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Older Workers and the Adoption of New Technologies

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Non-technical Summary

In the face of the demographic development, characterized by an increasing life expectancy and a simultaneous decrease in birthrates, the age structure of the working population is observably changing. The employment rate of individuals between 55 and 64 years has increased particularly in the last five years. In the EU-25 the employment rate of this age group has increased by 5.9 percentage points from 2000 to 2005 and amounted to about 42 percent in 2005. The employment rate of individuals between 15 and 24 years has decreased by about 1.3 percentage points in the same time period.

Several studies show that compared to younger employees older workers are less likely and less qualified to use information and communication technologies (ICT). In an economy that is marked by rapid technological progress, the demographic development on the one hand and the relationship between older workers and ICT on the other hand provide a great challenge for the firms. The question arises, whether firms engaging many older workers are less likely to adopt new or significantly improved technologies or software than firms with a younger workforce. For the first time, this question is analyzed for firms belonging to the German knowledge intensive service sector and the information and communication technology service sector. These sectors are particularly challenged by the mentioned coherences as they exhibit two main characteristics that have determined their economic performance. First, structure, quality and organization of human capital inside the firms are exceptionally important aspects in the production of the services they provide. Second, they make an intensive use of ICT, relying on a continuous adoption of new technologies and software.

Following the literature on the so called age-biased technological change in manufacturing sectors, this paper finds that also in the ICT and knowledge intensive services sector the age structure of the workforce is negatively related to the probability of adopting new or significantly improved technologies and software. Firms with a higher share of employees being younger than 30 years are more likely to adopt new technologies than firms with a higher share of 40 to 55 year-old workers. Furthermore, the results reveal that the older the workforce the less likely is the adoption of new technologies or software.

Previous studies find a complementary relationship between the use of ICT and modern human resource practices. Furthermore, there is some empirical evidence for the manufacturing sector, that the share of older workers is lower in firms with applied innovative workplace practices. Related to these findings the combined impact of the age structure of the workforce and changes in the workplace organization on the probability of adopting new technologies is analyzed. The results show that a specific age structure of the workforce should be accompanied by appropriate workplace organization. Part of the firms that flattened their hierarchies, enhanced their teamwork and exhibit a higher share of younger workers are less likely to adopt new or significantly improved technologies. By contrast some of the firms that changed their workplace organization and have a higher share of older employees are more likely to adopt new technologies.

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Abstract: For the first time data of German ICT and knowledge intensive service providers are used to analyze the relation between the age structure of the workforce and the probability of adopting new technologies. The results show that firms with a higher share of younger employees are more likely to adopt new technologies and the older the workforce the less likely is the adoption of new technologies. Furthermore the results exhibit that the age structure of the workforce should be accompanied by appropriate workplace organization. A part of the firms which enhanced teamwork or flattened their hierarchies are actually more likely to adopt new technologies and software when they have a higher share of older employees whereas they are less likely to introduce new technologies if they have a higher share of younger employees.

Keywords: age structure of the workforce, adoption of new technologies, ICT intensive services
JEL-Classification: J14, O31

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1 Introduction

In the face of the demographic development, characterized by an increasing life expectancy and a simultaneous decrease in birthrates, the age structure of the working population is observably changing. The employment rate of individuals between 55 and 64 years has increased particularly in the last five years. In the EU-25 the employment rate of this age group has increased by 5.9 percent from 2000 to 2005 and amounted to about 42 percent in 2005. The employment rate of individuals between 15 and 24 years has decreased by about 1.3 percentage points in the same time period (Eurostat 2007a). In Germany the employment rate of individuals between 55 and 64 years reaches a level of about 45 percent in the year 2005 (see Figure A.1 in the appendix). Several studies show that compared to younger employees older workers are less likely and less qualified to use information and communication technologies (ICT) (e.g. de Koning and Gelderblom 2006, Schleife 2006). In an economy that is marked by rapid technological progress, the demographic development on the one hand and the relationship between older workers and ICT on the other hand provide a great challenge for the firms. Especially for firms belonging to ICT intensive and human capital intensive sectors an efficient relationship between these two factors is crucial for the successful development of those sectors.

In particular, this is the case for knowledge intensive service providers (e.g. tax consultancy and accounting, architecture) and for information and communication technology service providers (e.g. telecommunication services, software and IT services). These sectors contribute to about 8 percent of the sales in the German Economy (Statistisches Bundesamt 2006). These industries exhibit two main characteristics that have determined their economic performance. First, structure, quality and organization of human capital inside the firms are exceptionally important aspects in the production of the services they provide. Second, they make an intensive use of ICT, relying on a continuous adoption of new technologies and software. Considering the previous empirical results concerning the relationship between older workers and ICT it can be hypothesized that firms of the mentioned industries engaging older workers are less likely to adopt new or significantly improved technologies than firms of these industries with a younger workforce.

This paper analyzes this hypothesis by focussing on the relationship between the age structure of the workforce and the adoption of new technologies of ICT and knowledge intensive service providers. Thereby it takes into account other factors that may affect the likelihood of the adoption of new technologies or software. The analyses are based on a data set of 374 German firms from the IT-related services sector. The paper also analyzes the robustness of the results by testing different specifications. The empirical results show that firms with a higher share of younger employees are more likely to adopt new technologies and the older the workforce the less likely is the adoption of new technologies. Besides the age of the workforce, the customer requirements, the introduction of product innovations and the firm size also impact the adoption of new or significantly improved technologies and software.

Previous studies find a complementary relationship between the use of ICT and modern human resource practices, such as team work and performance-related wages (Bresnahan, Brynjolfsson, and Hitt 2002, Bertschek and Kaiser 2004). Furthermore, there is some empirical evidence, that the share of older workers is lower in firms with applied innovative workplace practices (Beckmann 2001, Aubert, Caroli, and Roger 2006). Related to these findings the impact of an interaction between changes in the workplace organization and the age structure of the workforce on the probability of adopting new technologies is analyzed. The results show that a specific age structure of the workforce should be accompanied by appropriate workplace organization. Firms that flattened their hierarchies, enhanced their teamwork and have a higher share of younger workers are less likely to adopt new or significantly improved technologies. By contrast firms that changed their workplace organization and have a higher share of older employees are more likely to adopt new technologies. This result however only holds for some of the firms, depending on their predicted probability to adopt new technologies.

