics that self-select into cities.

Mills and Whitacre (2003) consider such household characteristics when explaining the large differences in Internet use between metropolitan and non-metropolitan areas in the U.S. They test the relative importance of household attributes versus region-based differences in analyzing the rural-urban digital divide. Their results suggest that nearly two thirds of the divide can be explained by differences in household characteristics like education (of household head) and income. One third stems from place-based characteristics, especially from network externalities.[7] Hindman (2000) also provides evidence that individual characteristics determine Internet use rather than the place of residence.

Besides individual characteristics Jäckel et al. (2005) consider the role of community size and analyze differences between German cities and rural areas in accessing and using the Internet. However, in their multivariate discriminant analysis the rural-urban impact on Internet use diminishes once education is taken into account.

In her analyses of Internet connectivity in rural regions of the U.S., Strover (2001) concludes that rural citizens are much less likely to connect. Competing telecommunication service providers are disproportionally clustered in urban areas. As a result, the Internet is provided at higher costs in rural regions. In addition, Strover (2001) argues that Internet connectivity is offered with fewer services and lower quality in these areas. Additional differences in infrastructure can emerge by a lower density of retailers supplying telecommunication goods and services in rural regions.

These considerations also hold for Germany. After the privatization of the German telecommunication market in the second half of the 1990s, new telecommunication service providers entered the market. This market opening led to a strong decline in access prices thereafter. However, remote areas also face higher prices and a lower network ca-

[7] See the next section for a discussion of network externalities.

pacity in Germany, and it is expected that for the time being this disadvantage will remain (Büllingen and Stamm, 2001).

The bivariate analyses of the (N)onliner-Atlas show that in 2002 the rural-urban divide with regard to the proportion of Internet users is much larger for East Germany than for West Germany (TNS Infratest, 2002). This finding will be considered in my analyses by adding separate estimations for the two parts of Germany.

At the beginning of the year 2001, broadband Internet connectivity was scarcely spread in Germany. Only a very small proportion of 4 percent of private user households in Germany used a broadband Internet connection (TNS Infratest, 2002). Thus, when explaining the underlying causes of the digital divide, differences in the availability and capacity of broadband Internet connections did not seem to be among the most important factors a few years ago.

4.1.4 The Importance of Network Effects

The importance of network effects in the technology diffusion process attracts more and more attention in the literature. Positive network effects arise if an individual's benefits of participating in a network increase with the size of the network (Goolsbee and Klenow, 2002).[8] Regarding the Internet these effects are obvious as a larger network increases the individual's communication possibilities (especially if family members or friends join the network) as well as the content that is available online. A survey of individuals carried out in 2005 shows that in Germany the majority of Internet users (75 percent) used the help of relatives and friends when learning how to use the Internet (Statistisches Bundesamt, 2006).

If one-time costs of joining a network or switching to another one exist, network effects are likely to cause inefficient outcomes (Goolsbee and Klenow, 2002). As a result, technology adoption can be too fast or too slow. For example, technology adoption may be too fast in the case of an inferior technology if too many people join this network (because it was available earlier, for example) instead of a superior one and they cannot move to the latter without any costs (ibid.). Thereby, the adoption of the superior technology may be too slow. As stated by Goolsbee and Klenow (2002), users and suppliers should take these

[8] Swann (2002) studies how the value of a network is related to its size. He concludes that the relationship between network size and individual utility is non-linear since it is unlikely that communication with every additional network user contributes the same value to a network participant. As the first members are assumed to provide the highest value, the individual utility increases less than proportionally with the size of the network.

network externalities and the resulting dynamics into account when making their decision to join and provide a network, respectively.

The term network effects also comprises social influence exerted by the user network that surrounds current non-users. Agarwal, Animesh, and Prasad (2005) state that the existence of such social networks can further increase the Internet adoption probability, for example due to learning from others or just due to pressure to conform. Learning from others is important as experienced users can teach a hitherto non-user how to use the Internet and what its benefits are. Rogers (2003) concludes that the diffusion of an interactive communication technology, such as the Internet, is characterized by a reciprocal interdependence: Early adopters influence late adopters by communicating their experience and knowledge. At the same time, late adopters have an impact on earlier adopters by directly increasing the network.

Agarwal et al. (2005) find evidence of the existence of such network effects. Thus, the authors conclude that an individual's decision to access the Internet is indeed influenced by the local number of users. The results of Mills and Whitacre (2003) also show that positive externalities exist because a higher regional density of Internet use is positively correlated with a household's probability of using the Internet.

The importance of network effects in the diffusion of ICT is studied in more detail by Goolsbee and Klenow (2002) focusing on the diffusion of home computers in the U.S. They find that households living in regions with a higher proportion of people that already own a computer are more likely to buy a first computer even if various individual characteristics are considered. By conducting a multitude of econometric tests, Goolsbee and Klenow (2002) show that the high network effect is robust as it cannot be explained by common unobserved traits or by the local economic environments of those living in the same region.

As explained by Goolsbee and Klenow (2002), models with network externalities and learning spillovers predict a steady increase in the adoption rate of new technologies when the level of cumulative adoption increases. The authors find evidence that the adoption rate is increasing with the size of the network across all analyzed ranges. This is in contrast to the basic theory of technology adoption provided in chapter 4.1.1 which predicts an S-shaped pattern of the diffusion curve.

4.1.5 The Digital Divide

Information technologies and telecommunication networks, especially the Internet, become increasingly important as more and more economic and social interactions are performed digitally. However, there are many differences in the use of new technologies between individuals, households, businesses, and geographic areas. These differences do not only comprise the opportunities to access information and communication technologies but include also their use for a wide variety of activities (OECD/DSTI, 2001). Thus, the digital divide has many facets. While the digital divide between geographic areas also refers to differences between countries, especially between industrialized and developing nations, I will focus on the national dimension.

Many economic research studies find evidence that the economies of counties, states, and countries benefit from investments in local telecommunication infrastructure (Parker, 2000). In particular for rural areas, the Internet provides many advantages as it can neutralize two major barriers to rural economic growth: the large distances and the lack of economies of scale due to smaller market size (ibid.). However, there are large differences in the geographic distribution of Internet use. Due to a lack in supply of fast, efficient, and inexpensive Internet infrastructure inhabitants of remote areas do not benefit from the possibilities the Internet offers. If Internet connectivity cannot be ensured in rural regions in the near future, rural areas will lose part of their attractiveness to (highly qualified and wealthy) individuals and businesses. Parker (2000) suggests that public programs should be launched which increase the financial incentives of firms to invest in the Internet infrastructure in remote regions.

Besides this regional digital divide due to a gap in infrastructure, many studies find evidence that there are large differences in the Internet use between members of different status groups. Earlier adopters of new technologies tend to be younger, more highly educated, and wealthier than those who adopt later.[9] According to Hindman (2000) the differences in Internet use between status groups are very likely to grow as most of the Internet content is designed for higher status groups. As a result, differences do not only exist with regard to the probability of accessing the Internet but also concerning the way it is used. Due to this digital divide the use of information technologies is expected to reinforce or increase existing social and economic inequalities between population groups.

Given the importance of network externalities and differences in household characteristics, Mills and Whitacre (2003) state that policies that are targeted solely at creating infrastructure and providing high-speed Internet access are not sufficient in order to close the digital gap. Goolsbee and Klenow (2002) underline the policy implications provided by network effects. Due to their impact the overall effect of public programs would be greater than their direct effects. Thus, the authors suggest that subsidies designed to close the

[9] See section 4.1.2.

digital divide should target those groups which are the most responsive to subsidies and those which confer the greatest externalities.

4.2 Data

The empirical analyses of this chapter are performed on the basis of two data sets: the SOEP, which provides detailed information on individuals, and INKAR[10], which comprises a wide range of official regional figures for Germany. With the combined data set various individual socio-economic as well as region-based characteristics can be considered when analyzing the inequalities in home Internet access between regions and individuals.

The SOEP is a representative longitudinal survey of private households.[11] For the analyses of this chapter the 2001 SOEP wave is considered. Besides other socio-economic variables it provides information on the individuals' computer and Internet use.[12] The 2001 SOEP wave covers more than 22,000 individuals aged 16 years or older. However, the SOEP data contains hardly any regional information which makes a second data set necessary to fill this gap.

The INKAR data set is provided by the German Federal Office for Building and Regional Planning[13] and contains a wide range of regional figures, for instance regarding the structure of population, employment, and industry, or levels of education, production and, wages.[14] Thus, INKAR does not only allow regions to be classified as rural or non-rural, but provides a much more detailed description of regions. The INKAR data is given for several regional levels. The county level which is used in the analyses of this chapter is the lowest aggregation level.[15] As most variables are given with a time lag, INKAR data sets of 2002 to 2005 are used. This provides information for the year 2001 used at regional level and for the year 2000 additionally used at individual level.[16] By merging the two data

[10]INKAR – Indikatoren und Karten zur Raumentwicklung (indicators and maps on land development).

[11]See section 2.2 for details.

[12]The related questions were: 'Do you use a computer and the Internet for activities not related to work? If yes, since when?' and 'Do you use a computer and the Internet at work or in your education? If yes, since when?'. Answers can be given separately for computer use and Internet use. Questions regarding ICT use are not included in every SOEP wave.

[13]Bundesamt für Bauwesen und Raumordnung – BBR.

[14]INKAR does not include information on ICT use and access.

[15]It is the level of the German "Kreise".

[16]As INKAR does not contain the required age structure figures for the year 2001, they are taken from an additional data set: 'Statistik regional 2003' provided by the Federal Statistical Office Germany.

sets, regional information can be assigned to individuals. At the individual level of the analyses, regional information can therefore be treated as a person-specific determinant.

Germany consists of 440 counties. Seven of these counties cannot be considered in the analyses since they do not match the SOEP data. Moreover, only counties that contain 20 or more observed SOEP individuals are considered. In addition, the sample only contains individuals aged between 16 and 64 and individuals who provided information regarding their Internet use. Thus the data set comprises 312 counties and 16,662 individuals.

4.3 The Regional Level

4.3.1 Hypotheses and Estimation Strategy

The analyses of the determinants of Internet use are carried out at regional and at individual level. At regional level, differences in the proportions of private Internet use between German counties are analyzed initially. The main research questions are: what are the regional characteristics that determine the degree of home Internet use in German counties? Can population density explain differences in Internet use between regions?

The information on individual Internet use given by the SOEP data has been aggregated by county. This leads to the respective regional proportion of Internet users in 2001, which represents the outcome variable of the econometric model. One of the main regional explanatory variables is a rural-urban indicator: the proportion of the population that lives in communities with less than 150 inhabitants per square kilometer, the so called *rurality*. It serves to assess the impact of population density on the proportion of Internet users. In recent papers it is often argued that technological differences, such as the availability and the quality of Internet connectivity, are one of the main reasons for differences in Internet use rates between rural areas and cities.[17] As mentioned above, this is also likely to hold for Germany, as remote areas faced higher prices and a lower network capacity even before the diffusion of broadband connectivity.

Sinai and Waldfogel (2004) state that due to the attainable benefits of using the Internet it may be both a substitute and a complement for cities.[18] Depending on which function outweighs the other, the relationship between population density and Internet use rates is

[17]See, for example, Strover (2001) and Greenstein and Prince (2006).

[18]See the discussion provided above.

positive or negative. Part of the rural-urban differences in Internet use caused by the Internet's complement or substitute properties could be explained by various region-specific characteristics, such as the regional size of minority groups like foreigners. Thus, the hypothesis is that the population density itself is not the crucial factor, but the regional size of specific population groups that have specific preferences regarding communication and consumption. Therefore, the significance of rurality is expected to decrease if additional regional factors are considered in the estimation approach. Further variables may be correlated with the proportions of Internet users and are therefore added in a further specification: the proportion of the population aged between 15 and 29, the size of the foreign population, the proportion of one-person households within all households, the proportion of employees in the county who are highly qualified, the proportion of students, the unemployment rate, and the mean disposable household income.[19]

The local proportion of young people is expected to be positively correlated with regional Internet use rates, as adolescents nowadays become familiar with ICT very early by using it in school, during their apprenticeship, or for communication as well as leisure activities among friends. They involve the use of a computer and the Internet within their families, thereby increasing the regional proportion of home Internet users.

Many studies find complementarities between skills and the use of new technologies, showing that educational level increases the probability of using a computer or the Internet at work.[20] By accumulating IT skills at work, highly qualified workers also become more likely to use computers and the Internet at home. Assuming that people work and live in the same county, a larger regional proportion of highly qualified employees is therefore expected to be accompanied by a higher rate of home Internet use.

As the availability of time and money – two important requirements for using the Internet – is often high in one-person households, a positive relationship of this factor with the county-wide proportion of Internet users should be observable.[21] Moreover, a higher mean disposable income should be positively correlated with the Internet use rate.

Unemployed people could highly benefit from using the Internet for their job search activities. But many studies ascertain that those people are less likely to own a computer at

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[19] Unfortunately, no data is available regarding the activities the Internet is used for or regarding the amount of region-specific websites. Sinai and Waldfogel (2004) use such data regarding local online content in order to evaluate the relationship between population density and Internet use more precisely.

[20] See footnote 19 in chapter 2.

[21] One-person households consist of those households where one person lives alone. However, this does not imply that the person is unmarried or single.

home and to have access to the Internet, presumably because of higher financial restrictions (McQuaid et al., 2004). Thus, the proportion of home Internet users is expected to be negatively correlated with the local proportion of unemployed persons.

Following the arguments of Sinai and Waldfogel (2004), foreigners tend to use the Internet to overcome local isolation. Thus, the larger the proportion of foreigners, the less the Internet is needed for their online communication or shopping activities. As a result, this Internet substitution function may intensify the anticipated negative impact of the proportion of the foreign population on the local proportion of Internet users, which can probably be explained by linguistic problems or shortcomings in education.

Part of the regional variation between German counties may be due to differences between East and West Germany with regard to population structure and economic conditions. This possibility will be considered in the estimation approach by including a dummy variable which takes the value one if a county belongs to West Germany and the value zero for East German counties.

Summarizing all these considerations, the hypotheses to be analyzed are: i) a greater rurality leads to a smaller regional proportion of home Internet users. ii) The impact of rurality declines when additional regional characteristics are considered. iii) The proportions of highly qualified employees, of young people, and of one-person households are positively correlated with the regional proportion of Internet users. iv) A higher unemployment rate and a larger proportion of foreigners in a county lead to a smaller proportion of Internet users. v) Differences between East and West German counties can explain part of the correlations.

The dependent variable of the econometric model, the county-wide proportion of home Internet users, is measured as a percentage. As the boundary values of zero and one hundred percent can possibly be observed, the hypotheses are tested by using the *fractional response model* as described in section 3.3.

4.3.2 Empirical Results

Tables C.1 and C.2 in the appendix provide an overview of the characteristics of the German counties in the sample. On average, the county-wide proportion of home Internet users is 33 percent in West Germany and 27 percent in East Germany in 2001. Large differences between the two parts of the country can be observed for the unemployment rate, the disposable household income, and the proportion of foreigners. The unemployment rate is much higher in the eastern part of the country (18 percent) than in the western

(8 percent). Disposable income and the proportion of foreigners are both lower in East Germany.

A comparison of rural, suburban, and urban counties shows that Internet use is significantly more prevalent in urban counties (34 percent) than in rural regions (26 percent).[22] The Internet use rate of suburban counties lies in between (31 percent). Moreover, compared with rural regions, urban counties have significantly larger proportions of highly qualified employees, one-person households, and foreigners, as well as a higher mean disposable household income per capita (Table C.2).

The results of the *fractional response model* estimations of the proportion of home Internet use in German counties are shown in Table 4.1.[23] The first specification includes rurality as the only explanatory variable. It shows the expected negative bivariate correlation with Internet use proportions indicating that counties with a larger proportion of persons living in rural areas show a lower Internet penetration compared to more densely populated regions.