This paper is organized as follows. The second section reviews the background discussion in existing economic literature on the relation between older workers, ICT and technology adoption and workplace organization. Then follows a description of the used data, the 46th wave of the quarterly business survey among IT-related service providers conducted by the Centre for European Economic Research (ZEW), and some descriptive statistics. In the fourth section the estimation strategy and the empirical results are presented. Section five concludes and gives an outlook on further demands on research.

2 Background Discussion

This paper focuses on the relationship between the age structure of the workforce and the adoption of new or significantly improved technologies or software in ICT and knowledge intensive service providing firms. Therefore it is related to several strands of the literature.

There is the literature on older workers and ICT. Furthermore, as the adoption of new technologies in the IT-related services sectors can be seen as a process innovation,[1] the literature on older workers and process innovations is also concerned. There are several studies using individual data that show that compared to younger employees older workers are less likely and less qualified to use ICT. Friedberg (2003) analyzes the relationship between computer use at work and the age of the workers using individual data on American workers in the year 1993. Her results reveal, that workers younger than 60 years use a computer more often than workers older than 60 years. Using individual-level data from 1997 of German male workers Schleife (2006) finds that the probability of computer use among workers aged between 55 and 64 years is significantly lower than that of workers between 25 and 34 years. Borghans and ter Weel

[1] According to the Oslo Manual (OECD, Eurostat 2005), "a process innovation is the implementation of a new or significantly improved production or delivery method". This includes significant changes in equipment, techniques and/or software (OECD, Eurostat 2005). The firms of these service industries are not inventing or creating new processes. As Hempell (2003) states, the service providing firms, especially those of the knowledge intensive branches rely on the inputs of the industry. So a process innovation is a change in the process of creating services, caused by the introduction of new technologies or software, provided by the industry or other service providers.

(2002) and de Koning and Gelderblom (2006) show in their analyses that the computer skills of younger employees are better than those of older workers. De Koning and Gelderblom (2006) additionally exhibit that the probability of using complicated ICT applications at work is lower among workers above 50 years. Other papers analyze the reverse effect, thus how does the use of IT or the adoption of new technologies affect the share of older workers. Bertschek (2004) shows in her analysis with German firm level data that the higher the IT-intensity, the lower the share of employees being 50 years or older. There is only weak empirical evidence for the opposite. Beckmann (2001) finds that a firm which has invested in IT leads to positive impacts on the employment of older workers. He measures ICT usage by using a dummy variable for ICT investments. This dummy variable, however, does not reflect to what extent the employees are affected by the corresponding investment in ICT.

The literature on the so called age-biased technological change using firm-level data finds that technological progress negatively impacts the share of older workers or older low-skilled workers (Behaghel and Greenan 2007). Aubert, Caroli, and Roger (2006) examine the impact of innovations on the wage-bill share of workers from different age groups in France. They find that the wage-bill share of older workers (aged 50 years and above) is lower in innovative firms, i.e. innovative firms tend to be biased against age. Beckmann (2005) finds that technological change has a negative impact on the share of older employees in West German firms. Schneider (2007) uses a linked employer-employee approach to analyze the impact of the age structure of the workforce on product innovations of German manufacturing firms. He finds signifcant effects of the age structure of the workforce on the technological innovativeness and an inverse u-shaped age innovation profile. There are only few empirical investigations, that analyze the relation between process innovation and the age of the workforce in manufacturing firms. Rouvinen (2002) analyzes the characteristics of product and process innovations in the Finnish manufacturing sector. He finds, that an increasing average employee age, although he uses this variable as proxy for firm age, reduces the probability of process innovation. Another analysis that examines the relation between innovation and the age of the workforce is the one from Nishimura, Minetaki, Shirai, and Kurokawa (2004). They investigate the interaction between age and qualification of the employees and its impact on technological progress in Japanese industries. They only have a small sample and find no significant impact of old workers (above 40 years) with high qualification (share of old workers with high education to the total labor inputs) on the rate of technological progress in non-manufacturing industries. But they find that the share of old workers with high qualification in the 1990s reduces the rate of technological progess in the manufacturing industries.

The relationship between technological change and ICT on the one hand and older workers on the other hand is explained by two main hypotheses: (1) Using two data sets from the U.S., Friedberg (2003) states that the more infrequent use of computers amongst older workers is related to the imminent retirement. Investment in computer skills does not pay off any longer. She finds that computer users tend to retire later than non-users probably due to comparative advantages and because they are ready to invest in training. Furthermore, her results reveal that the more infrequent use of computers amongst older workers can be explained by the differences across occupations and education. Empricial evidence for Germany by Schleife (2006) suggests that age does not play a significant role for the retirement decision when controlling for other factors such as qualification, work experience, etc. Borghans and ter Weel (2002) even find that the imminent retirement of older workers is no significant parameter affecting the disuse of computers. The discussion about technological change and the retirement decision is related to the vintage human capital models (MacDonald and Weisbach 2004). Within technological change and innovation human capital may become obsolete. So older workers may offer resistance to innovation when their human capital might be ridden off. (2) Weinberg (2004) argues from a different point of view. He states that the ability to learn how to use a computer declines with increasing age. This is in line with the so called "deficit-model" that explains the process of aging from a gerontological point of view. This model assumes that older people compared to younger ones loose important features, they show defects and deficits. This affects physical (fading physical strength or decelerated reactions) and psychic skills (cutback of brainpower, especially of fluid brainpower which is the one needed amongst others for new solutions and a fast processing of informations (Börsch-Supan, Düzgün, and Weiss 2005)) as well as constricted interests and reduced social activities (Walter 1995). This can be referenced to the economic context and the labor market. Asked what kind of attributes emerge in which age group and how important those features are, personnel officers reply that skills like learning aptitude, willingness to learn or flexibility can be less found by older workers compared to younger ones (Boockmann and Zwick 2004). These skills, however, are especially important for the implementation of process innovation in terms of adopting new technologies or software.

There is a broad literature suggesting that the implementation of new IT systems often goes hand in hand with organizational changes in firms. Therefore, IT investment and organizational investment are interpreted as strategic complementarities (Brynjolfsson and Hitt 2000, Bresnahan, Brynjolfsson, and Hitt 2002, Bertschek and Kaiser 2004). This discussion is mainly focussed on decentralizing organizational measures implying more involvement of employees in decision making processes and more responsibilities of employees. Some examples are team work, flat hierarchies, autonomous working groups or incentive pay - measures supposed to positively affect the information flow within firms and the motivation of the employees. The use of innovative workplace practices such as teamwork and flat hierarchies (Gera and Gu 2004, Webster 2004) may provide a better environment for the adoption of new technologies because of the existing complementarities (Milgrom and Roberts 1990, Hitt and Brynjolfsson 1997, Bresnahan, Brynjolfsson, and Hitt 2002). The implementation of a new information and communication or software system often requires a restructuring of the firm to use the new system efficiently. Thus, it appears likely that workplace reorganization has to be changed accordingly to make the operating process more efficient. But the other way round, it is also possible, that the introduction or enhancement of teamwork and the flattening of hierarchies may have an impact on the probability of introducing new technologies or software.

Taking into account the complementary relationship between ICT and workplace organization, there is also some empirical evidence on the relationship between older workers and organizational structures. These studies find that innovative workplace practices giving more decision-making authority and responsibility to employees is negatively related to the employment of older workers. Using West German firm level data for the years 1993 to 1995 Beckmann (2001, 2005) finds that organizational changes have significantly negative effects on the precentage share of workers aged 50 or more. Aubert, Caroli, and Roger (2006) provide empirical evidence for France using linked employer-employee data. They find that the more innovative workplace practices are applied in the firm the lower is the percentage share of older workers. But not only the internal organization may affect the probability to introduce new technologies or software, but also the external environment of the firm. The market and customers with their requirements (de Jong, Bruins, Dolfsma, and Meijaard 2003) and the competitive situation may result in the need to introduce new technologies or software to keep up with the surrounding development.

3 Data and Descriptive Statistics

The data used for the empirical analyses is taken from the quarterly business survey among IT-related service providers conducted by the Centre for European Economic Research (ZEW). The IT-related services sector comprises the information and communication technology service providers (enterprises of the branches software and IT services, ICT specialized trade as well as telecommunication services) and knowledge intensive service providers (enterprises of the branches tax consultancy and accounting, management consultancy, architecture, technical consultancy and planning, research and development as well as advertising). This work mainly uses the data of the 46th wave (3rd quarter 2005). The dataset is designed as panel data. Some informations also have been taken from the 45th, 48th and 49th wave. The final dataset includes 374 firms.[2]

The adoption of new or significantly improved technologies and software is embodied by a dummy variable.[3] To analyze how the age of the workforce affects the adoption of new technologies or software, four age groups of employees that have been surveyed are used. In a second step, interactions between these age groups and a change in the workplace organization are provided to test whether complementarities exist.[4]

Table 3.1 shows some descriptive statistics of the data, comparing those firms that adopted new or significantly improved technologies in the last twelve months to those firms that did not. Most of the employees are older than 30 years and younger than 55 years. About 57.4 percent of the employees of those firms that adopted new technologies are younger than 40 years compared to about 49 percent of the employees of the firms that did not adopt new technologies. The share of older workers is higher in firms that did not adopt new technologies. As Table 3.1 shows, about

[2]For the composition of the used sample and further details see the appendix.
[3]The firms answered the following question: Did you adopt new or significantly improved technologies in the last 12 months?
[4]A list of the variables used and some summary statistics can be found in Table A.2 in the appendix.

39 percent of the employees in firms not having adopted new technologies are between 40 and 55 years old compared to 32.6 percent of the employees of firms that adopted new technologies. The share of employees being 55 years and older is about 12 percent in the firms that did not adopt new or improved technologies compared to about 10 percent in the firms with technology adoption.

Table 3.1: Descriptive statistics

feature	firms that adopted new technologies	firms that did not adopt new technologies	total sample
share of employees below 30 years	24.7%	18.0%	21.4%
share of employees between 30 and 40 years	32.7%	31.0%	31.8%
share of employees between 40 and 55 years	32.6%	38.7%	35.6%
share of employees above 55 years	10.2%	12.3%	11.2%
share of highly qualified employees	37.9%	36.9%	37.4%
flattening of hierachies	34.9%	21.8%	28.5%
enhancement of teamwork	48.8%	29.2%	39.1%
changed customer requirements	80.1%	53.3%	67.0%
foreign competitors	59.1%	45.3%	52.3%
firm size (number of employees)	53.0	32.3	42.8
exporters	36.1%	33.0%	34.5%

Source: ZEW, own calculations

Comparing firms that adopted new or significantly improved technologies to those that did not adopt new technologies one can see that there is nearly no difference between them in terms of the share of highly qualified employees, in particular 38 percent compared to about 37 percent (see Table 3.1). This seems striking as there has been a lot of discussion in the skill-biased technological change literature (e.g. **?**, **?**), suggesting that the use of new technologies and the diffusion of IT change the skill requirements (**?**, **?**) and thus lead to an increase in demand for highly qualified labour (see for instance **?** for the case of Germany).

Table 3.1 reveals that amongst firms that adopted new technologies the share of firms whose workplace organization changed (enhancement of teamwork and flattening of hierachies) in the last three years is higher than amongst firms that did not adopt new technologies. On the one hand, this can be a signal for the generally higher propensity to change and innovate in certain firms. On the other hand it reflects the complementary relationship between ICT and workplace organization.

More than half of the firms that adopted new technologies is competing with foreign firms, whereas this share is lower among the firms that did not adopt new or significantly improved technology as Table 3.1 shows. About 80 percent of the firms that adopted new technologies report changed customer requirements in the last three years, just more than half of the firms that did not adopt new technologies had to face changed customer requirements.

The exporting activities between the two types of firms differ only sligtly. About 36 percent of the firms that adopted new or improved technologies in the last twelve months is exporting services abroad, but only 33 percent of the firms that did not adopt new technologies is doing so. Moreover, larger firms are adopting new technologies rather than smaller firms. Those firms that adopted new technologies or software in the last twelve months have on average about 53 employees, whereas firms, that did not adopt new technologies have only about 32 employees on average.