As expected, the impact of rurality declines and even becomes insignificant when further regional characteristics are included in the estimation approach (specification (2)). The results show significantly positive correlations between the proportion of highly qualified employees as well as the proportion of students and the regional penetration rates of home Internet use. These findings support the hypothesis that human capital is an important factor for the technological diffusion process. The regional unemployment rate as well as the size of the foreign population show a significantly negative correlation with Internet penetration rates, which also supports the expectations.

The negative effect of the proportion of foreigners could be the result of shortcomings in education and income. Moreover, it can be intensified by a strong Internet substitute function regarding communication, information, and shopping activities of local minorities, as described above.

In contrast to the expectations, the proportion of young people has a highly significantly negative effect. Thus, the data on German counties does not provide evidence that young people encourage their families to use new technologies, although adolescents are very likely to use ICT. However, the analyzed year 2001 may be too early to observe the results of this transfer process already.

[22] For the definition of rural, suburban, and urban see section 4.4.1.

[23] The OLS approach was applied for comparison. It provides very similar results.

Table 4.1: Diffusion of home Internet use at county level in 2001 – FRM results

dependent variable: proportion of population with home Internet use			
regional characteristics	**(1)**	**(2)**	**(3)**
rurality[i]	-.658 (.134)***	-.264 (.201)	-.252 (.203)
prop. of population aged betw. 15 and 29		-7.355 (2.694)***	-6.709 (3.022)**
prop. of highly qualified employees		3.125 (1.353)**	3.622 (1.882)*
prop. of one-person households		.719 (.604)	.646 (.623)
prop. of students		2.832 (1.316)**	2.624 (1.419)*
unemployment rate		-3.295 (1.018)***	-2.807 (1.389)**
prop. of foreign population		-2.118 (.946)**	-2.379 (1.104)**
household income per capita (log)		-.217 (.371)	-.212 (.371)
west			.109 (.237)
constant	-.620 (.042)***	2.086 (2.894)	1.816 (2.940)
log pseudolikelihood	-132.794	-131.580	-131.572
number of observations	312	312	312

Notes: Fractional response model (FRM). ***, **, * indicate significance at the 1%, 5% and 10% level. Standard errors in parentheses.
[i]) Proportion of population in communities with a population density of less than 150 inhabitants per square kilometer.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2003.

Taking into account whether a county belongs to East or West Germany reduces some of the significant effects (specification (3)). However, those variables which were significant in specification (2) remain of significant size in specification (3), at least at the 10 percent level. The effect of the 'west' dummy variable itself turns out to be not significantly different from zero. Thus, differences in the population structure between East and West Germany cannot explain regional differences in the diffusion of home Internet use.

4.4 The Individual Level

4.4.1 Hypotheses and Estimation Strategy

At an individual level, differences in the probability of becoming a new Internet user are analyzed. Besides several individual demographic and employment-related characteristics, the rurality of the individual's home county and the local proportion of experienced Internet users are taken into account. The main questions are: which individual factors determine the probability of starting to use the Internet? Is the rurality of the home county an influencing factor? And what is the role of network effects when analyzing individual differences in Internet access?

Contrary to the regional level, where differences in the proportions of Internet users between counties are explored, the focus is now on the individual decision to *start* using the Internet. By exploiting the information on the duration of Internet use provided by the SOEP data from 2001, 'beginners' are defined as those individuals who declared that they had used the Internet at home since 2000 or 2001.[24]

The data set comprises 2,346 individuals who are new users, compared to 11,280 individuals who have not started to use the Internet so far. The remaining 3,036 individuals are those with a usage experience of more than one year. Thus, 17 percent of those individuals who had not used the Internet by 2000, connected to the Internet for the first time within the following two years. The proportion of new users differed only slightly between East and West Germany (16.9 percent compared to 17.3 percent). Since much less than half of the population used the Internet in the years between 1999 and 2001, the new users belong to the early majority group of users as defined by Rogers (2003).[25]

As the rurality variable used for my analysis at county level is not provided for the year 2000, a *county type* variable is used which categorizes the counties into 'urban', 'suburban', and 'rural'. The definition follows the basic county type classification of the BBR which distinguishes between 'urban agglomeration', 'urbanized areas', and 'rural areas'.[26]

The place of residence may have an additional impact on the individual Internet access decision induced by spillovers from experienced users, as described above. To account for such network effects, the regional proportion of experienced Internet users is considered in the estimation approach.

The hypotheses analyzed at individual level are: i) young and highly qualified individuals have a higher probability of starting home Internet use. ii) Individuals living in rural areas are less likely to become a home Internet user than individuals in urban areas. iii) There is

[24]The question concerning the duration of usage is addressed to users only. In order to increase the number of new users in the data set, not only one but two years are taken into account. Thus, new users of 2000 *and* 2001 are defined as 'beginners'.

[25]See section 4.1.1.

[26]These basic types of regional population structures are generated by taking into account a region's population density as well as the importance and function of the region's core. See Bundesamt für Bauwesen und Raumordnung BBR (2002) for details.

a positive network effect: in counties with large proportions of experienced Internet users non-using individuals have a higher probability of accessing the Internet for the first time.

The impact of individual and regional factors on the individual's decision to become a new Internet user is examined by including these variables in a PROBIT model of the form:

$$\begin{aligned} Pr(y_i = 1|X_i) &= \Phi(\alpha + \beta \cdot X_i + \gamma \cdot countytype_r + \delta \cdot west_r \\ &\quad + \lambda \cdot userrate_r + \varepsilon_{ri}) \end{aligned} \tag{4.1}$$

$$\text{with} \quad r = 1 \ldots k \quad \text{and} \quad i = 1 \ldots n,$$

where y_i is the dependent variable indicating whether an individual i connects to the Internet at home for the first time in the years 2000 or 2001 ($y_i = 1$) or not ($y_i = 0$). The coefficient vector β shows the effects of various individual observables X_i.[27] The coefficient γ describes the impact of the *county type* of the region r the individual lives in on the decision to connect. Whether living in West Germany is correlated with the decision to access the Internet is measured by the dummy variable *west* and its coefficient δ. The variable *userrate* indicates the regional proportion of experienced Internet users, that is individuals who stated that they have been using the Internet since 1999 or earlier. The size of the *userrate* effect on the probability of becoming a new user is measured by λ. The error term ε_{ri} covers unobservable individual and regional characteristics. Φ is the cumulative normal distribution function.

4.4.2 Empirical Results

Table C.3 in the appendix shows the average individual characteristics of new Internet users, non users, and experienced users. It shows that compared to non-users, new users are significantly younger, better educated, and richer. In addition, new users are significantly more likely to work in a full-time job and to be male, single, and German. Similarly, compared to new users, those individuals who have already been using the Internet for more than one year are better educated, richer, and more likely to work in a full-time job and to be male and single.

As can be seen in Table C.4 in the appendix, in rural regions there is a larger proportion of individuals not using the Internet and a lower proportion of experienced users compared to urban areas. The proportion of individuals accessing the Internet for the first time is

[27] The demographic characteristics are taken from the year 2001. For simplicity it is assumed that they are constant within the observation period 2000/2001.

also lower in rural areas (15.1 percent) than in suburban and urban regions (17.3 and 17.6 percent). Taking only the proportion of non-users into consideration, it turns out that the proportion of new users is significantly larger in urban areas (Table C.5). On average, 15 percent of non-users in rural counties start using the Internet in the years 2000 or 2001. In urban counties the proportion is 18 percent.

Thus, although in suburban and urban regions a higher proportion already uses the Internet compared to rural areas, the access rates of first time users are still higher. This indicates an increasing gap in the rate of Internet use between densely populated areas and rural regions in Germany.

The results of the PROBIT model, that estimates the individual's probability of becoming a new Internet user, are shown in Table 4.2.[28] The first specification examines how the county type affects the tendency to connect to the Internet without considering further control variables. It largely reflects possible regional differences in infrastructure. In addition, as described by Sinai and Waldfogel (2004), such population density figures (like the county type) can be interpreted as a measure of local offline product variety and information availability, as discussed above. Thus, they are useful for analyzing the substitute and complement functions of the Internet.

The results reveal that compared to city regions, individuals living in rural areas have a significantly lower probability of becoming new users. In line with the results at regional level, this denotes a predominant complementarity of the Internet to cities, caused for example by the number of websites offering local information. However, it could also be the result of differences in Internet infrastructure or price structure. In order to find out whether these differences in the access probability are an effect of population density itself or whether other determinants can explain this relationship, several individual factors are included in a further specification.

[28] All of the standard errors of regional determinants are corrected for the fact that they do not vary between individuals living in the same county. For later comparison with the results of the PROBIT-IV approach the estimated coefficients instead of marginal effects are shown in the table.

Table 4.2: Determinants of starting home Internet use in 2000 or 2001 – Probit results

dependent variable: probability of starting home Internet use				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
county type (ref.: urban)				
rural	-.117 (.053)**	-.155 (.053)***	-.093 (.057)	-.097 (.057)*
suburban	-.039 (.044)	-.071 (.044)	-.036 (.044)	-.037 (.044)
userrate[i]			.786 (.241)***	.807 (.243)***
west				-.035 (.039)
age in years (ref.: age less than 25)				
25-34		.239 (.059)***	.241 (.059)***	.236 (.060)***
35-44		-.186 (.046)***	-.186 (.046)***	-.187 (.046)***
45-54		-.443 (.053)***	-.446 (.054)***	-.449 (.054)***
55-64		-.792 (.061)***	-.800 (.061)***	-.802 (.061)***
male		.184 (.029)***	.190 (.029)***	.190 (.029)***
single		-.090 (.046)*	-.092 (.046)**	-.093 (.046)**
one-person household		.190 (.056)***	.164 (.056)***	.170 (.056)***
German nationality (ref: foreigner)		.500 (.071)***	.507 (.070)***	.498 (.070)***
education (ref.: university degree)				
lower secondary education or less		-.646 (.068)***	-.640 (.068)***	-.633 (.068)***
other vocational education		-.522 (.122)***	-.522 (.123)***	-.518 (.123)***
apprenticeship		-.560 (.062)***	-.557 (.062)***	-.551 (.061)***
specialized vocational school		-.436 (.067)***	-.429 (.067)***	-.425 (.067)***
technical/commercial college		-.365 (.090)***	-.357 (.090)***	-.353 (.090)***
civil servant college		-.314 (.108)***	-.326 (.108)***	-.317 (.108)***
polytechnic or college abroad[ii]		-.255 (.063)***	-.247 (.063)***	-.248 (.063)***
occup. status (ref.: employed full-time)				
employed part-time		.142 (.044)***	.137 (.044)***	.141 (.044)***
apprentice		-.055 (.077)	-.047 (.077)	-.047 (.077)
not employed		.009 (.040)	.008 (.040)	.009 (.040)
retired		-.228 (.071)***	-.227 (.071)***	-.226 (.071)***
log net income of household		.476 (.048)***	.461 (.048)***	.469 (.046)***
pseudo-R^2	.001	.093	.095	.095
number of observations	12,480	12,480	12,480	12,480

Notes: The table shows the estimated coefficients. Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
[i]) Proportion of Internet users with more than one year usage experience by county.
[ii]) College abroad: In the data it is not clear what kind of degree is meant.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

As can be seen by the results of specification (2) in Table 4.2, the county type effect remains significantly different from zero and even increases when including individual determinants. The effects of the individual characteristics largely show the expected signs: the probability of connecting to the Internet for the first time decreases with age but increases with the level of education as well as with the level of household income. Males are more likely to go online than females, German individuals are more likely to become new Internet users than foreign residents. In addition, part-time employees have a higher probability of starting to use the Internet at home than individuals working full-time. This may be an effect of the additional time that is available at home when individuals work part-time. Retired individuals have a significantly lower probability of accessing the Internet at home than those working full-time, a result that is also found in many other studies. Moreover, individuals who live alone are significantly more likely to connect to the Internet than individuals in multiple person households. Being single shows the opposite effect, but this is only weakly significant. The results indicate that individual characteristics are crucial when explaining the individual decision to become a new Internet user.

In order to examine the regional network effect, specification (3) additionally includes the regional proportion of experienced Internet users (*userrate*). The results support the hypothesis that the probability of becoming an Internet user increases with the size of the regional network even after considering the county type as well as various individual characteristics. The correlation is highly significant. On average, an increase in the proportion of experienced users by 10 percentage points increases the probability of accessing the Internet by 1.8 percent (not shown in the table). Moreover, considering the local proportion of experienced Internet users results in an insignificant county type effect. Thus, the effect of the user network strongly reduces the effect of the population density.

Specification (4) additionally controls for differences due to living in a West German county instead of an East German one, which turns out to be an insignificant factor. However, controlling for this regional difference slightly increases the absolute value of living in a rural county, which becomes significant at the 10 percent level. Thus, besides the positive impact of the local proportion of experienced Internet users, the individual decision to become a new Internet user is negatively affected by the population density, although the relationship is not strong. It is likely that this reflects rural-urban differences in Internet infrastructure.

Table 4.3: Determinants of starting home Internet use in 2000 or 2001 – East Germany, Probit results

dependent variable: probability of starting home Internet use			
variable (reference group)	**(1)**	**(2)**	**(3)**
county type (ref.: urban)			
rural	-.374 (.075)***	-.388 (.079)***	-.342 (.082)***
suburban	-.164 (.072)**	-.139 (.072)*	-.108 (.068)
userrate[i]			.486 (.303)
age in years (ref.: age less than 25)			
25-34		.274 (.110)**	.276 (.110)**
35-44		-.180 (.100)*	-.178 (.100)*
45-54		-.607 (.100)***	-.608 (.100)***
55-64		-.830 (.112)***	-.835 (.112)***
male		.116 (.045)***	.120 (.045)***
single		-.173 (.099)*	-.177 (.099)*
one-person household		.221 (.110)**	.202 (.112)*
German nationality (ref: foreigner)		-.010 (.190)	.018 (.192)
education (ref.: university degree)			
lower secondary education or less		-.643 (.135)***	-.642 (.134)***
other vocational education		-.900 (.243)***	-.906 (.243)***
apprenticeship		-.776 (.108)***	-.770 (.108)***
specialized vocational school		-.633 (.107)***	-.631 (.107)***
technical/commercial college		-.632 (.147)***	-.628 (.149)***
civil servant college		-.574 (.230)**	-.588 (.233)**
polytechnic or college abroad[ii]		-.220 (.098)**	-.213 (.097)**
occup. status (ref.: employed full-time)			
employed part-time		.037 (.087)	.040 (.088)
apprentice		-.193 (.123)	-.179 (.123)
not employed		.018 (.068)	.019 (.068)
retired		-.354 (.139)**	-.354 (.138)**
log net income of household		.461 (.111)***	.454 (.112)***
pseudo-R^2	.009	.115	.116
number of observations	3,590	3,590	3,590

Notes: The table shows the estimated coefficients. Standard errors (clustered at regional level) in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level.

[i]) Proportion of Internet users with more than one year usage experience by county.

[ii]) College abroad: In the data it is not clear what kind of degree is meant.

Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

Table 4.4: **Determinants of starting home Internet use in 2000 or 2001 – West Germany, Probit results**

dependent variable: probability of starting home Internet use			
variable (reference group)	**(1)**	**(2)**	**(3)**
county type (ref.: urban)			
rural	.035 (.059)	-.017 (.060)	.037 (.067)
suburban	.005 (.051)	-.046 (.052)	-.016 (.053)
userrate[i]			.862 (.303)***
age in years (ref.: age less than 25)			
25-34		.190 (.073)***	.188 (.073)***
35-44		-.208 (.051)***	-.210 (.052)***
45-54		-.402 (.062)***	-.408 (.062)***
55-64		-.809 (.075)***	-.818 (.075)***
male		.229 (.038)***	.235 (.038)***
single		-.058 (.051)	-.058 (.051)
one-person household		.176 (.068)***	.153 (.068)**
German nationality (ref: foreigner)		.486 (.074)***	.487 (.073)***
education (ref.: university degree)			
lower secondary education or less		-.623 (.080)***	-.611 (.081)***
other vocational education		-.350 (.148)**	-.343 (.148)**
apprenticeship		-.467 (.069)***	-.462 (.070)***
specialized vocational school		-.339 (.081)***	-.327 (.082)***
technical/commercial college		-.234 (.103)**	-.221 (.105)**
civil servant college		-.246 (.120)**	-.251 (.120)**
polytechnic or college abroad[ii]		-.307 (.082)***	-.304 (.083)***
occup. status (ref.: employed full-time)			
employed part-time		.181 (.052)***	.177 (.052)***
apprentice		.009 (.099)	.010 (.099)
not employed		.020 (.051)	.020 (.051)
retired		-.165 (.085)*	-.163 (.085)*
log net income of household		.488 (.048)***	.477 (.048)***
pseudo-R^2	.000	.092	.094
number of observations	8,890	8,890	8,890

Notes: The table shows the estimated coefficients. Standard errors (clustered at regional level) in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level.

[i]) Proportion of Internet users with more than one year usage experience by county.

[ii]) College abroad: In the data it is not clear what kind of degree is meant.

Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

The results of the previous estimations reveal that differences between East and West Germany cannot explain differences in the probability of becoming a new Internet user. However, there may be differences in the determinants if they are analyzed *within* both parts of the country. Therefore, the analyses are repeated separately for East and West Germany. The results are shown in Tables 4.3 and 4.4.

While the effects of the individual characteristics are quite similar for East and West Germany, the results clearly indicate differences in the impact of population density and network effects within the two parts of the country. In East Germany, individuals in rural and suburban regions are significantly less likely to become new Internet users compared with individuals in urban areas, even when individual characteristics are considered. Contrary to the results for Germany as a whole and for West Germany, the network effect is not significant. This result could be explained by large differences in the Internet infrastructure between East German cities and remote areas. As a result, differences in infrastructure can explain a good deal of the regional differences in the proportion of experienced users.

In West Germany, however, network effects turn out to be a crucial factor. The county type effects are not significantly different from zero. The differences in the county type effects between East and West Germany could have been expected from the differences in the proportions of new users between the county types shown in Table C.5 in the appendix.

4.4.3 Controlling for Selectivity Bias

When empirically analyzing local spillovers, two important difficulties need to be considered. Firstly, there may be a problem of unobserved individual variables, as for example people who have a greater affinity for technology may self-select into regions where many experienced users live (Goolsbee and Klenow, 2002). Secondly, people living in the same region face similar infrastructure conditions and price structures (Agarwal et al., 2005). These unobserved regional factors may influence both the individual and the group choice of accessing the Internet. The resulting correlation between individual choice and group choice could lead to a bias in the measured network effect.

Following the reasoning of Agarwal et al. (2005), one might be less worried about regional unobservables. Many regional variables, for example unobservable access barriers due to the infrastructure, can be assumed to be correlated with the county type of the region. As this factor is included in the estimation approach it will correct for a large part of the potential bias.

However, a potential simultaneity bias remains. A possible approach to consistently estimating the model with a binary dependent variable and a potential simultaneity bias is the *instrumental variables PROBIT* (IV-PROBIT) approach.[29] Similar to the model description in section 2.4.1.2, the idea is to find one or more observable variables (the instruments) that have an impact on the local proportion of experienced Internet users (the *userrate*) but are otherwise uncorrelated with the individual decision to access the Internet for the first time.

On average, people who have reached a higher level of education are more likely to use the Internet than less educated individuals. Thus, individuals living in areas with a larger proportion of highly educated individuals are more likely to be surrounded by Internet users. The local proportion of highly qualified employees is therefore included as an instrument in my IV estimation approach. Further instruments are the regional unemployment rate and the proportion of foreigners, which are assumed to be negatively correlated with the proportion of experienced users. Unemployed people are less likely to own a computer and to have access to the Internet due to tighter financial restrictions. As described above, the larger the local proportion of foreigners, the less the Internet is needed for their online communication or shopping activities. Thus, individuals living in areas with a higher proportion of foreigners may be surrounded by fewer Internet users. Moreover, the proportion of one-person households is used as an instrumental variable. It is assumed to be positively correlated with the local proportion of experienced Internet users because of a higher availability of time and money in one-person households. The mentioned regional characteristics are not expected to be correlated with the individual decision to start using the Internet.

The instruments are assumed to be plausible due to these considerations, but they also need to be empirically valid. An assessment of the validity is provided by the instruments' coefficients at the first stage of the instrumental variables approach. As mentioned above, valid instruments should be correlated with the local proportion of experienced Internet users. A Wald test of the null hypothesis that the estimated coefficients associated with the instruments are jointly equal to zero can clearly be rejected for all specifications, as the test statistics far exceed their critical values. In addition, nearly all instrumental variables have themselves a significant coefficient. Thus, the instruments are correlated with the first-stage outcome variable. This holds for the German sample as a whole, but also for the subsamples for East and West Germany. The results of the first-stage regressions are shown in the Tables C.6 and C.8 in the appendix.[30]

[29] See Wooldridge (2002) for the theory behind the model.

[30] The unemployment rate is not used as an instrument in the subsamples' regressions, because here it does not fulfill the criterions of being a valid instrument.

Table 4.5: Determinants of starting home Internet use in 2000 or 2001 – IV-Probit results, second-stage regressions

dependent variable: probability of starting home Internet use		
variable (reference group)	**(1)**	**(2)**
userrate^{i}	1.730 (.679)**	2.021 (.682)***
county type (ref.: urban)		
rural	-.018 (.078)	-.005 (.080)
suburban	.005 (.052)	.015 (.053)
west		-.063 (.042)
further covariates^{ii}	demographic and job-related characteristics	
constant	-1.766 (.158)***	-1.786 (.158)***
log pseudolikelihood	8672.861	8682.445
number of observations	12,480	12,480

Notes: Standard errors (clustered at regional level) in parentheses.
***, ** indicate significance at the 1% and 5% level.
Instruments for *userrate*: proportion of highly qualified employees, regional unemployment rate, proportion of foreigners, and proportion of one-person households.
^{i}) Proportion of Internet users with more than one year usage experience by county.
^{ii}) Further covariates are: male, single, one-person household, German nationality, education, log net income of household, occupational status. See Table C.7 in the appendix for all coefficients.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

The regional variables used as instruments will not be valid instruments if they are correlated with individual unobservables (Goolsbee and Klenow, 2002). But Goolsbee and Klenow (2002) argue that since individual observables are included in the regressions, any correlation between observables and unobservables should not bias the coefficient on *userrate* (at most the β coefficients of the observables). Following their illustration of the problem, one might argue that there is a positive correlation because, for example, people with a special interest in technology may predominantly live in cities with a larger proportion of highly educated people. However, the coefficient on individual educational level should absorb any correlation between technology affinity and the proportion of well-educated inhabitants. A correlation between the proportion of the highly educated population and technological affinity would mean that, given that the individual education is controlled for, an increase in the local proportion of well-educated people leads to a higher individual technology affinity. Such a relationship is not very plausible.

Table 4.6: Determinants of starting home Internet use in 2000 or 2001 – East and West Germany, IV-Probit results, second-stage regressions

dependent variable: probability of starting home Internet use		
variable (reference group)	**East**	**West**
userrate[i]	1.406 (.728)*	1.814 (.802)**
county type (ref.: urban)		
rural	-.248 (.119)**	.095 (.083)
suburban	-.052 (.093)	.018 (.059)
further covariates[ii]	demographic and job-related characteristics	
constant	-.973 (.265)***	-1.923 (.185)***
log pseudolikelihood	2916.646	6201.775
number of observations	3,590	8,890

Notes: Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
Instruments for *userrate*: proportion of highly qualified employees, proportion of foreigners, and proportion of one-person households.
[i]) Proportion of Internet users with more than one year usage experience by county.
[ii]) Further covariates are: male, single, one-person household, German nationality, education, log net income of household, occupational status. See Table C.9 in the appendix for all coefficients.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

The results of the IV-PROBIT estimations are shown in the Tables 4.5 and 4.6. The results are very similar to those of the PROBIT model without instruments and I therefore reach the same conclusions. Given the validity of the chosen instruments, endogeneity seems to be a minor problem. This assumption is supported by the results of the Wald test of exogeneity shown for every IV-PROBIT specification in the Tables C.7 and C.9 in the appendix. The null hypothesis of this test is that there is no endogeneity in the baseline equation. As the test is insignificant in all specifications (except for one), there is not sufficient information in the sample to reject the null hypothesis. Thus, the regular PROBIT approach may be appropriate.

4.5 Concluding Remarks

Although Internet use has spread rapidly in recent years in Germany, large discrepancies still exist between population groups regarding their Internet access. This so-called *digital divide* has many dimensions. Besides differences due to individual characteristics such as age, educational background, and income, there is also a regional gap in ICT use: rural regions show smaller Internet use rates than cities. In order to reduce the existing divides, it is crucial to understand the driving forces behind that development. The aim of this chapter is to analyze descriptively as well as econometrically the relationship between individual as well as regional characteristics and home Internet access.

At regional level, the results of the bivariate analyses support the hypothesis that a greater rurality is related to a lower Internet use rate. However, the correlation becomes insignificant if further regional characteristics are considered. Several county characteristics are identified that exhibit a high correlation with home Internet use rates. As expected, the proportion of highly qualified employees as well as the proportion of students have a positive impact on regional Internet use penetration. Regions with a higher unemployment rate and those with a larger size of foreign population exhibit a smaller proportion of Internet users.

At individual level, the results underline the importance of individual factors, such as education, age, and income for the decision to start Internet use. Furthermore, a positive network effect is observable for the German and the West German data set. Thus, the probability of becoming a new Internet user is higher for individuals that are surrounded by experienced users. Besides, living in a rural region remains important in the German data set and, in particular, in East Germany. This effect is assumed to capture differences in the Internet infrastructure as well as in retail and price structures. These differences seem to be more pronounced in East than in West Germany.

It can be concluded that especially in East Germany differences in the Internet infrastructure between rural and urban regions need to be reduced to increase the diffusion of Internet access. Moreover, policies aimed at decreasing the digital divide should provide programs which encourage the Internet literacy of less qualified, unemployed, and older individuals. Furthermore, due to the existence of network effects, experienced users should be involved in public programs in order to motivate non-users by teaching them how to use the Internet and by showing them its advantages.

5 Conclusion

Information and communication technologies are rapidly diffusing throughout the German labor market and society. However, not all population groups are participating equally in this diffusion process. Due to the increasing importance of IT skills, in particular with regard to information gathering and exchange, closing the digital divide has become one of the major political challenges.

This dissertation contributes to the research on the digital divide with regard to its dimensions and origins. The focus is on two important facets of the digital divide in Germany: age-specific and regional aspects. The results of my empirical analyses confirm that the use of new technologies is lower for older individuals. But they also show that providing older workers with IT training can significantly increase their employment chances. This effect is particularly marked in IT intensive firms which generally tend to employ less older workers.

Moreover, in line with the results of previous studies, I find lower rates of Internet use in rural regions compared with urban areas. This is accompanied by a lower probability of starting to use the Internet for people living in rural regions (especially in East Germany). Network effects turn out to be an important enhancing factor with regard to the individual probability of becoming an Internet user. That is, the higher the local proportion of experienced Internet users the higher the probability of current non-users adopting the Internet. This relation is likely to be caused by increased communication opportunities, broader local online content, and learning spillovers due to the larger network size.

My results show that older workers fall behind in using new technologies, which is likely to make them less employable. This is a growing problem in the light of the sustained demographic changes. In Germany, the labor market participation of people over fifty is of particular importance as the size of the older labor force increases in both relative and absolute terms, not least due to very low fertility rates. But still a great proportion of the over fifties is unemployed or makes use of the opportunity to retire early. Thus, their actual employment participation is low and the financial burden on the German social systems constantly grows.

In order to reduce this financial burden and reverse the tendency to economically and socially exclude older workers, they should be encouraged to remain in the labor force as long as possible. One strategy that would help encourage them to do so, as well as to increase their value on the labor market, is to ensure that older workers are provided with the necessary training opportunities to avoid skill obsolescence and increase employability (Wooden et al., 2001). This is particularly important with regard to the rapid introduction of ICT into many jobs as this requires a lot of new skills and competencies. The results of my dissertation support the view that IT training for older workers increases their employability and raises the firms' labor demand for older workers.

For several years researchers and politicians have been cautioning against the so-called "Fachkräftemangel" (shortage of skilled labor) in those business areas where highly qualified manpower is needed. Recent data from a survey conducted by BITKOM in 2007 evinces a number of at least 43,000 vacancies for qualified ICT employees in the German economy (BITKOM, 2007b). The "2007 Report on Germany's Technological Performance" concludes that by 2014 the labor demand for engineers and other academics will exceed the labor supply by 41,000 to 62,000 employees every year (Bundesministerium für Bildung und Forschung, 2007). An increased participation of older workers in IT training activities and employment is one possibility of counteracting the predicted shortage of skilled labor.

However, employers still tend to search for younger employees rather than for older ones and provide an insufficient amount of training for people over fifty. Employers therefore need to adjust their employment behavior. Several complementary human resources policy instruments can be implemented that help to enhance the employability and work motivation of older employees. Besides regular training activities, further strategies are: providing them career prospects, flexible working hours, and workplaces with less physical and mental stress (Buchhorn, Müller, and Werle, 2004). Instead of paying wages that automatically increase with the worker's age, firms could decide to pay wages that depend on the workers' productivity and responsibility (ibid.). In addition, a system of mentorships between young and old and learning partnerships can intensify skills transfer and communication within the workforce (Schemme, 2003). The aforementioned activities can enhance the employment prospects of older workers and can thereby also increase their incentive to invest in IT training as more time is left for them to amortize the training effort. Public policy programs should encourage employers to employ and train older workers and should also support people over fifty in learning how to use ICT and in postponing retirement. Below, I provide a short overview of current policy projects.

Several programs have been launched by the German government as well as by the European Commission in recent years that aim at reducing the barriers with regard to access and use of new technologies, thereby closing the digital divide. Corresponding commitments were expressed in the Riga Ministerial Declaration signed at the "ICT for an inclusive society" conference in 2006 (European Commission, 2006). They particularly include the reduction of deficits in ICT use and ICT skills of older people but also the considerable increase in broadband Internet coverage especially in rural regions.

To achieve these goals the European Commission will start a new campaign "eInclusion, be part of it!" this year (European Commission, 2007b). This campaign will build on and complement already existing programs.[1] Among the established programs is the action plan "Ageing Well in the Information Society" launched in 2007. It aims at offering older people the chance to live independently and actively. For this purpose it intends to remove technical and regulatory barriers that prevent people over fifty from using new technologies and also to stimulate research and development by the industry with regard to age appropriate products. A similar program came into force in 2005 which specifically targets the accessibility of ICT with regard to older and disabled people ("eAccessibility").

In Germany, the "iD2010" action program provides the framework for several initiatives and strategies of the Federal Government in the fields of ICT and new media. Created in 2006, it supports the "i2010" initiative of the EU at the national level. The program not only promotes the legislative and technical framework but also provides advice and support in the realms of education, research, and market-related developments (Bundesministerium für Wirtschaft und Technologie, 2006b). Continuing the process of digital integration of older people is thereby given a high degree of priority (ibid.).