The descriptive analysis of the data also shows, that the adoption of new or significantly improved technologies varies across industries. Firms belonging to the software and IT services branch are the ones, that mostly adopted new technologies. Slightly more than 60 percent of these firms introduced new technologies or software within the last twelve months. Firms belonging to the research and development sector, however, are rarely adopting new technologies, about 36 percent report to have adopted new or significantly improved technologies (see Figure A.2 in the appendix).

4 Empirical Analysis

4.1 Estimation Strategy

In the following, the hypothesis that firms with a higher share of older workers are less likely to adopt new or significantly improved technologies is analyzed. The variable measuring the decision to adopt new or significantly improved technologies and software is a dummy variable and has the following form:

$$\text{technology adoption} = \begin{cases} 1 & \text{if the firm adopted new technologies} \\ 0 & \text{if the firm did not.} \end{cases}$$

Thus, the impact of several independent variables on a dichotomous dependent variable will be examined.[5]

$$prob(technology\ adoption = 1) = F(\alpha + \beta age + \gamma X + \delta controls + \epsilon) \qquad (1)$$

where $prob(\cdot)$ is the probability that a firm adopts a new or significantly improved technology, β is a coefficient vector that describes the impact of four different age groups of employees. The coefficient vector γ shows the effects of several other firm and market characteristics, δ represents a vector of coefficients regarding controls such as sector dummies and a dummy variable for East Germany and ϵ is the unobservable error term. A Probit model is used, assuming the error term ϵ is normally distributed.

The impact of each age group on the probability of adopting new technologies is estimated seperately. Additionally, all four age groups are estimated altogether, taking the group of employees below 30 years as the reference group. To check the robustness of the results, four different specifications are taken into account. In specification (1) besides the age structure and the controls, the share of highly qualified employees and dummy variables for the firm size are

[5] All calculations and estimations of this paper have been done with STATA 9.1.

considered.[6] Additionally, in specification (2), the firm age, a dummy variable for exporting activity and a dummy variable for foreign competition are regarded. Older firms may be more traditional than their younger counterparts and therefore less inclined to change the operating process. Exporters may depend on the latest communication technologies in order to stay in contact with their customers abroad. In specification (3) dummy variables for changes in the workplace organization (enhancement of teamwork and flattening of hierarchies) and a change in the customer and market requirements within the last three years are added. The share of employees working predominantly with a computer measures the IT-intensity of the firm. This share and a dummy variable for product innovation are additionally considered in specification (4). The introduction of a product innovation may lead to a change in the operating process and therefore to the adoption of new technologies.[7]

Taking into account the relationship between ICT and workplace organization as well as between workplace organization and older workers, in a second step, the interaction between the age groups and a change in the workplace organization is taken into account. As the magnitude of the interaction effect in a Probit model does not equal the marginal effect of the interaction term, the method proposed by Ai and Norton (2003) and Norton, Wang, and Ai (2004) is used.[8] In a Probit model, the magnitude of a interaction effect requires computing the cross derivative or cross difference of the expected value of the dependent variable. When one continuous and one dummy variable are interacted with each other the interaction effect is the discrete difference (with respect to the dummy variable) of the single derivative (with respect to the continuous variable). Using their method, the interaction effect is found by computing the cross derivatives (or differences). The standard error of the interaction effect is computed by applying the Delta method. The test for statistical significance has to be based on the estimated cross-partial derivative.

4.2 Results

The estimation results can be found in Tables A.3 to A.6 in the appendix. As the estimated coefficients in a Probit model only allow to make a statement on the significance and the sign of an effect but not on the extent, only the marginal effects are discussed in the following. Table 4.1 reports the average marginal effects of the four age groups in the Probit estimations of the four different specifications. As the data is cross sectional the results only reveal correlations and no causal relationships. It can be seen that firms with a higher share of employees being younger than 30 years have a higher probability to adopt new technologies, whereas firms with a higher share of employees being between 40 and 55 years have a lower likelihood to introduce new or significantly improved technologies. The results also reveal, that the older the workforce the less probable the adoption of new or significantly improved technologies.

[6] Bigger firms may profit from emerging economies of scale.

[7] Note however, that there may be some endogeneity problems. The age of the workforce may be endogenous, but at this stage, it is assumed that the age of the workforce is a constant factor, that doesn't significantly change within twelve months. Moreover, the dummy variable for product innovation may be endogenous, but the data doesn't provide appropriate instruments to control for this endogeneity.

[8] Only specification (4) is used to estimate the impact of the interaction effects between the age groups and the workplace organization.

In particular, an increase in the share of employees below 30 years by one percent is related to an increase in the probability of adopting new technologies by 0.43 percentage points (see second column of Table 4.1, specification (1)). This result holds for all four specifications and the marginal effect lies between 0.42 and 0.49. This may be due to two reasons. Workers below 30 years have a high productivity and a high potential concerning the mastery of equipment and software (?). Moreover, the knowledge of this age group may still be up to date as their educational attainment has been achieved recently.

The likelihood of adopting new technologies and software is related to a decrease of 0.25 percentage points in the likelihood of adopting new technologies if the share of employees between 40 and 55 years increases by one percent (see fourth column of Table 4.1, specification (1)). This finding is robust, as the effect is valid for all four specifications, although in specification (3) and (4) the significance level of the marginal effect is lower. The marginal effect is between 0.21 and 0.27. It may seem striking that it is not the group of employees being older than 55 years, but the group of employees between 40 and 55 years that has a negative impact on the probability of adopting new technologies. On the one hand, this may be due to data restrictions, as the variation in the variable share of employees above 55 years is rather small. On the other hand however, this result is in line with further findings. De Koning and Gelderbloom (2006) find that the negative impact of age on ICT skills is higher for employees being between 50 and 54 years, than for those being older than 55 years. Furthermore, the result of the estimation may be explained by the different tasks the employees are doing. Workers between 40 and 55 years may be fully involved in the service creation process and therefore are affected by the adoption of new technologies or software. Employees above 55 years however may have rather administrative duties and not be occupied in the production of the provided services and therefore are not affected by the adoption of new technologies or software. Finally, this result could also be explained by some selectivity, which means that only the capable workers are still employed at the age of 55 or more.

The last column of Table 4.1 contains the result of estimating all four age groups together. Compared to the share of employees below 30 years an increase in the share of employees being older than 30 years is related to a decrease in the probability of adopting new or significantly improved technologies, whereas the older the workforce the less likely is the adoption of new technologies or software. Table 4.1 shows that the probability to adopt new technologies is related to a decrease of 0.32 percentage points if the share of employees between 30 and 40 years decreases by one percent compared to the share of employees below 30 years (specification (1)). An increase in the share of employees between 40 and 55 years by one percent lowers the probability of introducing new technologies and software by about 0.46 percentage points (specification (1)). An increase in the share of workers older than 55 years by one percent, compared to the share of workers below 30 years, is related to a decrease of 0.47 percentage points in the likelihood of the adoption of new technologies or software (specification (1)). This result is robust as it holds for all four specifications.

Table 4.1: Marginal effects of Probit estimations

Variable	marg. effect (std. error)	marg. effect (std. error)	marg. effect (std. error)	marg. effect (std. error)	marg. effect (std. error)
(1)					
share of employees below 30 years	0.432*** (0.138)				reference categorie
share of employees between 30 and 40 years		0.059 (0.132)			-0.318* (0.172)
share of employees between 40 and 55 years			-0.253** (0.113)		-0.460*** (0.147)
share of employees above 55 years				-0.217 (0.113)	-0.467** (0.212)
(2)					
share of employees below 30 years	0.453*** (0.140)				reference categorie
share of employees between 30 and 40 years		0.087 (0.139)			-0.306* (0.177)
share of employees between 40 and 55 years			-0.268** (0.117)		-0.465*** (0.150)
share of employees above 55 years				-0.347* (0.209)	-0.567*** (0.221)
(3)					
share of employees below 30 years	0.421*** (0.149)				reference categorie
share of employees between 30 and 40 years		0.016 (0.142)			-0.329* (0.187)
share of employees between 40 and 55 years			-0.207* (0.118)		-0.415*** (0.156)
share of employees above 55 years				-0.351 (0.218)	-0.575** (0.236)
(4)					
share of employees below 30 years	0.491*** (0.165)				reference categorie
share of employees between 30 and 40 years		0.007 (0.156)			-0.403* (0.211)
share of employees between 40 and 55 years			-0.216* (0.123)		-0.487*** (0.171)
share of employees above 55 years				-0.340 (0.248)	-0.603** (0.259)

Significance levels : * : 10% ** : 5% *** : 1%

An older staff hence is negatively related to the likelihood of introducing new or significantly improved technologies in the operating process. This is partly in line with the finding of Schneider (2007) who finds an inverse u-shaped age innovation profile in the manufacturing sector. Furthermore, the results support the empirical evidence found by Rouvinen (2002) and Nishimura, Minetaki, Shirai, and Kurokawa (2004). They also find a negative influence of older employees on the (process) innovation probability in the manufacturing industries. This issue may be explained by two different hypotheses. Firstly, it may be that older workers have more problems to adopt to changes in the operating process, especially when they have a longer tenure. This is supported by the "deficit-model" mentioned before and by the study of Morris and Venkatesh (2000). This effect could be boosted by the kind of changes, if especially new technologies or software cause problems for older workers as stated by e.g. de Koning and Gelderblom (2006) and Schleife (2006) or Borghans and ter Weel (2002), who find that employees being older than 30 years have lower ICT-skills. Secondly, older firms which mainly employ older workers with longer job tenure may be more traditional itself and therefore less inclined to innovate or to change the working routine at all. This explanation, however, can be excluded, as the firm age has no significant impact on the likelihood of adopting new technologies (see Tables A.4 - A.6 in the appendix).

Besides the age of the workforce the adoption of new or significantly improved technologies is simultaneously affected by some other factors. The analysis however reveals that not all of the variables controlled for are significant. It can be seen that the firm size positively affects the probability of adopting new technologies. Firms with more than 9 employees are more likely to adopt new technologies (see Tables A.3 - A.6 in the appendix). This can be explained by emerging economies of scale. The larger the firm, the cheaper the introduction of new technologies or software per employee. Another point may be decreasing training costs, as the adoption of new technologies or software involves training requirements (**?**).

Furthermore, changed customer requirements positively affect the probability of adopting new or significantly improved technologies. Firms that had to face changed market or customer requirements within the last three years are more likely to adopt new technologies (see Tables A.5 and A.6 in the appendix). This result seems plausible since the provision of knowledge intensive services and ICT services comes along with a high degree of interaction with clients and customers respectively (**?**). On the other hand, the firms analyzed in this study are mostly small and medium sized firms. **?**De Jong and Brouwer (1999) find in their literature review that the customer information and a close cooperation with them is one of the main sources for (product) innovation in SMEs. As, especially in the service sector, a change in the operating process through new methods (in this case especially new information and communication technologies) may lead to improved services, the influence of the customer requirements is indispensable.

The introduction of product innovations is positively related to the likelihood of adopting new technologies and software. Firms that offer new services are more likely to adopt new technologies (see Table A.6 in the appendix). On the one hand, this can be explained by a generally higher willingness of the firm to innovate or renew the operating process itself. On the other hand, in the services sector product innovations and process innovations can't be distinguished easily. A process innovation, as the adoption of new or significantly improved technologies, allows to improve the quantity or quality of a provided service by keeping the input constant, reducing the supply costs or accelerating the process (Hempell 2003). This change in the provided service, caused by a process innovation, is in turn interpretable as product innovation. The data don't offer apropriate instruments to control for endogeneity or simultaneity problems arising in this context.

Table A.7 in the appendix shows the interaction effects between changes in the workplace organization and the share of employees belonging to one of the four age groups, their standard errors and their z-statistics, computed by the method of Ai and Norton (2003) and Norton, Wang, and Ai (2004) instead of using the standard STATA output. The interpretation of the interaction effect is based on figures A.3 and A.4 in the appendix, as the interaction effect, the standard errors and the z-statistic are calculated for each observation.[9] For each interaction effect two graphs are presented. The first graph plots two interaction effects (one is calculated by the method of Norton, Wang, and Ai (2004), and the other one is calculated by the conventional linear method) against predicted probabilities and the second graph of each interaction effect plots the z-statistics against predicted probabilities.