Supported by the Federal Ministry of Education and Research the association BITKOM is going to launch a new project "IT 50plus" this year together with the IG Metall (union of the metal industry), which aims at counteracting the prospective shortage of skilled labor in Germany by increasing the employability of older skilled workers, enhancing their chances of being reemployed after a longer period of unemployment, and extending the IT training system (BITKOM/IG Metall, 2008). The program particularly addresses firms of the ICT sector and firms that intensely use ICT, but also personnel managers and staff specialized in ICT (ibid.). Younger ICT workers are also involved in the initiative to assure their employability in the long term.

[1] The concept "i2010 – A European Information Society for Growth and Employment" generates the strategic EU policy framework for this campaign and corresponding action plans. An overview is given on the "i2010" website of the European Commission (European Commission, 2007c).

The results of my dissertation show that older workers make less use of ICT than younger workers and that this is likely to hamper their employment chances. Thus, the aforementioned programs are important and should be advanced as they directly aim at reducing ICT access barriers and increasing the IT skills of people over fifty.

Further programs particularly concentrate on improving the employment situation of people over fifty, without focusing on ICT issues. The “Initiative 50plus” of the German Federal Ministry of Labor and Social Affairs was initiated in September 2005 and pools various activities of the Federal Government. The main goals of this initiative are: a significant increase in the employment rate of people aged 50 and above, enhanced reemployment opportunities for older unemployed persons by partially subsidizing their wages (*Kombilohn*), and an intensified participation of older workers in occupational training activities (Bundesministerium für Arbeit und Soziales, 2006). Other established programs will continue: framed by the “INQA” initiative (initiative new quality of work) various practical programs have been launched since 2002 which aim at assuring health and qualification in the workplace. Firms and public administrations are supported in designing modern and age appropriate workplaces (ibid.). Since 2005 the program “Perspektive 50plus” has been supporting a multitude of regional projects that aim at reintegrating older unemployed persons into employment. Region-specific strategies are intended to bring unemployed persons and potential employers together (ibid.). In 2008 the program will enter its second phase lasting until 2010. Thus, the German government is aware of the need for action to integrate the over fifties into the labor market. Not least the gradual increase of the statutory retirement age to 67 years, the reduction of options to retire early, and the rise in the actuarial adjustments for retirement before the statutory retirement age are steps in the right direction. As described in my dissertation, the relationship of employment prospects and ICT use is mutual. Thus, better employment chances can increase the incentive to postpone retirement and to learn how to use ICT and vice versa. The outlined projects directly aim at improving the employment situation of people over fifty and can thereby also provide the basis of enhancing their ICT use.

While many programs exist that aim at reducing the age-specific digital divide, less action has been implemented for diminishing the regional digital gaps. Most of the programs focus on equalizing the supply of broadband connectivity. On EU level, for example, initiatives were initiated within the EU framework “Bridging the Broadband Gap” to reduce differences in broadband supply between rural and urban regions (European Commission, 2007c). Moreover, research work in the field of ICT infrastructure is also part of the “7th EU Framework Programme of Research”. In Germany, the “Breitbandatlas” provided by the Federal Ministry of Economics and Technology since 2005 aims at detecting the gaps in broadband availability and bringing together supply and demand of broadband technology in order to close the gaps. The results of my dissertation provide evidence that infrastructure differences can explain part of the variation in individual Internet access. Thus, providing fast and inexpensive broadband Internet connectivity in all areas of the country is an important goal of public policy programs in Germany.

However, as individual characteristics play a major role in the probability of accessing the Internet, policies that aim at decreasing the digital divide should additionally provide programs which encourage the Internet literacy of less qualified, unemployed, and older individuals living in remote areas. Furthermore, as I also detect that network effects are important for the individual decision to use the Internet, experienced users should be involved in public programs in order to motivate non-users by teaching them how to use the Internet and by showing them its advantages. Some local programs particularly targeting wider Internet diffusion and IT competencies in rural regions have been started in recent years. One of them is the program “start und klick!” supported by the Landesstiftung Baden-Württemberg foundation, which provides many IT training courses all over the federal state of Baden-Württemberg (Hoffmann and Gehring, 2006). These courses are not only carried out by established suppliers but also by ICT experienced members of social facilities, academic and ecclesiastical initiatives, and private associations. In my opinion, such programs are a good way to enhance the ICT knowledge of people living in rural regions. As described in my dissertation, people living in remote areas can particularly benefit from advanced Internet infrastructure and ICT literacy as the Internet facilitates the access to information, communication, consumption, and job markets.

In the course of the broadening use of ICT and the ever-growing digital content, applications, and communication opportunities, further considerable efforts need to be made to overcome the digital divide and provide all population groups equal chances to participate in the information society. The main contribution of this dissertation is to draw the reader’s attention to age-specific and regional aspects of the digital divide in Germany and to identify requirements for policy actions with regard to closing the digital gap.

Due to the rapid diffusion of computers and the Internet in the German population, future research focusing on facets of the digital divide should include deeper analyses on what these technologies are used for instead of whether or not they are used. Differences in usage behavior and in Internet users’ online skills have recently become known as the *second-level digital divide* (Hargittai, 2002). It comprises the time spent in using ICT, concrete tasks that are applied, and the amount of online content generated by users themselves, for example. It can be assumed that once online, not everyone benefits equally from using the Internet.

For these research purposes it is crucial to enhance the existing data base with regard to ICT use information. For example, individual data sets often do not include information on usage patterns as described above. In addition, information on the duration of prior ICT use is scarcely provided. This is particularly important when there is a break in occupational ICT use due to unemployment for example. In such a case, data on IT skills and the duration of use is likely to be underestimated. Information on training courses is also weak in most data sets, in particular regarding IT-specific courses. Firm data scarcely includes information on specific (IT) training activities for older workers and on the content and level of the courses. Moreover, in order to improve the estimation of employment effects of older workers' training activities, information is needed on who exactly takes part in the training and whether those workers who participated remain in the firm longer than those who did not participate. Linked employer-employee data sets that include such information and the application of panel data analyses could be helpful for this purpose. Not least, research data on the given Internet infrastructure at a household level is very rare in Germany and should be strongly enhanced to improve regional analyses.

Deutschsprachige Zusammenfassung

Innerhalb der vergangenen zehn Jahre hat in Deutschland die Nutzung von Informationstechnologien und Telekommunikationsnetzen, insbesondere des Internets, rasant zugenommen. Informations- und Kommunikationstechnologien (IKT) haben dabei sowohl auf die deutsche Wirtschaft insgesamt, als auch auf die wirtschaftlichen Verhältnisse von Unternehmen und die Lebensverhältnisse von Individuen stark an Einfluss gewonnen. Einige Zahlen sollen dies verdeutlichen: Die Zahl der Beschäftigten im IKT-Sektor erreichte im Jahr 2007 eine Höhe von rund 800.000, weitere 650.000 IKT-Fachkräfte arbeiteten in anderen Industriezweigen (TNS Infratest, 2007b).[2] Die Bruttowertschöpfung des deutschen IKT-Sektors stieg bis zum Jahr 2005 auf 74 Milliarden Euro, was einem Zuwachs von 50 Prozent gegenüber 1995 entspricht (BITKOM, 2007a). Aktuell veröffentlichte Zahlen des Statistischen Bundesamts weisen für 2007 eine Bruttowertschöpfung von 92 Milliarden Euro aus (Statistisches Bundesamt, 2008). Damit liegt der IKT-Sektor mittlerweile deutlich vor den in Deutschland traditionell starken Industrien, wie dem Maschinenbau, der Automobilindustrie und der Metallindustrie (BITKOM, 2007a). Dies verdeutlicht, dass die Entwicklung Deutschlands von einer Industriegesellschaft hin zu einer Informationsgesellschaft weiter voranschreitet.

Weitere Entwicklungen bestätigen diesen Trend: So nutzt ein immer größerer Anteil der Beschäftigten in Deutschland einen Computer am Arbeitsplatz. Während der Anteil im Jahr 2003 noch 44 Prozent betrug, stieg er bis 2007 auf 61 Prozent (Eurostat, 2007).[3] In immer mehr Unternehmen kommt E-Business zum Einsatz, um unternehmensinterne und -externe Geschäftsprozesse computergestützt zu vernetzen und zu automatisieren.

[2] Die Definition des IKT-Sektors variiert leicht zwischen verschiedenen Studien. Sie orientiert sich häufig an der Definition der OECD, die jene Industriezweige zum IKT-Sektor zählt, deren hergestellte Produkte oder angebotenen Dienstleistungen die Speicherung, Verarbeitung und Übertragung von Information in elektronischer Form ermöglichen (OECD, 2007a). Hierzu zählen beispielsweise die Herstellung von IKT-Produkten, der Handel mit IKT-Gütern sowie Anbieter von IKT-Dienstleistungen, z.B. Fernmeldedienste, Datenverarbeitung und Online-Dienste (ebenda).

[3] Gemessen wurde hier der Anteil der Computernutzer in allen Firmen mit 10 oder mehr Beschäftigten in Deutschland.

Eurostat (2007) ermittelte, dass 2007 mehr als die Hälfte (52 Prozent) der Unternehmen in Deutschland Online-Käufe tätigte und 24 Prozent ihre Aufträge online entgegennahmen.

Ebenso steigt der Anteil der Individuen, die das Internet zu privaten Kommunikations- und Informationszwecken, für ihre Arbeitsplatzsuche oder für Online-Einkäufe nutzen, weiter stark an. Weltweit nutzen mittlerweile über 1,2 Milliarden Menschen das Internet, sei es zu Hause oder am Arbeitsplatz (BITKOM, 2007a). In Deutschland betrug die Zahl der Internetnutzer im vergangenen Jahr fast 40 Millionen, was einem Anteil von etwa 60 Prozent der deutschen Bevölkerung ab 14 Jahren entspricht. Gegenüber 2001 ist der Anteil der Internetnutzer damit um 23 Prozent gestiegen (TNS Infratest, 2007a). Bereits 38 Prozent der Personen im Alter zwischen 16 und 74 Jahren nutzten das Internet 2006 für private Online-Einkäufe, was nahezu einer Verdopplung gegenüber 2003 gleichkommt (BITKOM, 2007a).

Bei all diesen Zahlen und Entwicklungen scheint es aus ökonomischer wie privater Sicht nahezu unmöglich, sich ein Leben ohne IKT vorzustellen. Nach wie vor existieren jedoch große Unterschiede im Ausmaß der IKT-Nutzung zwischen verschiedenen Bevölkerungsgruppen. Aktuelle Daten für die EU25-Länder zeigen, dass weniger gut ausgebildete, ältere und wirtschaftlich inaktive Personen weniger Computer- und Interneterfahrung aufweisen (European Commission, 2007b). Diese Unterschiede zeigen sich auch für Deutschland. Im Jahr 2004 haben lediglich 31 Prozent der Personen im Alter ab 55 Jahren einen Computer genutzt, während die Anteile der 25- bis 34-Jährigen bei 82 Prozent und die der 10- bis 24-Jährigen sogar bei 95 Prozent lagen (Statistisches Bundesamt, 2005).[4] Der (N)onliner-Atlas untersucht Unterschiede in der Nutzung des Internets in Deutschland und bestätigt, dass vor allem jüngere, höher qualifizierte und gut verdienende Personen das Internet nutzen (TNS Infratest, 2007a). Diese Zusammenhänge bleiben bestehen, wenn multivariate Analysemethoden angewendet werden, wie auch die Ergebnisse meiner eigenen Untersuchungen zeigen.[5]

Auch regionale Eigenheiten, zum Beispiel die gegebene IKT-Infrastruktur oder die Preisstruktur von IKT-Gütern, können die individuelle Wahrscheinlichkeit, das Internet zu nutzen, beeinflussen. Innerhalb Deutschlands ist die Internetnutzung regional ungleichmäßig verteilt. So lassen sich Unterschiede in den Nutzungsraten zwischen Ost- und Westdeutschland, zwischen einzelnen Bundesländern und zwischen ländlichen und städtischen Regionen erkennen. Im Jahr 2006 lag bspw. die Rate der Internetnutzer in allen ostdeutschen

[4] Hierbei wurde nicht zwischen privater und beruflicher Nutzung unterschieden.

[5] Siehe auch Korupp et al. (2006), Korupp and Szydlik (2005), Haisken-DeNew et al. (2000), und Prince (2008).

Bundesländern unter dem bundesdeutschen Durchschnitt, mit Ausnahme des Stadtstaats Berlin (TNS Infratest, 2006). Besonders ausgeprägt sind die Ost-West-Unterschiede bei den Anteilen der über 50-jährigen Internetnutzer in den jeweiligen Bundesländern (ebd.). Zwischen ländlichen Ortschaften mit weniger als 5.000 Einwohnern und Städten mit mehr als 500.000 Einwohnern betrug der Unterschied im Anteil der Internetnutzer 11 Prozentpunkte, eine Differenz, die im Laufe der Jahre sogar leicht zugenommen hat (ebd.).

Die beschriebenen Unterschiede in der Computer- und Internetnutzung sind Ausprägungen der so genannten *digitalen Kluft*. Von der OECD wird sie definiert als die „auf unterschiedlichen sozio-ökonomischen Eigenschaften basierende Diskrepanz zwischen Individuen, Haushalten, Unternehmen und Regionen sowohl hinsichtlich ihrer Möglichkeiten, Zugang zu Informations und Kommunikationstechnologien zu haben, als auch das Internet für eine Vielzahl von Aktivitäten zu nutzen“ (OECD/DSTI, 2001, S. 5, eigene Übersetzung). Da das Internet den Zugang zu Informationen und Dienstleistungen sowie den Austausch von Wissen erleichtert, können Menschen, die nicht an der Nutzung neuer Informationstechnologien (IT)[6] teilhaben, aus sozialer wie ökonomischer Sicht schnell den Anschluss verlieren. Auf der anderen Seite können Beschäftigte und Firmen, die IKT intensiv nutzen, häufig von einem starken Anstieg ihrer Produktivität aufgrund der IKT-Nutzung profitieren.

Die digitale Kluft zwischen Nationen aber auch innerhalb der Länder zu schließen, ist ein derzeit bedeutendes politisches Ziel. Daher ist es wichtig, den Ursprung, die Ausprägungen und die Auswirkungen der Unterschiede in der IKT-Nutzung zu kennen. Die vorliegende Dissertation untersucht auf nationaler Ebene zwei wichtige Facetten der digitalen Kluft: altersspezifische und regionale Aspekte. Zunächst wird speziell für ältere Beschäftigte untersucht, wie sich ihre Computernutzung sowie ihre Teilnahme an IT-Weiterbildungsmaßnahmen im Unternehmen auf ihre Beschäftigungschancen auswirken. Im Anschluss stehen regionale Unterschiede in der Internetnutzung im Mittelpunkt der Untersuchung. Dabei wird die individuelle Wahrscheinlichkeit, mit der Internetnutzung zu beginnen, analysiert, wobei verschiedene individuelle und regionale Faktoren berücksichtigt werden.

Vor dem Hintergrund des anhaltenden demographischen Wandels in Deutschland sind insbesondere alterspezifische Aspekte der digitalen Kluft in den Mittelpunkt des politischen Interesses gerückt. Höhere Lebenserwartung, abnehmende Geburtenraten und die Alterung der geburtenstarken Jahrgänge („Baby-Boom-Generation“) haben zu einem stetigen Anstieg des Durchschnittsalters der deutschen Bevölkerung geführt. Dessen ungeachtet blieb das Durchschnittsalter der Erwerbsbevölkerung nahezu unverändert. Großzügige Frühver-

[6]Die Abkürzungen IT und IKT werden in dieser Arbeit synonym verwendet.

rentungsprogramme sorgten in Deutschland in den vergangenen Jahrzehnten für eine stark rückläufige Partizipation Älterer am Erwerbsleben. In der früheren Bundesrepublik ging das durchschnittliche Renteneinstiegsalter von Männern zwischen 1973 und 2000 von 62,2 auf 59,8 Jahre zurück (Clemens et al., 2003).[7] Damit einher ging im Zeitraum 1970 bis 2000 ein extremer Rückgang der Erwerbsquote[8] um 37 Prozentpunkte für Männer im Alter zwischen 60 und 64 Jahren sowie um 10 Prozentpunkte für jene im Alter zwischen 55 und 59 Jahren (ebd.).[9] Für Gesamtdeutschland lag die Erwerbsquote für Männer zwischen 55 und 64 Jahren im Jahr 2000 bei 52 Prozent (Eurostat, 2007).[10] Die Erwerbsquote von Männern zwischen 30 und 45 Jahren blieb hingegen nahezu konstant und lag im Jahr 2000 bei über 90 Prozent (Statistisches Bundesamt, 2001). Daraus resultierte ein stagnierendes Durchschnittsalter der Erwerbsbevölkerung in den letzten drei Jahrzehnten des vergangenen Jahrhunderts. Im früheren Bundesgebiet lag es im Zeitraum 1970 bis 1990 zwischen 38 und 39 Jahren und betrug auch 2002 lediglich 40 Jahre (ebd.).

Eine mögliche Erklärung für diese Entwicklungen sind die Auswirkungen von Reformen des deutschen Rentensystems in den 1970er und 1990er Jahren. Sie beinhalteten die Schaffung zahlreicher Möglichkeiten, vorzeitig und ohne größere finanzielle Einbußen in Rente zu gehen.[11] Aufgrund der seit einigen Jahren rasant zunehmenden finanziellen Belastung für das deutsche Rentensystem, hervorgerufen durch die stark steigende Zahl von Rentnern, ist die Erhöhung der Arbeitsmarktteilnahme Älterer ein wichtiges Thema in der aktuellen politischen Debatte. Seine Bedeutung wird weiter zunehmen, da aufgrund geburtenschwacher Jahrgänge zukünftig mit einem Rückgang des Arbeitsangebots junger hochqualifizierter Fachkräfte gerechnet werden muss. Werden ältere Beschäftigte weiterhin frühzeitig aus dem Erwerbsleben entlassen, könnte das in nicht allzu ferner Zukunft zu einem Mangel an qualifiziertem Personal in den Unternehmen führen. Anhand der Ergebnisse einer Unternehmensbefragung weist der Branchenverband BITKOM bereits heute 43.000 offene Stellen für qualifizierte IT-Fachkräfte in der deutschen Wirtschaft aus (BITKOM, 2007b). Im „Bericht zur technologischen Leistungsfähigkeit Deutschlands 2007“ prognostizieren die

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[7] Nach 2001 stieg das Renteneinstiegsalter langsam an, hat jedoch 2006 erst das Niveau von 1973 erreicht (Eurostat, 2007).

[8] Die Erwerbsquote ist definiert als Anteil der Erwerbspersonen an der Bevölkerung im erwerbsfähigen Alter (15 bis 64 Jahre), wobei sowohl Erwerbstätige als auch Erwerbslose zu den Erwerbspersonen zählen.

[9] Die Erwerbsquote der Männer im Alter zwischen 60 und 64 Jahren sank von 70 auf 33 Prozent, jene der Männer im Alter zwischen 55 und 59 Jahren von 88 auf 78 Prozent.

[10] 2006 lag der Wert bei 64 Prozent. Dabei muss jedoch berücksichtigt werden, dass nur 56 Prozent der Männer in der betreffenden Altersgruppe tatsächlich einer Erwerbstätigkeit nachgingen (Eurostat, 2007).

[11] Nähere Erläuterungen liefern zum Beispiel Berkel and Börsch-Supan (2003) sowie Arnds and Bonin (2003b).

Autoren, dass ab dem Jahr 2014 die Arbeitsnachfrage nach Ingenieuren und anderen Akademikern das Arbeitsangebot jährlich um etwa 41.000 bis 62.000 Beschäftigte übersteigen wird (Bundesministerium für Bildung und Forschung, 2007).

Nicht zuletzt kann im Allgemeinen davon ausgegangen werden, dass ein großer Teil der frühverrenteten Arbeitnehmer bevorzugt hätte, länger aktiv und in Erwerbstätigkeit zu bleiben (Gelderblom and de Koning, 2002). Werden Ältere aus dem Erwerbsleben gedrängt, kann man demnach durchaus von „sozialer Ausgrenzung“ sprechen. Die Erwerbsbeteiligung Älterer zu erhöhen, ist somit sowohl aus unternehmerischer als auch aus sozialer Sicht von großer Bedeutung (ebd.).

Die rasche Verbreitung von Informations- und Kommunikationstechnologien in der Arbeitswelt wird als zusätzliche mögliche Ursache für die geringe Arbeitsmarktteilnahme Älterer angesehen. IKT kommen heute in nahezu allen Bereichen der Wirtschaft zum Einsatz. Im Laufe der letzten Jahre haben sie zu starken Veränderungen in Produktionsprozessen, Arbeitsabläufen und beruflichen Anforderungen geführt. Ältere bleiben jedoch in der Nutzung neuer Technologien am Arbeitsplatz zurück: Daten, die das Zentrum für europäische Wirtschaftsforschung (ZEW) 2004 im Rahmen seiner IKT-Umfrage in Unternehmen des verarbeitenden Gewerbes und ausgewählter Dienstleistungssektoren erhoben hat, zeigen beispielsweise, dass im Jahr 2003 48 Pozent der unter 50-Jährigen einen Computer am Arbeitsplatz nutzten, während dies bei nur 34 Prozent der Beschäftigten ab 50 Jahren der Fall war. Eine geringe IT-Nutzung Älterer kann sich negativ auf ihre Beschäftigungsfähigkeit auswirken.

Für Ältere, die kurz vor einem möglichen Renteneinstieg stehen, ist die Zeitspanne, in der sich die Erträge aus einer Weiterbildungsinvestition amortisieren können, nur kurz. Verglichen mit jüngeren Beschäftigten ist daher ihre Motivation, in Weiterbildung zu investieren, geringer. Da IT-Kenntnisse für eine immer größere Zahl von Jobs benötigt werden, können unzureichendend vorhandene IT-Fähigkeiten den Anreiz für Ältere vergrößern, die gegebenen Frühverrentungsmöglichkeiten zu nutzen. Andererseits könnte wiederum der Erwerb von Computerkenntnissen sowie der Umgang mit dem Computer am Arbeitsplatz den Anreiz erhöhen, den Renteneinstieg zu verschieben. Somit wird die Entscheidung, in IT-Weiterbildung zu investieren, von den gesetzlich gegebenen Möglichkeiten zur Frühverrentung beeinflusst und ist seinerseits ein wesentlicher Faktor, der die Arbeitsangebotsentscheidung von Älteren bestimmt.

In Kapitel 2 meiner Dissertation untersuche ich empirisch den Zusammenhang zwischen der Computernutzung älterer Beschäftigter im Alter zwischen 50 und 60 Jahren im Jahre 1997 und ihrem Erwerbsstatus in den darauf folgenden Jahren. Dabei analysiere ich, welche

Eigenschaften die Computernutzung von Beschäftigten begünstigen und inwiefern ältere Computernutzer eine höhere Wahrscheinlichkeit haben, Vollzeit erwerbstätig zu bleiben, als ältere Nichtnutzer. Für die Analysen verwende ich Daten der Wellen 1997, 1999 und 2001 des Sozio-ökonomischen Panels (SOEP), einer jährlich durchgeführten, repräsentativen Befragung privater Haushalte in Deutschland. Aufgrund der spezifischen Erwerbssituation älterer Frauen in Deutschland, konzentrieren sich meine Analysen auf Männer.[12] Die Ergebnisse meiner multivariaten Analysen zeigen, dass ältere Beschäftigte eine geringere Wahrscheinlichkeit haben, einen Computer am Arbeitsplatz zu nutzen, als jüngere, was die Resultate früherer Studien bestätigt. Es lässt jedoch kein eindeutiger Zusammenhang zwischen der Computernutzung Älterer und einem potenziellen Erwerbsstatuswechsel finden. Unter Berücksichtigung möglicher Verzerrungen aufgrund von Endogenität kann somit kein klarer Beweis dafür erbracht werden, dass ältere Computernutzer eher dazu neigen, ihren Renteneintritt aufzuschieben, als Nichtnutzer.

Um die Auswirkungen neuer Technologien auf die Arbeitsmarktteilnahme Älterer abschätzen zu können, ist die Fokussierung auf den Aspekt der Computernutzung jedoch möglicherweise nicht ausreichend. Dies gilt insbesondere, da die Entscheidung zur Teilnahme an IT-Weiterbildung häufig nicht allein beim Beschäftigten liegt, sondern auch davon beeinflusst wird, inwiefern der Arbeitgeber derartige Trainingsmaßnahmen für Ältere anbietet. Der Schwerpunkt von Kapitel 3 meiner Dissertation liegt deshalb auf der Untersuchung des Zusammenhangs zwischen der Teilnahmequote Beschäftigter im Alter ab 50 Jahren an unternehmensinterner IT-Weiterbildung und ihrem Beschäftigungsanteil im Unternehmen. Ich wende mich damit der Arbeitsnachfrageseite zu und nutze Unternehmensdaten, um weitere altersspezifische Aspekte der digitalen Kluft in Deutschland zu analysieren. Die verwendeten Daten stammen aus den Wellen 2004 und 2007 der IKT-Umfrage des ZEW.

Das Angebot unternehmensinterner Weiterbildung zielt darauf ab, die firmenspezifischen Fähigkeiten und Kenntnisse von Mitarbeitern zu erweitern und somit ihre Produktivität und Beschäftigungsfähigkeit zu erhöhen. Verschiedene Studien für Deutschland zeigen einen positiven Einfluss der Teilnahme von Beschäftigten an allgemeiner Weiterbildung und ihrer individuellen Beschäftigungswahrscheinlichkeit.[13] Da jüngere Kohorten kleiner

[12] Verglichen mit Männern geht ein deutlich geringerer Anteil von Frauen ab 50 Jahren einer Vollzeitbeschäftigung nach bzw. steht überhaupt dem Arbeitsmarkt zur Verfügung. Seit 1995 liegt bspw. die Erwerbsquote von Frauen zwischen 60 und 64 Jahren bei relativ konstanten 10 Prozent, die der Männer bei etwa 30 Prozent (Clemens et al., 2003). Vor allem Frauen im Westen Deutschlands sowie verheiratete Frauen weisen in fortgeschrittenem Alter geringere Erwerbsquoten auf (ebd.).

[13] Siehe zum Beispiel Christensen (2001), Fitzenberger and Prey (1999) sowie Hübler (1998).

sind als ältere und vermutlich in nicht allzu ferner Zukunft eine unzureichende Zahl Hochqualifizierter hervorbringen werden, wird es für Unternehmen zunehmend wichtig, Weiterbildungsmaßnahmen speziell für ältere Beschäftigte anzubieten. Zudem kann davon ausgegangen werden, dass der technologische Wandel eine Veralterung von Wissen hervorruft bzw. beschleunigt (Bartel and Sicherman, 1993). Werden also vermehrt neue Technologien im Unternehmen eingesetzt, ist kontinuierliche Weiterbildung unerlässlich. Die Verbreitung neuer Technologien kann aufgrund unzureichender IT-Fähigkeiten insbesondere zu einer sinkenden Nachfrage nach Älteren führen, einerseits, da ihre ursprüngliche Ausbildung bereits weiter zurückliegt als bei ihren jüngeren Kollegen, andererseits, da sie aufgrund ihres bevorstehenden Ruhestands dazu tendieren, seltener an Weiterbildungsaktivitäten teilzunehmen. Man spricht in diesem Zusammenhang vom so genannten „age-biased technological change“ (Aubert et al., 2006). Die Ergebnisse meiner Analysen in Kapitel 3 bestätigen den negativen Zusammenhang zwischen der Intensität der Nutzung von IT in Unternehmen und ihrem Anteil älterer Beschäftigter. Das Ausmaß der IT-Nutzung wird dabei mit Hilfe eines Indikators gemessen, der unter anderem verschiedene IT-Anwendungen, den Anteil der Computernutzer im Unternehmen und die IT-Kosten pro Beschäftigtem beinhaltet.

IT-Weiterbildung für ältere Beschäftigte ist eine geeignete Maßnahme, den negativen Einfluss der IT-Intensität zu verringern, da Ältere dabei den Umgang mit neuen Technologien erlernen und damit an Produktivität und Beschäftigungsfähigkeit gewinnen können. Meine Untersuchungsergebnisse zeigen, dass eine höhere Teilnehmerquote älterer Beschäftigter an IT-Weiterbildungsmaßnahmen mit einem höheren Beschäftigungsanteil Älterer im Unternehmen einhergeht. Um herauszufinden, ob sich dieser Zusammenhang zwischen IT-intensiven und weniger IT-intensiven Unternehmen unterscheidet, werden für die entsprechenden Teilgruppen von Unternehmen zusätzliche multivariate Schätzungen durchgeführt. Die Ergebnisse verdeutlichen, dass sich der positive Zusammenhang nur bei IT-intensiven Unternehmen zeigen lässt. Dies lässt schlussfolgern, dass die Teilnahme Älterer an IT-Weiterbildung in IT-intensiven Betrieben von besonderer Bedeutung und besonders wirksam ist. Diese Betriebe weisen im Allgemeinen einen geringeren Anteil Älterer an ihrer Gesamtbeschäftigung auf.

Während sich Kapitel 2 und 3 auf die altersspezifischen Unterschiede in der Nutzung neuer Technologien und deren Auswirkungen auf die Arbeitsmarktteilnahme Älterer konzentrieren, befasst sich Kapitel 4 mit regionalen Aspekten der digitalen Kluft. Im Mittelpunkt stehen dabei Unterschiede in der privaten Internetnutzung in Regionen mit unterschiedlicher Bevölkerungsdichte. Gerade für Bewohner ländlicher Regionen bietet das Internet zahlreiche Vorteile, da es insbesondere zwei bedeutende Faktoren, die das Wirtschaftswachstum ländlicher Regionen hemmen können, zu überwinden hilft: die großen Entfernungen zwischen Märkten und die geringe Marktdichte (Parker, 2000). Aus eben diesen Gründen jedoch – große Entfernungen und geringe Marktdichte – ist der Anreiz für Internetservice-Anbieter gering, in ländlichen Regionen zu investieren. Der daraus resultierende Mangel an einer schnellen, leistungsfähigen und kostengünstigen Internetinfrastruktur beschränkt die Internetzugangs- und Internetnutzungsmöglichkeiten für die Bewohner ländlicher Regionen. Sie können dementsprechend häufig nicht von den Möglichkeiten, die das Internet bietet, profitieren.

Wichtige regionale Einflussfaktoren, die im Hinblick auf Unterschiede in der IKT-Nutzung mehr und mehr in den Mittelpunkt des Forschungsinteresses rücken, sind so genannte *Netzwerkeffekte*. Positive Netzwerkeffekte treten dann auf, wenn die individuelle Wahrscheinlichkeit, an einem Netzwerk zu partizipieren, von der Größe des Netzwerks positiv beeinflusst wird (Goolsbee and Klenow, 2002). So erweitert ein höherer lokaler Anteil von Internetnutzern nicht nur die Kommunikationsmöglichkeiten, z.B. mit Verwandten und Freunden, die ebenfalls das Internet nutzen. Er führt auch zur Erweiterung der Online-Inhalte, die für potenzielle Internetnutzer von Interesse sein könnten, da Internetseiten häufig Informationen über wirtschaftliche, politische oder kulturelle Aktivitäten und Veranstaltungen in der eigenen Region beinhalten. Auch das Lernen von anderen ist ein wichtiger lokaler Netzwerkeffekt, da erfahrene Internetnutzer bisherigen Nichtnutzern den Umgang mit dem Internet beibringen und dessen Vorteile aufzeigen können. Darüber hinaus ist die Zahl öffentlicher Räume, in denen man den Umgang mit dem Internet beobachten kann (z.B. Internetcafés), größer, je mehr Internetnutzer es in einer Region gibt. Diese öffentlichen Zugangsorte erweitern die Möglichkeiten, von anderen zu lernen.