As the upper left graph in Figure A.3 shows, firms with a higher share of younger workers and an enhancement of teamwork in the last three years are less likely to adopt new technologies as firms that did not enhance teamwork. This effect is lower for firms whose probability to adopt new technologies or software is rather low or rather high in absolute terms and higher for firms whose probability to adopt new technologies or software lies between 0.2 and 0.8. The effect however is only significant for the latter firms, as can be seen in the upper right graph in Figure A.3. Regarding the interaction between the enhancement of teamwork and the share of employees between 40 and 55 years, the interaction effect is reverse. Firms that enhanced teamwork in the last three years and have a higher share of employees between 40 and 55 years are more likely to adopt new technologies compared to firms that did not enhance teamwork. This effect is higher for firms whose probability to adopt new or significantly improved technologies is about 0.5 (see lower left graph in Figure A.3 in the appendix). Nevertheless, only few of the firms that have a predicted probability to adopt new technologies between 0.25 and 0.75 have statistically significant effects, as can be seen in the lower right graph in Figure A.3 in the appendix.

With respect to the flattening of hierarchies in the last three years, a similar picture is drawn. Firms that flattened their hierarchies and have a higher share of employees below 30 years are less likely to adopt new technologies compared to firms without a change in the workplace organization. This effect is higher for firms whose predicted probability to adopt new technologies is around 0.5 and smaller for firms whose predicted probability is rather high or low, as we can see in the upper left graph in Figure A.4 in the appendix. But this effect is only significant

[9] Only the significant effects are reported.

for those firms whose predicted probability is between 0.2 and 0.8, as the upper right graph in Figure A.4 in the appendix shows. The effect of the share of employees between 40 and 55 years in firms that flattened their hierarchies is also reverse. As we can see in the lower left graph in Figure A.4 in the appendix, firms that flattened their hierarchies and have a higher share of workers being between 40 and 55 years old are more likely to adopt new technologies and software than firms that did not flattened their hierarchies. This effect is higher for those firms whose predicted probability is around 0.5 and lower for those whose predicted probability is rather low or high. Nevertheless, here the effect is only significant for some of those firms whose predicted probability is between 0.3 and 0.7 as the lower right graph in Figure A.4 in the appendix shows.

The empirical results show that the age structure of firms has to be combined with appropriate workplace organizations in order to keep up with the technological development. A part of the firms with a higher share of younger workers and innovative workplace practices are less likely to adopt new technologies and some firms with a higher share of workers between 40 and 55 years and enhanced teamwork and flattened hierarchies have a higher probability to adopt new technologies. This is in contrast to former empirical evidence from the manufacturing sector, which finds that workplace reorganization is negatively related to the share of older employees (e.g. Beckmann 2005, Aubert, Caroli, and Roger 2006). However, the results presented here are only significant for some firms in the sample and furthermore are regarding a certain part of the services sector.

5 Conclusion

Due to the demographic development the workforce is getting older. As older people appear to be less likely and less qualified to use ICT, the age structure of the workforce may have an impact on the efficiency of the adoption of new or significantly improved technologies and software. In particular this may be the case for industries that are ICT intensive, relying on the continuous adoption of new technologies or software.

Using a cross-sectional data set of 374 firms of the German ICT and the knowledge intensive service providers in the year 2005 this paper finds that the age structure of the workforce is negatively related to the probability of adopting new or significantly improved technologies and software. Firms with a higher share of younger employees are more likely to adopt new technologies. This is in line with the literature that analyzes the impact of the age of the employees on the probability of technological change and innovations in the manufacturing industries. The results reveal that firms with a higher share of employees being younger than 30 years have a higher probability to adopt new technologies, whereas firms with a higher share of employees being between 40 and 55 years have a lower likelihood to introduce new technologies or software. After comparing the four age groups it becomes clear, that the older the workforce the less likely is the adoption of new technologies or software.

The use of innovative workplace practices may provide a better environment for the adoption of new technologies and the relationship between ICT and workplace organization is complementary. Therefore, the interaction between the share of employees below 30 years and the share of employees between 40 and 55 years, the flattening of hierarchies and the enhancement of teamwork is analyzed. The results exhibit contrary effects. Firms that flattened their hierarchies, enhanced their teamwork and have a high share of younger workers are less likely to adopt new technologies than firms that did not change their workplace organization. Firms that changed their workplace organization and have a higher share of older employees are more probable to adopt new technologies compared to firms without workplace reorganization. It seems that firms with a certain age structure of the workforce need appropriate workplace organization to keep up with the technological development. This result, however, is only significant for some firms in the sample, depending on their predicted probability to adopt new technologies.

Finally, the analyses show that there are further factors affecting the adoption of new or significantly improved technologies and software such as firm size, the change of market and customer requirements and the introduction of product innovation.

As the cross-sectional data on the one hand do not allow to give statements about causality but only about correlations and on the other hand offer no appropriate instruments to control for potential endogeneity of the age of the workforce as well as of the endogeneity of the introduction of product innovations, future research shall focus on this caveat. Analyzing the relationship between the age structure of the workforce and the adoption of new technologies and software by using a panel dataset could also help to control for unobserved heterogeneity in this context.

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A Appendix

The ZEW quarterly business survey in the German IT-related services sector includes the following industries (codes of the German Classification of Economic Activities, Edition 2003 in parentheses): software and IT services (71.33.0, 72.10.0-72.60.2), ICT specialized trade (51.43.1, 51.43.3-3.4, 51.84.0, 52.45.2, 52.49.5-9.6), telecommunication services (64.30.1-0.4), tax consultancy and accounting (74.12.1-2.5), management consultancy (74.11.1-1.5, 74.13.1-3.2, 74.14.1-4.2), architecture (74.20.1-0.5), technical consultancy and planning (74.20.5-0.9), research and development (73.10.1-73.20.2) and advertising (74.40.1-0.2). Table A.1 shows, how the industries are distributed in the sample.