In Kapitel 4 untersuche ich mögliche Determinanten der Internetnutzung in privaten Haushalten sowohl auf Kreis- als auch auf Individualebene. Hierfür verbinde ich zwei umfangreiche Datensätze: das SOEP, welches Informationen zu den untersuchten Individuen liefert, und den INKAR-Datensatz (Indikatoren und Karten zur Raumentwicklung), welcher eine Vielzahl amtlicher regionaler Indikatoren für Deutschland auf unterschiedlichen Aggregationsniveaus beinhaltet. Auf der Ebene von Kreisen werden regionale Charakteristika analysiert, die mit dem lokalen Anteil der Internetnutzer korreliert sein können. Die Ergebnisse der multivartiaten Analysen können die Hypothese, dass eine geringere Einwohnerdichte mit einer geringeren Internetnutzungsrate einhergeht, nicht bestätigen. Vielmehr sind andere regionale Charakteristika, wie der Anteil an Ausländern und Hochqualifizierten sowie die regionale Arbeitslosenquote, von Bedeutung.

Auf der Individualebene untersuche ich insbesondere die Rolle von Netzwerkeffekten, dass heißt den Einfluss des regionalen Anteils erfahrener Internetnutzer, auf die individuelle

Wahrscheinlichkeit, mit der Internetnutzung zu beginnen. Regionale Faktoren werden dabei wiederum auf Kreisebene gemessen. Die Ergebnisse meiner ökonometrischen Schätzungen bestätigen die Resultate früherer Studien: Die individuelle Zugangswahrscheinlichkeit wird insbesondere durch persönliche Charakteristika, wie das Alter, den Bildungsstand und das Einkommen beeinflusst. Zudem lassen sich deutlich positive Netzwerkeffekte beobachten, vor allem im Westen Deutschlands. Insbesondere im Osten der Bundesrepublik bleibt jedoch auch unter Berücksichtigung der Netzwerkeffekte der Einfluss der Bevölkerungsdichte signifikant. Dies wird vermutlich durch große Unterschiede in der Internetinfrastruktur zwischen städtischen und ländlichen Regionen hervorgerufen.

Sowohl auf EU-weiter als auch auf nationaler Ebene wurden in den vergangenen Jahren verschiedene Programme ins Leben gerufen, die das Ziel haben, IKT-Zugangs- und IKT-Nutzungsbarrieren abzubauen. Entsprechende Ziele wurden auf der Ministerkonferenz von Riga „IKT für eine integrative Gesellschaft“ im Jahr 2006 vereinbart (European Commission, 2006). Sie beinhalten unter anderem die Reduzierung der Defizite in der IKT-Nutzung und in den digitalen Fähigkeiten von älteren Menschen aber auch die deutliche Erhöhung der Breitbandversorgung insbesondere in ländlichen Regionen.

Zur Erreichung dieser Ziele startet die Europäische Kommission in diesem Jahr eine Kampagne mit dem Titel „eInclusion – Die Informationsgesellschaft geht alle an!“ (*eInclusion, be part of it!*) (European Commission, 2007b). Diese Kampagne baut auf bereits bestehenden Programmen auf und ergänzt diese.[14] Zu den etablierten Programmen zählt bspw. der Aktionsplan „Wohltuendes Altern in der Informationsgesellschaft“ (*Ageing Well in the Information Society*), der Mitte 2007 ins Leben gerufen wurde. Ziel ist es, Älteren mit Hilfe von IKT ein eigenständiges und aktives Leben zu ermöglichen. Hierbei gilt es einerseits, Barrieren für Ältere hinsichtlich des Zugangs zu IKT abzubauen, andererseits die Industrie bei der Entwicklung altersgerechter Technologien zu unterstützen. Ein weiteres Programm zielt speziell auf die Barrierefreiheit der IKT-Nutzung ab, um die Handhabbarkeit von IKT für ältere und behinderte Menschen zu erhöhen (*eAccessibility*). Dieses Programm begann bereits im Jahr 2005.

In Deutschland bildet das Programm „iD2010“ den Rahmen für verschiedene Maßnahmen und Strategien der Bundesregierung in den Bereichen IKT und neue Medien. Ende 2006 ins Leben gerufen unterstützt es die i2010-Initiative der EU. Das Programm umfasst nicht nur

[14] Den strategischen Rahmen für diese Kampagne und zugehörige Aktionsprogramme bildet das Konzept „i2010 – Eine europäische Informationsgesellschaft für Wachstum und Beschäftigung“ (*i2010 – A European Information Society for Growth and Employment*). Eine Übersicht findet sich auf der i2010-Homepage der Europäischen Kommission (European Commission, 2007c).

neue IKT-relevante Gesetzesvorhaben, die die Rahmenbedingungen für die Nutzung neuer Netze und Dienste liefern sollen, sondern auch Maßnahmen zur Technologieförderung sowie zur Anwendung von IKT in Wirtschaft, Staat und Gesellschaft (Bundesministerium für Wirtschaft und Technologie, 2006b). Die Fortsetzung der digitalen Integration von Älteren ist dabei von besonderer Bedeutung (Bundesministerium für Wirtschaft und Technologie, 2006a).

Der Branchenverband BITKOM bringt derzeit gemeinsam mit der IG Metall das Projekt „IT 50plus“ auf den Weg, mit dem insbesondere dem IT-Fachkräftemangel entgegengewirkt werden soll (BITKOM/IG Metall, 2008). Dabei haben sich die Projektpartner zum Ziel gesetzt, die Beschäftigungsfähigkeit älterer Fachkräfte zu verbessern, ihre Wiedereingliederung nach längerer Arbeitslosigkeit zu erleichtern und das IT-Weiterbildungssystem zu erweitern. Das Programm richtet sich speziell an Unternehmen der IKT-Branche sowie IT-Anwenderunternehmen, aber auch an Personalverantwortliche und IT-Fachkräfte (ebd.). Dabei werden auch jüngere IT-Fachkräfte einbezogen, um ihre Beschäftigung langfristig zu sichern.

Die Ergebnisse meiner Dissertation zeigen, dass ältere Beschäftigte zu einem geringeren Anteil IKT nutzen als ihre jüngeren Kollegen. Aufgrund der starken Durchdringung des deutschen Arbeitsmarkts mit IKT, kann dies zu einer verminderten Beschäftigungsfähigkeit Älterer führen. Da die genannten Programme direkt darauf abzielen, IT-Zugangsbarrieren für Ältere abzubauen und ihre IT-Fähigkeiten zu stärken, sind sie von großer Bedeutung, um die Arbeitsmarktbeteiligung Älterer zu erhöhen.

Weitere Programme konzentrieren sich auf die verstärkte Arbeitsmarktteilnahme von Älteren, haben jedoch keinen IT-Fokus. Der Europäische Rat von Stockholm (2001) und Barcelona (2002) betonte, wie wichtig eine höhere Arbeitsmarktbeteiligung ist und formulierte entsprechende Ziele (z.B. die Erhöhung der EU-weiten Beschäftigungsrate älterer Männer und Frauen auf 50 Prozent sowie die Anhebung des durchschittlichen Auststiegsalters aus dem Erwerbsleben auf 65 Jahre bis 2010)(European Commission, 2003). Diese Ziele bilden den Hintergrund für nationale Arbeitsmarktprogramme. In Deutschland wurde die „Initiative 50plus“ des Bundesministeriums für Arbeit und Soziales im September 2006 vom Kabinett verabschiedet und bündelt verschiedene Maßnahmen der Bundesregierung. Zu den Zielen der Initiative gehören insbesondere: die Erwerbstätigenquote der über 50-Jährigen deutlich zu erhöhen, ältere Arbeitslose mit Hilfe von Kombilohn und Eingliederungszuschüssen wieder in die Erwerbstätigkeit zu integrieren und die Teilnahme Älterer an beruflicher Weiterbildung zu fördern (Bundesministerium für Arbeit und Soziales, 2006). Bereits bestehende Programme mit ähnlicher Zielsetzung werden dabei fortgeführt. Im

Rahmen der Initiative „INQA“ (Initiative Neue Qualität der Arbeit) werden bereits seit 2002 praxisrelevante Projekte zur Sicherung von Gesundheit und Qualifikation am Arbeitsplatz durchgeführt. Betriebe und Verwaltungen werden dabei unterstützt, moderne und altersgerechte Arbeitsplätze zu gestalten (ebd.). Das Programm „Perspektive 50plus – Beschäftigungspakte für Ältere in den Regionen“ fördert seit 2005 regionale Projekte zur beruflichen Wiedereingliederung älterer Langzeitarbeitsloser. Speziell auf die jeweilige Region zugeschnittene Strategien sollen Arbeitslose und Betriebe zusammenführen (ebd.). 2008 geht das Programm in seine zweite Phase, die bis 2010 andauern wird.

Die deutsche Regierung hat also den Handlungsbedarf bei der Integration Älterer in den Arbeitsmarkt durchaus erkannt. Nicht zuletzt die stufenweise Anhebung des gesetzlichen Renteneintrittsalters auf 67 Jahre, die Einschränkung von Frühverrentungsmöglichkeiten sowie die Erhöhung der finanziellen Abschläge bei vorzeitigem Renteneintritt zielen in die richtige Richtung. Wie in der vorliegenden Dissertation beschrieben, besteht ein wechselseitiger Zusammenhang zwischen Beschäftigungsaussichten und IKT-Nutzung. Bessere Beschäftigungschancen erhöhen den Anreiz, den Renteneintritt zu verschieben und die Nutzung neuer Technologien zu erlernen und umgekehrt. Progamme, die die Beschäftigungssituation Älterer verbessern, bilden somit eine wichtige Basis für die verstärkte IT-Nutzung Älterer.

Dies gilt in gleichem Maße für Maßnahmen auf Seiten der Unternehmen. Bei ihnen muss ein Umdenken erfolgen, da bei zu besetzenden Stellen noch immer eher nach jungen Fachkräften Ausschau gehalten wird. Weiterbildung bis ins hohe Alter wird nicht flächendeckend angeboten, wie auch die Ergebnisse meiner eigenen Analysen bestätigen. Dies mag für die kurze Frist rational sein. Die demographische Entwicklung deutet jedoch darauf hin, dass zukünftig ein Mangel an qualifizierten Fachkräften herrschen könnte, der eine Beschäftigung hochqualifizierter Älterer erforderlich macht. Mit oft relativ einfachen personalpolitischen Mitteln ließen sich die Beschäftigungsfähigkeit und Arbeitsmotivation von Älteren auch vor dem Hintergrund des vermehrten Einsatzes von IKT deutlich erhöhen. Hierzu zählen neben kontinuierlichen Weiterbildungsaktivitäten bspw. das Aufzeigen von Karriereperspektiven, die Gewährung flexibler Arbeitszeiten sowie die Gestaltung von Arbeitspätzen mit weniger starker körperlicher Belastung (Buchhorn et al., 2004). Anstelle einer altersabhängigen Entlohnung könnten Unternehmen auf eine leistungs- und verantwortungsabhängige Entlohnung umsteigen (ebd.). Ein System von Patenschaften zwischen Alt und Jung, Lernpartnerschaften und Kompetenz-Tandems kann zudem für einen stetigen Wissenaustausch und eine intensive Kommunikation innerhalb der Belegschaft sorgen (Schemme, 2003).

Während mittlerweile zahlreiche Programme darauf abzielen, die IT-Weiterbildung von Älteren zu verstärken, damit sie den Anschluss in der heutigen Informationsgesellschaft nicht verlieren und bis ins hohe Erwerbsalter motiviert und beschäftigungsfähig bleiben, sind weniger Initiativen auf den Weg gebracht worden, die sich auf die Verringerung regionaler Unterschiede in der Internetnutzung konzentrieren. Auf EU-Ebene wurden im Rahmen des EU-Politikprogramms zur „Verringerung der digitalen Breitbandkluft" (*Bridging the Broadband Gap*) verschiedene Projekte gestartet, um Unterschiede in der Breitbandversorgung zwischen städtischen und ländlichen Regionen abzubauen (European Commission, 2007c). Im Jahr 2005 ging zudem der vom Bundesministerium für Wirtschaft und Technologie initiierte „Breitbandatlas" online. Er hat das Ziel, Lücken in der Breitbandversorgung in Deutschland aufzudecken sowie Anbieter und Nachfrager der Breitbandtechnologie zusammenzubringen, um diese Lücken zu schließen. Die Ergebnisse meiner Dissertation zeigen, dass Infrastrukturunterschiede zu Differenzen in der Rate der Internetnutzung zwischen Bewohnern ländlicher und städtischer Regionen beitragen. Internetanbieter haben geringere Anreize, ihr Angebot auf ländliche Regionen auszuweiten, was zu einer Unterversorgung des ländlichen Raumes mit Breitbandanschlüssen führt. Entsprechende Anreize für Anbieter zu vergrößern und die flächendeckende Versorgung mit schnellen und kostengünstigen Internetverbindungen sicherzustellen, ist somit ein wichtiges politisches Ziel, um regionale Unterschiede in der Internetnutzung und nicht zuletzt in der regionalen Wirtschaftsentwicklung in Deutschland auszugleichen.

Neben möglichen Infrastrukturunterschieden spielen jedoch vor allem indiviuelle Faktoren eine wichtige Rolle für die Wahrscheinlichkeit, Internetnutzer zu werden. Politikmaßnahmen, die darauf abzielen, die digitale Kluft zu verringern, sollten daher vor allem Programme beinhalten, die die IT-Fähigkeiten von gering qualifizierten, arbeitslosen und älteren Personen speziell in ländlichen Regionen verbessern. Da meine Dissertation zudem deutlich zeigt, wie wichtig Netzwerkeffekte für die IKT-Nutzungswahrscheinlichkeit sind, sollten erfahrene Internetnutzer in die entsprechenden Programme involviert werden, um ihr Wissen an bisherige Nichtnutzer weitergeben zu können. Verschiedene regionale Programme wurden in den vergangenen Jahren ins Leben gerufen, um speziell ländliche Regionen bei der Verbreitung des Internets zu unterstützen und die Medienkompetenz ihrer Bewohner zu stärken. Mit der Durchführung einer Vielzahl von PC- und Internetkursen zählt hierzu bspw. das Einsteigerprogramm „start und klick!" der Landesstiftung Baden-Württemberg (Hoffmann and Gehring, 2006). Diese Kurse werden nicht nur von etablierten Anbietern durchgeführt, sondern auch von Internet-erfahrenen Mitgliedern sozialer Einrichtungen, schulischer und kirchlicher Initiativen und privater Vereine. Derartige regionalspezifische Programme sind eine gute Möglichkeit, die IT-Fähigkeiten der Bewohner ländlicher Regionen zu verbessern. Wie bereits erwähnt, ist dies für sie von besonderer Bedeutung, da das Internet dabei hilft, ihnen den Zugang zu Informationen, Konsum- und Arbeitsmärkten zu erleichtern.

Im Zuge der weiteren Verbreitung von IKT und der immer neuen digitalen Anwendungen und Kommunikationsmöglichkeiten müssen auch zukünftig Anstrengungen unternommen werden, um die digitale Kluft zu überwinden und allen Bevölkerungsgruppen die gleichen Möglichkeiten zur Partizipation an der Informationsgesellschaft zu eröffnen. Der besondere Beitrag der vorliegenden Dissertation liegt darin, die Aufmerksamkeit des Lesers auf die alters- und regionalspezifischen Aspekte der digitalen Kluft in Deutschland zu lenken und den Bedarf weiterer politischer Aktivitäten aufzuzeigen, um die beschriebenen Diskrepanzen zu beseitigen.

A Appendix for Chapter 2

Table A.1: Sample and computer use proportions by various characteristics[i]

	prop.[ii]	users	non-users	N
age				
19-24	.06	30	70	200
25-34	.32	46	54	1,157
35-44	.29	50	50	1,058
45-54	.22	50	50	796
55-64	.12	36	64	427
nationality				
German	.83	51	49	3,021
foreigner	.17	20	80	617
region				
east	.27	41	59	966
west	.73	48	52	2,672
without any degree				
lower secondary education or less	.16	20	80	564
upper secondary education				
other vocational education	.06	14	86	232
apprenticeship	.42	37	63	1,507
specialized vocational school	.05	52	48	168
technical/commercial college	.08	59	41	305
civil servant college	.03	79	21	106
tertiary education				
polytechnic or college abroad[iii]	.09	77	23	314
university	.12	86	14	415
computer use at home				
yes	.32	86	14	1,109
no	.68	23	77	2,334

Continued on next page

Table A.1 – continued from previous page

	prop.^{ii}	users	non-users	N
occupational status				
blue collar low-level	.18	10	90	653
blue collar high-level	.30	20	80	1,099
clerical worker low-level	.06	42	58	203
clerical worker high-level	.28	84	16	1,010
civil servant low-level	.03	71	29	113
civil servant high-level	.05	83	17	166
self-employed	.10	60	40	376
firm size				
less than 5 employees	.12	46	54	446
5 to 19	.16	33	67	574
20 to 199	.27	39	61	987
200 to 1999	.21	47	53	758
2,000 or more	.24	61	39	868
industry				
agriculture, forestry, fisheries	.02	21	79	68
mining, utilities	.03	52	48	97
building industry	.15	22	78	534
manufacturing	.35	43	57	1,214
wholesale, retail trade	.10	50	50	335
hotels & restaurants	.02	28	72	53
transport, communications	.07	40	60	241
credit, insurance, real estate	.04	90	10	125
data processing, R&D, business services	.05	80	20	158
other services	.09	56	44	315
public sector	.08	74	26	281
other sectors	.02	31	69	83

Notes: ^{i}) Sample: male workers who were employed full-time and less than 65 years old in 1997.
^{ii}) Percentage in sample.
^{iii}) College abroad: in the data it is not clear what kind of degree is meant.
Example: A proportion of 51 percent of the German men declared to use a computer on the job.
Source: Author's calculations based on SOEP 1997.

Table A.2: Employment status change of older workers[i] from 1997 to 1999 – OLS results, full table

dependent variable: change in employment status 1997 → 1999				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.142 (.030)***	-.127 (.029)***	-.093 (.041)**	-.116 (.043)***
age (ref.: age 50-54)				
age 55-60		.214 (.030)***	.213 (.032)***	.225 (.034)***
education (ref.: university degree)				
lower secondary education or less			.096 (.095)	.004 (.098)
other vocational education			-.024 (.099)	-.114 (.105)
apprenticeship			.076 (.057)	.021 (.064)
specialized vocational school			.051 (.099)	.006 (.104)
technical/commercial college			-.073 (.063)	-.109 (.067)
civil servant college			.037 (.098)	.032 (.104)
polytechnic or college abroad			.039 (.059)	-.014 (.062)
nationality (ref.: foreign)				
German			.126 (.076)*	.106 (.075)
region (ref.: west)				
east			-.015 (.053)	.007 (.055)
log hourly wage			-.077 (.049)	-.025 (.055)
tenure			-.004 (.006)	-.000 (.006)
tenure^2			.014 (.015)	.003 (.016)
self-employed			-.105 (.048)**	-.196 (.098)**
firm size (ref.: 20 to 199 employees)				
less than 5				.089 (.106)
5 to 19				.072 (.067)
200 to 1,999				.016 (.043)
2,000 or more				.070 (.045)
industry (ref.: public sector)				
agriculture, forestry, fisheries				.273 (.145)*
mining, utilities				.185 (.120)
building industry				.070 (.088)
manufacturing				.092 (.076)
wholesale, retail trade				.132 (.094)
hotels & restaurants				.456 (.267)*
transport, communications				.198 (.098)**
credit, insurance, real estate				.006 (.094)
data processing, R&D, business services				.027 (.095)
other services				-.009 (.082)
other sectors				.216 (.145)
constant	.244 (.023)***	.128 (.022)***	.252 (.217)	.008 (.248)
R^2	.033	.108	.151	.187
number of observations	581	581	527	515

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses.

[i]) Men who were between 50 and 60 years old in 1997.

Source: Author's calculations based on SOEP 1997 and 1999.

Table A.3: Employment status change of older workers[i] from 1997 to 2001 – OLS results, full table

dependent variable: change in employment status 1997 → 2001				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.080 (.040)**	-.051 (.037)	-.058 (.050)	-.068 (.053)
age (ref.: age 50-54)				
age 55-60		.390 (.036)***	.388 (.040)***	.410 (.041)***
education (ref.: university degree)				
lower secondary education or less			.123 (.103)	.048 (.115)
other vocational education			.084 (.133)	.004 (.142)
apprenticeship			.151 (.067)**	.120 (.076)
specialized vocational school			.108 (.100)	.100 (.102)
technical/commercial college			.069 (.083)	.052 (.092)
civil servant college			.121 (.123)	.206 (.133)
polytechnic or college abroad			.100 (.073)	.068 (.083)
nationality (ref.: foreign)				
German			.110 (.082)	.077 (.083)
region (ref.: west)				
east			.010 (.061)	.033 (.064)
log hourly wage			.048 (.062)	.088 (.065)
tenure			-.007 (.006)	-.001 (.007)
tenure^2			.021 (.016)	.007 (.017)
self-employed			-.173 (.062)***	-.343 (.110)***
firm size (ref.: 20 to 199 employees)				
less than 5				.217 (.118)*
5 to 19				.061 (.070)
200 to 1,999				-.045 (.057)
2,000 or more				.039 (.057)
industry (ref.: public sector)				
agriculture, forestry, fisheries				.216 (.158)
mining, utilities				.295 (.137)**
building industry				.157 (.109)
manufacturing				.211 (.097)**
wholesale, retail trade				.154 (.111)
hotels & restaurants				.151 (.261)
transport, communications				.279 (.110)**
credit, insurance, real estate				.097 (.145)
data processing, R&D, business services				.133 (.122)
other services				.128 (.107)
other sectors				.366 (.173)**
constant	.390 (.027)***	.178 (.028)***	-.131 (.261)	-.437 (.295)
R^2	.007	.172	.215	.248
number of observations	581	581	527	515

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses.

[i]) Men who were between 50 and 60 years old in 1997.

Source: Author's calculations based on SOEP 1997, 1999 and 2001.

Table A.4: Employment status change of older workers[i] – TSLS results, first-stage regressions, full table

dependent variable: computer use at work				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at home	.671 (.034)***	.668 (.034)***	.462 (.049)***	.462 (.048)***
age (ref.: age 50-54)				
age 55-60		-.031 (.034)	-.060 (.033)*	-.045 (.033)
education (ref.: university degree)				
lower secondary education or less			-.357 (.083)***	-.383 (.096)***
other vocational education			-.294 (.092)***	-.318 (.102)***
apprenticeship			-.150 (.066)**	-.188 (.073)**
specialized vocational school			-.288 (.095)***	-.323 (.095)***
technical/commercial college			-.062 (.085)	-.059 (.088)
civil servant college			.076 (.112)	-.031 (.126)
polytechnic or college abroad			.084 (.070)	.063 (.074)
nationality (ref.: foreign)				
German			.034 (.051)	.009 (.061)
region (ref.: west)				
east			-.092 (.054)*	-.069 (.056)
log hourly wage			.201 (.061)***	.221 (.063)***
tenure			-.002 (.006)	.000 (.006)
tenure^2			.010 (.014)	.005 (.016)
self-employed			.080 (.070)	-.031 (.086)
firm size (ref.: 20 to 199 employees)				
less than 5				.126 (.079)
5 to 19				.103 (.054)*
200 to 1,999				.044 (.043)
2,000 or more				.037 (.049)
industry (ref.: public sector)				
agriculture, forestry, fisheries				.016 (.161)
mining, utilities				.018 (.143)
building industry				-.198 (.101)*
manufacturing				-.110 (.098)
wholesale, retail trade				-.001 (.119)
hotels & restaurants				-.246 (.154)
transport, communications				.007 (.119)
credit, insurance, real estate				.069 (.123)
data processing, R&D, business services				-.069 (.118)
other services				-.206 (.096)**
other sectors				-.072 (.147)
constant	.223 (.021)***	.240 (.028)***	-.243 (.244)	-.227 (.264)
R^2	.349	.350	.488	.519
number of observations	544	544	492	481

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses.

[i]) Men who were between 50 and 60 years old in 1997.

Source: Author's calculations based on SOEP 1997, 1999 and 2001.

Table A.5: Employment status change of older workers[i] from 1997 to 1999 – TSLS results, second-stage regressions, full table

dependent variable: change in employment status 1997 → 1999				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.172 (.049)***	-.140 (.048)***	-.114 (.086)	-.110 (.085)
age (ref.: age 50-54)				
age 55-60		.219 (.031)***	.212 (.033)***	.222 (.034)***
education (ref.: university degree)				
lower secondary education or less			.093 (.104)	.031 (.106)
other vocational education			-.023 (.108)	-.082 (.112)
apprenticeship			.052 (.061)	.016 (.068)
specialized vocational school			-.052 (.098)	-.074 (.106)
technical/commercial college			-.101 (.068)	-.121 (.071)*
civil servant college			-.030 (.081)	-.033 (.095)
polytechnic or college abroad			-.023 (.108)	-.015 (.065)
nationality (ref.: foreign)				
German			.158 (.079)**	.137 (.077)*
region (ref.: west)				
east			-.019 (.056)	.001 (.056)
log hourly wage			-.075 (.060)	-.032 (.065)
tenure			-.005 (.006)	-.001 (.006)
tenure^2			.014 (.015)	.005 (.015)
self-employed			-.098 (.052)*	-.193 (.098)**
firm size (ref.: 20 to 199 employees)				
less than 5				.076 (.109)
5 to 19				.051 (.065)
200 to 1,999				.009 (.043)
2,000 or more				.055 (.047)
industry (ref.: public sector)				
agriculture, forestry, fisheries				.278 (.145)*
mining, utilities				.192 (.127)
building industry				.046 (.091)
manufacturing				.054 (.079)
wholesale, retail trade				.092 (.092)
hotels & restaurants				.435 (.267)
transport, communications				.137 (.097)
credit, insurance, real estate				-.005 (.096)
data processing, R&D, business services				.014 (.100)
other services				-.024 (.088)
other sectors				.195 (.164)
constant	.252 (.028)***	.128 (.026)***	.248 (.233)	.054 (.263)
R^2	.037	.116	.160	.191
number of observations	544	544	492	481

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses.

[i]) Men who were between 50 and 60 years old in 1997.

Source: Author's calculations based on SOEP 1997 and 1999.

Table A.6: Employment status change of older workers[i] from 1997 to 2001 – TSLS results, second-stage regressions, full table

dependent variable: change in employment status 1997 → 2001				
variable (reference group)	**(1)**	**(2)**	**(3)**	**(4)**
computer use at work	-.117 (.069)*	-.060 (.062)	.009 (.109)	.024 (.107)
age (ref.: age 50-54)				
age 55-60		.393 (.038)***	.393 (.041)***	.410 (.042)***
education (ref.: university degree)				
lower secondary education or less			.177 (.116)	.111 (.125)
other vocational education			.104 (.137)	.027 (.143)
apprenticeship			.182 (.072)**	.159 (.080)**
specialized vocational school			.119 (.114)	.135 (.116)
technical/commercial college			.087 (.090)	.071 (.096)
civil servant college			.082 (.118)	.193 (.131)
polytechnic or college abroad			.114 (.077)	.081 (.083)
nationality (ref.: foreign)				
German			.103 (.085)	.068 (.085)
region (ref.: west)				
east			.032 (.062)	.050 (.064)
log hourly wage			.031 (.073)	.064 (.078)
tenure			-.006 (.007)	-.001 (.007)
tenure^2			.019 (.017)	.005 (.018)
self-employed			-.168 (.069)**	-.365 (.109)***
firm size (ref.: 20 to 199 employees)				
less than 5				.245 (.119)**
5 to 19				.054 (.069)
200 to 1,999				-.062(.057)
2,000 or more				.018 (.059)
industry (ref.: public sector)				
agriculture, forestry, fisheries				.251 (.162)
mining, utilities				.358 (.138)***
building industry				.156 (.112)
manufacturing				.223 (.101)**
wholesale, retail trade				.103 (.111)
hotels & restaurants				.155 (.270)
transport, communications				.230 (.112)**
credit, insurance, real estate				.123 (.147)
data processing, R&D, business services				.159 (.125)
other services				.133 (.110)
other sectors				.426 (.194)**
constant	.400 (.034)***	.177 (.036)***	-.139 (.276)	-.427 (.310)
R^2	.009	.177	.214	.248
number of observations	544	544	492	481

Notes: ***, **, * indicate significance at the 1%, 5% and 10% level. Robust standard errors in parentheses.

[i]) Men who were between 50 and 60 years old in 1997.

Source: Author's calculations based on SOEP 1997, 1999 and 2001.

B Appendix for Chapter 3

Table B.1: Firm characteristics I

	proportion^{i}	N
firm size (in groups)		
less than 10 employees	.21	221
10-49	.39	404
50-249	.29	295
250-499	.05	56
500 or more employees	.06	59
firm age less than 7 years	.11	118
industry		
consumer goods	.08	81
chemical industry	.05	56
other raw materials	.07	70
metal and machine construction	.12	123
electrical engineering	.06	66
precision instruments	.09	88
automobile manufacturing	.05	51
wholesale trade	.05	48
retail trade	.08	85
transportation and postal services	.07	73
banks and insurances	.05	53
electronic processing/telecommunication	.07	75
technical services	.08	86
other business-related services	.08	80
region		
east	.24	244
west	.76	791
expected development of turnover^{ii}		
decline	.22	226
constant	.40	416
increase	.38	393
works council exists	.32	334
firm provides training	.81	837
firm provides IT training	.61	636
firm provides IT training for older workers	.29	296

Notes: Characteristics of firms included in the sample for analyzing the proportion of older workers. N = 1,035.

^{i}) Percentage in sample.

^{ii}) Expectation concerning the development of turnover in 2004 compared to 2003.

Source: Author's calculations based on ZEW ICT survey 2004.