Table A.1: Distribution of industries in the sample

Industry	Percentage
software and IT services	9.63
ICT specialized trade	17.65
telecommunication services	4.28
tax consultancy and accounting	16.58
management consultancy	8.82
architecture	13.64
technical consultancy and planning	11.50
research and development	12.03
advertising	5.88
sum	100

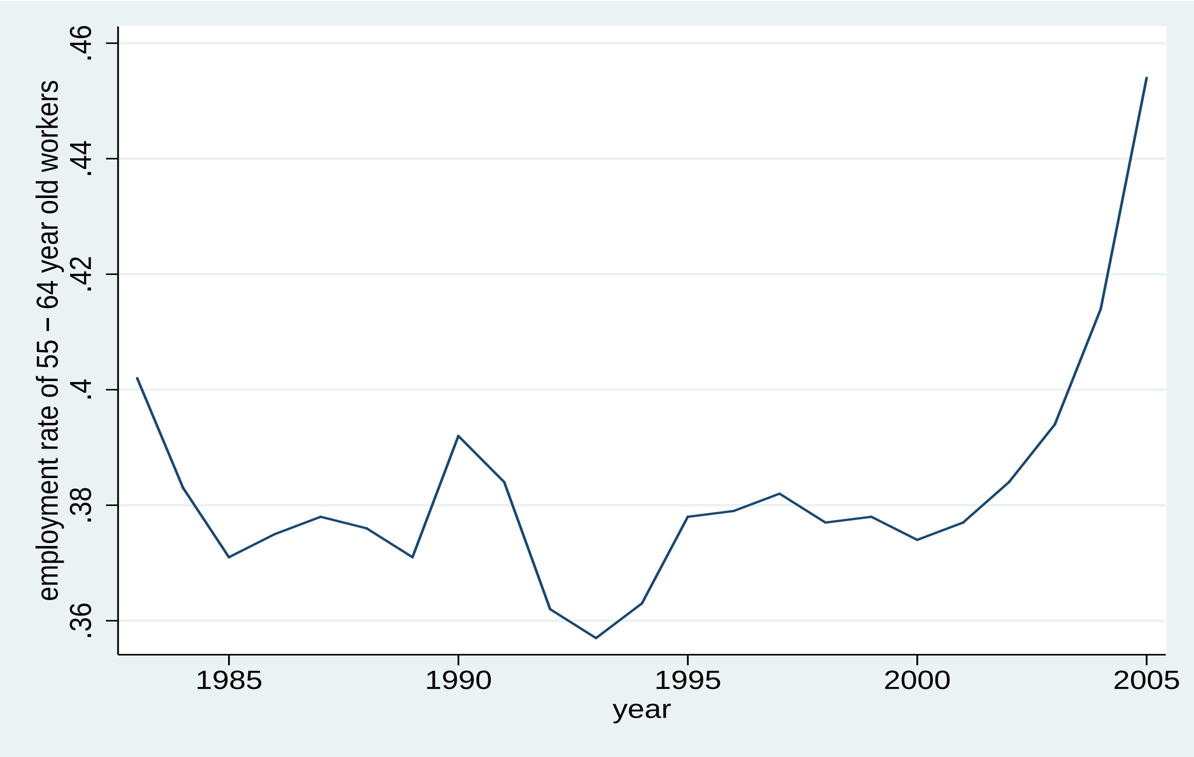
Source: ZEW, own calculations

It contains mostly small- or medium-sized firms. In the composed sample the biggest firm has about 1,033 employees.

The 46th wave of the survey, used here, includes information on the age structure of the workforce, the qualification level of the employees, the implemented process, product and organizational innovations, the export activity and foreign competitors.

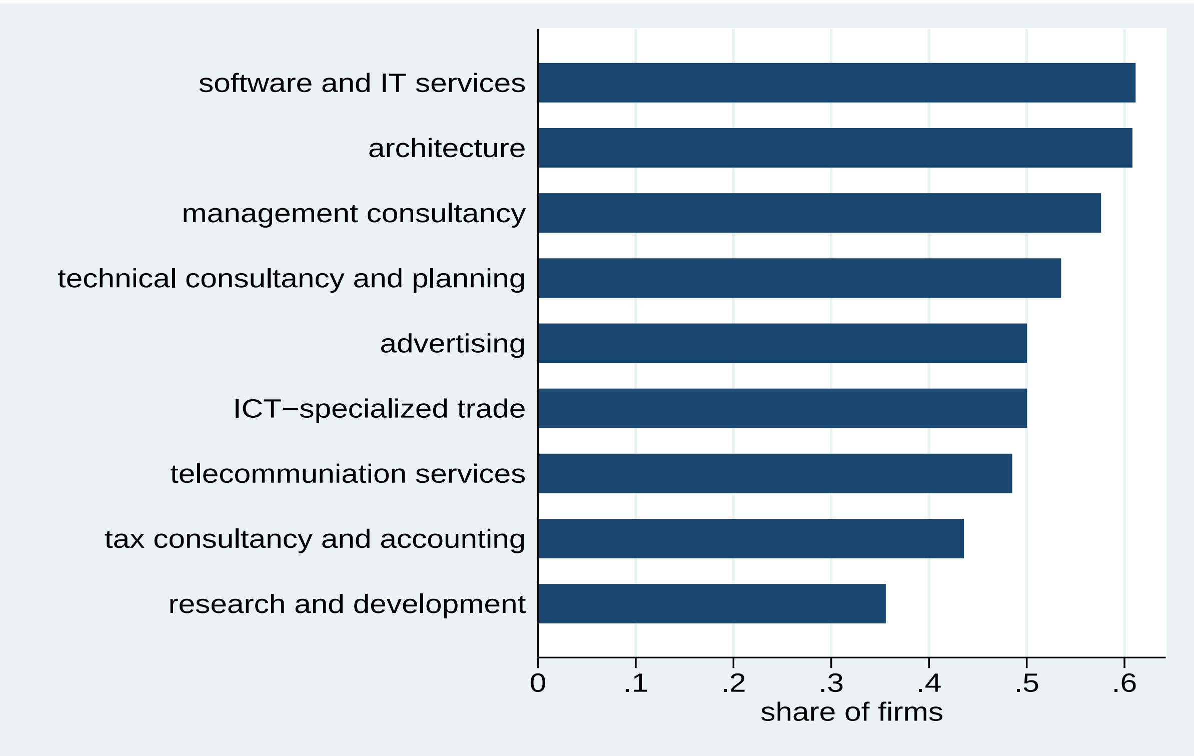
As the survey is constructed as a panel, gaps can be filled with data from other waves. The number of employees is created from the information on the age structure and the qualification level of the employees from the 46th wave. The information on the share of employees working predominantly with a computer (IT-intensity) is taken from the 45th, 48th and 49th wave.