Table B.2: Firm characteristics II

	Mean	Std. Dev.	Min	Max
firm size	129	408.53	1	8,000
prop. of older workers in 2006	.21	.17	0	1
prop. of workers with a university degree	.22	.26	0	1
prop. of part-time workers	.12	.16	0	1
prop. of workers using a computer^{i}	.48	.34	0	1
prop. of workers receiving IT training	.13	.21	0	1
prop. of older workers receiving IT training	.10	.23	0	1
prop. of younger workers receiving IT training	.13	.22	0	1
IT intensity^{ii}	.00	1.00	-2.74	3.01

Notes: Number of observations: 1,035. Characteristics of firms included in the sample for analyzing the proportion (prop.) of older workers. All variables are taken from wave 2004, except the proportion of older workers in 2006 (taken from wave 2007).
Older workers are those aged 50 years or above. Younger workers are less than 50 years old.
^{i}) Employees who predominantly work with a computer.
^{ii}) IT intensity is an indicator comprising several IT variables. See section 3.2.2 for details.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

Table B.3: Firm characteristics I of subsamples

	IT-intensive firms[i]		less IT-intensive firms[i]	
	prop.[ii]	**N**	**prop.**[ii]	**N**
firm size (in groups)				
less than 10 employees	.16	89	.27	132
10-49	.38	207	.41	197
50-249	.31	169	.26	126
250-499	.08	43	.03	13
500 or more employees	.08	44	.03	15
firm age less than 7 years	.12	68	.10	50
industry				
consumer goods	.07	41	.08	40
chemical industry	.05	25	.06	31
other raw materials	.05	29	.08	41
metal and machine construction	.09	50	.15	73
electrical engineering	.07	37	.06	29
precision instruments	.07	41	.10	47
automobile manufacturing	.03	18	.07	33
wholesale trade	.05	25	.05	23
retail trade	.05	28	.12	57
transportation and postal services	.05	29	.09	44
banks and insurances	.08	42	.02	11
electronic processing/telecommunication	.13	73	.00	2
technical services	.12	67	.04	19
other business-related services	.09	47	.07	33
region				
east	.19	105	.29	139
west	.81	447	.71	344
works council exists	.38	211	.26	123
expected development of turnover[iii]				
decline	.19	106	.25	120
constant	.37	205	.44	211
increase	.44	241	.31	152
firm provides training	.90	498	.70	339
firm provides IT training	.78	429	.43	207
firm provides IT training for older workers	.40	220	.16	76

Notes: Characteristics of firms included in the subsamples for analyzing the proportion (prop.) of older workers.

[i]) IT intensity is an indicator comprising several IT variables. IT-intensive firms are those firms with IT intensity greater than zero (N=552), less IT-intensive firms have an IT intensity of less than or equal to zero (N=483). See section 3.2.2 for details.

[ii]) Percentage in sample.

[iii]) Expectation concerning the development of turnover in 2004 compared to 2003.

Source: Author's calculations based on ZEW ICT survey 2004.

Table B.4: Firm characteristics II – subsample: IT-intensive firms

	Mean	Std. Dev.	Min	Max
firm size	177	531.34	1	8,000
prop. of older workers in 2006	.17	.15	0	.83
prop. of workers with a university degree	.30	.28	0	1
prop. of part-time workers	.11	.14	0	.95
prop. of workers using a computer^{i}	.65	.31	0	1
prop. of workers receiving IT training	.18	.24	0	1
prop. of older workers receiving IT training	.15	.28	0	1
prop. of younger workers receiving IT training	.19	.25	0	1
IT intensity^{ii}	.74	.56	0	3.01

Notes: Number of observations: 552. Characteristics of subsample firms. All variables are taken from wave 2004, except the proportion (prop.) of older workers in 2006 (taken from wave 2007). Older workers are those aged 50 years or above. Younger workers are less than 50 years old.
^{i}) Employees who predominantly work with a computer.
^{ii}) IT intensity is an indicator comprising several IT variables. IT-intensive firms are those firms with IT intensity greater than zero, less IT-intensive firms have an IT intensity of less than or equal to zero. See section 3.2.2 for details.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

Table B.5: Firm characteristics II – subsample: less IT-intensive firms

	Mean	Std. Dev.	Min	Max
firm size	74	172.20	1	2,000
prop. of older workers in 2006	.25	.19	0	1
prop. of workers with a university degree	.12	.19	0	1
prop. of part-time workers	.13	.17	0	1
prop. of workers using a computer^{i}	.28	.25	0	1
prop. of workers receiving IT training	.06	.13	0	1
prop. of older workers receiving IT training	.04	.14	0	1
prop. of younger workers receiving IT training	.07	.15	0	1
IT intensity^{ii}	-.85	.66	-2.74	0

Notes: Number of observations: 483. See Table B.4.
Source: Author's calculations based on ZEW ICT survey 2004 and 2007.

C Appendix for Chapter 4

Table C.1: Regional characteristics of East and West German counties, 2001

regional variable	Germany	East	West
proportion of Internet users	0.32	0.27***	0.33
rurality^{i}	0.24	0.37***	0.20
proportion of population aged between 15 and 29	0.17	0.19***	0.17
proportion of highly qualified employees	0.07	0.09***	0.07
proportion of one-person households	0.34	0.33	0.34
proportion of students	0.02	0.02	0.02
unemployment rate	0.11	0.18***	0.08
proportion of foreign population	0.07	0.02***	0.09
disposable household income per capita (in Euro)	1,336	1,149***	1,405
number of counties	312	85	227

Notes: Mean values of regional figures for the year 2001.
*** indicates that East German means significantly differ from West German values at the 1% level (measured by a t-test on the equality of means).
^{i}) Proportion of population in communities with a population density of less than 150 inhabitants per square kilometer.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2003.

Table C.2: Comparison of rural, suburban, and urban German counties, 2001

regional variable	rural	suburban	urban
proportion of Internet users	0.26***	0.31	0.34
rurality[i]	0.55***	0.25***	0.12
proportion of population aged between 15 and 29	0.18***	0.18***	0.17
proportion of highly qualified employees	0.05***	0.07***	0.09
proportion of one-person households	0.30***	0.33*	0.35
proportion of students	0.01**	0.02	0.02
unemployment rate	0.11*	0.11*	0.10
proportion of foreign population	0.04***	0.06***	0.10
disposable household income per capita (in Euro)	1,211***	1,305***	1,418
number of counties	49	137	126

Notes: Mean values of regional figures for the year 2001.
***, **, * indicate that means are significantly different from urban means at the 1%, 5% and 10% level (measured by a t-test on the equality of means).
[i]) Proportion of population in communities with a population density of less than 150 inhabitants per square kilometer.
Source: Author's calculations based on SOEP 2001, INKAR 2002 and 2003, Statistik regional 2002.

Table C.3: Characteristics of new Internet users, non-users, and experienced users^{i}, 2001

individual variable	non-users	new users	experienced users
number of individuals	11,280	2,346	3,036
age in years	42.6	36.8***	36.7
male	0.45	0.51***	0.62***
single	0.20	0.27***	0.34***
one-person-household	0.10	0.08***	0.11***
German nationality	0.87	0.94***	0.95
education			
number of individuals^{ii}	11,028	2,293	2,973
lower secondary education or less	0.26	0.22***	0.20
other vocational education	0.02	0.01	0.01
apprenticeship	0.42	0.35***	0.29***
specialized vocational school	0.11	0.11	0.08***
technical/commercial college	0.05	0.06**	0.07
civil servant college	0.02	0.03***	0.03
polytechnic or college abroad^{iii}	0.08	0.11***	0.12**
university	0.05	0.13***	0.20***
occupational status			
number of individuals^{ii}	11,159	2,299	2,984
employed full-time	0.46	0.54***	0.61***
employed part-time	0.15	0.17***	0.14***
apprentice	0.04	0.05***	0.04***
not employed	0.25	0.21***	0.20
retired	0.11	0.03***	0.02***
income of household (in 1,000 Euro)	4.44	5.44***	5.87***

Notes: Mean values of individual characteristics for 2001.
***, ** indicate that means are significantly different at the 1% and 5% level: means of new users are compared with those of non-users, means of experienced users are compared with those of new users (measured by a t-test on the equality of means).
^{i}) Experienced Internet users are those with more than one year usage experience.
^{ii}) Differences in the number of observations originate from missing values in the data set.
^{iii}) College abroad: in the data it is not clear what kind of degree is meant.
Example: In 2001, the proportion of singles among the new users is 27 percent, among the non-users the single proportion is 20 percent.
Source: Author's calculations based on SOEP 2001.

Table C.4: Proportion of new users[i], experienced users[ii], and non-users by county type

regional variable	total	rural	suburban	urban
Germany				
new users	0.14	0.13	0.15	0.14
experienced users	0.18	0.13	0.16	0.21
non-users	0.68	0.74	0.69	0.65
number of individuals	16,662	1,839	5,787	9,036
East Germany				
new users	0.14	0.11	0.14	0.16
experienced users	0.16	0.10	0.13	0.20
non-users	0.70	0.80	0.73	0.64
number of individuals	4,533	781	1,691	2,061
West Germany				
new users	0.14	0.15	0.15	0.13
experienced users	0.19	0.15	0.17	0.21
non-users	0.67	0.70	0.68	0.66
number of individuals	12,129	1,058	4,096	6,975

Notes: Mean values for the year 2000.
[i]) Proportion of total population of those who became new users in 2000 or 2001.
[ii]) Proportion of total population of those with more than one year Internet use experience.
Source: Author's calculations based on SOEP 2001, INKAR 2002.

Table C.5: Proportion of new users among hitherto non-users by county type

new users	total	rural	suburban	urban
Germany	0.17	0.15**	0.17	0.18
number of individuals	2,346	243	841	1,262
East Germany	0.17	0.12***	0.16***	0.20
number of individuals	645	83	235	327
West Germany	0.17	0.18	0.18	0.17
number of individuals	1,701	160	606	935

Notes: Mean values for the year 2000.
*** and ** indicate that means are significantly different from urban means at the 1% and 5% level (measured by a t-test on the equality of means).
Source: Author's calculations based on SOEP 2001, INKAR 2002.

Table C.6: Determinants of starting home Internet use in 2000 or 2001 – IV-Probit results, first-stage regressions

dependent variable: proportion of experienced Internet users		
variable (reference group)	**(1)**	**(2)**
county type (ref.: urban)		
rural	-.047 (.015)***	-.047 (.015)***
suburban	-.030 (.011)***	-.030 (.011)***
west		.018 (.046)
prop. of highly qualified employees	.512 (.166)***	.605 (.305)**
unemployment rate	-.465 (.124)***	-.375 (.207)*
prop. of foreigners	-.249 (.187)	-.284 (.223)
prop. of one-person households	.250 (.096)***	.229 (.121)*
further covariates[i]	demographic and job-related characteristics	
constant	.114 (.031)***	.094 (.048)*
number of observations	12,480	12,480

Notes: Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
[i]) Further covariates are: male, single, one-person household, German nationality, education, log net income of household, occupational status.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

Table C.7: Determinants of starting home Internet use in 2000 or 2001 – IV-Probit results, second-stage regressions, full table

dependent variable: probability of starting home Internet use		
variable (reference group)	**(1)**	**(2)**
userrate[i]	1.730 (.679)**	2.021 (.682)***
county type (ref.: urban)		
rural	-.018 (.078)	-.005 (.080)
suburban	.005 (.052)	.015 (.053)
west		-.063 (.042)
age in years (ref.: age less than 25)		
25-34	.240 (.059)***	.232 (.059)***
35-44	-.184 (.046)***	-.186 (.046)***
45-54	-.449 (.054)***	-.453 (.054)***
55-64	-.803 (.061)***	-.807 (.061)***
male	.194 (.029)***	.197 (.029)***
single	-.094 (.046)**	-.095 (.046)**
one-person household	.135 (.059)**	.138 (.059)**
German nationality (ref: foreigner)	.507 (.069)***	.492 (.070)***
education (ref.: university degree)		
lower secondary education or less	-.628 (.068)***	-.611 (.068)***
other vocational education	-.516 (.123)***	-.505 (.122)***
apprenticeship	-.548 (.062)***	-.533 (.063)***
specialized vocational school	-.417 (.068)***	-.407 (.068)***
technical/commercial college	-.342 (.091)***	-.332 (.093)***
civil servant college	-.339 (.108)***	-.326 (.108)***
polytechnic or college abroad	-.236 (.063)***	-.234 (.064)***
occup. status (ref.: employed full-time)		
employed part-time	.130 (.044)***	.135 (.044)***
apprentice	-.038 (.077)	-.036 (.077)
not employed	.008 (.040)	.009 (.040)
retired	-.222 (.070)***	-.220 (.069)***
log net income of household	.442 (.049)***	.451 (.048)***
constant	-1.766 (.158)***	-1.786 (.158)***
log pseudolikelihood	8672.861	8682.445
number of observations	12,480	12,480
Wald test of exogeneity $chi^2(Prob < chi^2)$	2.20 (.138)	3.39 (.066)*

Notes: Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
Instruments for *userrate*: proportion of highly qualified employees, regional unemployment rate, proportion of foreigners, and proportion of one-person households.
[i]) Proportion of Internet users with more than one year usage experience by county.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

Table C.8: Determinants of starting home Internet use in 2000 or 2001 – East and West Germany, IV-Probit results, first-stage regressions

dependent variable: proportion of experienced Internet users		
variable (reference group)	**East**	**West**
county type (ref.: urban)		
rural	-.028 (.025)	-.049 (.019)***
suburban	-.014 (.020)	-.028 (.013)**
prop. of highly qualified employees	.539 (.303)*	1.240 (.290)***
prop. of foreigners	.811 (.267)***	-.569 (.231)**
prop. of one-person households	.149 (.179)	.036 (.107)
further covariates[i]	demographic and job-related characteristics	
constant	.021 (.046)	.135 (.029)***
number of observations	3,590	8,890

Notes: Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
[i]) Further covariates are: male, single, one-person household, German nationality, education, log net income of household, occupational status.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

Table C.9: Determinants of starting home Internet use in 2000 or 2001 – East and West Germany, IV-Probit results, second-stage regressions, full table

dependent variable: probability of starting home Internet use		
variable (reference group)	**East**	**West**
userrate^{i}	1.406 (.728)*	1.814 (.802)**
county type (ref.: urban)		
rural	-.248 (.119)**	.095 (.083)
suburban	-.052 (.093)	.018 (.059)
age in years (ref.: age less than 25)		
25-34	.278 (.109)**	.185 (.072)**
35-44	-.176 (.0909)*	-.210 (.052)***
45-54	-.610 (.100)***	-.414 (.063)***
55-64	-.845 (.110)***	-.824 (.074)***
male	.126 (.045)***	.240 (.037)***
single	-.182 (.099)*	-.059 (.052)
one-person household	.171 (.113)	.130 (.069)*
German nationality (ref: foreigner)	.073 (.181)	.484 (.074)***
education (ref.: university degree)		
lower secondary education or less	-.639 (.133)***	-.592 (.082)***
other vocational education	-.900 (.239)***	-.333 (.149)**
apprenticeship	-.755 (.113)***	-.449 (.072)***
specialized vocational school	-.625 (.108)***	-.309 (.083)***
technical/commercial college	-.618 (.154)***	-.200 (.108)*
civil servant college	-.628 (.244)***	-.252 (.120)**
polytechnic or college abroad	-.202 (.100)**	-.295 (.083)***
occup. status (ref.: employed full-time)		
employed part-time	.044 (.089)	.171 (.052)***
apprentice	-.155 (.124)	.013 (.099)
not employed	.022 (.067)	.020 (.050)
retired	-.347 (.135)***	-.156 (.084)*
log net income of household	.443 (.112)***	.463 (.050)***
constant	-.973 (.265)***	-1.923 (.185)***
log pseudolikelihood	2916.646	6201.775
number of observations	3,590	8,890
Wald test of exogeneity $chi^2(Prob < chi^2)$	1.53 (.217)	1.62 (.203)

Notes: Standard errors (clustered at regional level) in parentheses.
***, **, * indicate significance at the 1%, 5% and 10% level.
Instruments for *userrate*: proportion of highly qualified employees, proportion of foreigners, and proportion of one-person households.
^{i}) Proportion of Internet users with more than one year usage experience by county.
Source: Author's calculations based on SOEP 2001, INKAR 2002 to 2005, Statistik regional 2002.

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Mannheim, 16. April 2008 *Katrin Schleife*