Figure A.1: Development of the employment rate of 55 - 64 year old workers



Source: Eurostat (2007b)

Figure A.2: Share of firms that adopted new technologies by sectors



Source: ZEW, own calculations

Table A.2: Summary Statistics

Variable	Number of observations	mean
process innovation	374	0.5053
product innovation	334	0.4940
share of employees below 30 years	374	0.2136
share of employees between 30 and 40 years	374	0.3185
share of employees between 40 and 55 years	374	0.3562
share of employees above 55 years	374	0.1117
share of highly qualified employees	374	0.3743
teamwork	338	0.3905
flat hierarchies	337	0.2849
customer requirements	336	0.6696
firm size 1-9 employees	374	0.3021
firm size 10-19 employees	374	0.2540
firm size 20-49 employees	374	0.2086
firm size more than 50 employees	374	0.2353
firm age	370	19.5
foreign competitors	348	0.5230
exporter	365	0.3452
IT-intensity (share of employees working predominantly with a computer)	319	0.7747
East Germany	374	0.2674
software and computer services	374	0.0963
ICT specialized trade	374	0.1765
telecommunication services	374	0.0428
tax consultancy and accounting	374	0.1658
management consultancy	374	0.0882
architecture	374	0.1362
technical consultancy and planning	374	0.1150
research and development	374	0.1203
advertising	374	0.0588

Source: ZEW, own calculations

Table A.3: Results of Probit estimation (1)

	dependent variable: dummy for adoption of new technologies				
Variable	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**
share of employees below 30 years	1.150***				reference
	(0.381)				categorie
share of employees between 30 and 40 years		0.155			-0.848*
		(0.345)			(0.466)
share of employees between 40 and 55 years			-0.668**		-1.228***
			(0.302)		(0.408)
share of employees above 55 years				-0.568	-1.247**
				(0.514)	(0.577)
share of highly qualified employees	0.150	0.013	0.038	0.019	0.114
	(0.254)	(0.253)	(0.253)	(0.253)	(0.257)
firm size (dummy variable=1 if 1-9 employees)			reference categorie		
firm size (dummy variable=1 if 10-19 employees)	0.265	0.332*	0.306*	0.303	0.237
	(0.183)	(0.181)	(0.182)	(0.184)	(0.187)
firm size (dummy variable=1 if 20-49 employees)	0.297	0.412**	0.347*	0.387*	0.259
	(0.202)	(0.198)	(0.201)	(0.200)	(0.206)
firm size (dummy variable=1 if 50 or more employees)	0.321*	0.430**	0.371*	0.404**	0.286
	(0.194)	(0.190)	(0.193)	(0.192)	(0.198)
East Germany	-0.081	-0.111	-0.091	-0.105	-0.069
	(0.162)	(0.162)	(0.162)	(0.163)	(0.162)
industry dummies jointly significant	no	no	no	no	no
Intercept	-0.634*	-0.381	-0.094	-0.269	0.487
	(0.348)	(0.316)	(0.330)	(0.314)	(0.432)
N	374	374	374	374	374
Log-likelihood	-245.181	-249.561	-247.386	-249.007	-244.613
$\chi^2_{(14)}$	27.491	17.88	23.134	19.412	
$\chi^2_{(16)}$					28.399

Significance levels : $*$: 10% $**$: 5% $***$: 1% heteroscedasticity-robust standard errors

Table A.4: Results of Probit estimation (2)

dependent variable: dummy for adoption of new technologies					
Variable	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**
share of employees below 30 years	1.231***				reference
	(0.396)				(categorie)
share of employees between 30 and 40 years		0.231			-0.835*
		(0.370)			(0.491)
share of employees between 40 and 55 years			-0.722**		-1.270***
			(0.322)		(0.426)
share of employees above 55 years				-0.929*	-1.551**
				(0.559)	(0.620)
share of highly qualified employees	0.124	-0.066	-0.015	-0.048	0.081
	(0.286)	(0.285)	(0.287)	(0.285)	(0.289)
firm size (dummy variable=1 if 1-9 employees)			reference categorie		
firm size (dummy variable=1 if 10-19 employees)	0.407**	0.462**	0.440**	0.423**	0.364*
	(0.195)	(0.195)	(0.196)	(0.199)	(0.200)
firm size (dummy variable=1 if 20-49 employees)	0.341	0.467**	0.402*	0.432**	0.297
	(0.222)	(0.217)	(0.221)	(0.219)	(0.227)
firm size (dummy variable=1 if 50 or more employees)	0.311	0.420**	0.359*	0.384*	0.263
	(0.214)	(0.209)	(0.213)	(0.211)	(0.218)
firm age	0.000	0.000	0.000	0.000	0.000
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
exporter	0.035	0.048	0.065	0.024	0.034
	(0.171)	(0.168)	(0.169)	(0.169)	(0.171)
foreign competitors	0.239	0.259*	0.226	0.272*	0.228
	(0.156)	(0.155)	(0.156)	(0.155)	(0.157)
East Germany	-0.225	-0.233	-0.215	-0.239	-0.214
	(0.183)	(0.183)	(0.183)	(0.184)	(0.183)
industry dummies jointly significant	no	no	no	no	no
Intercept	-0.916**	-0.672*	-0.338	-0.512	0.266
	(0.369)	(0.359)	(0.372)	(0.427)	(0.469)
N	339	339	339	339	339
Log-likelihood	-217.815	-222.337	-220.214	-221.181	-216.905
$\chi^2_{(17)}$	32.329	22.961	27.779	26.027	
$\chi^2_{(19)}$					34.629

Significance levels : $*$: 10% $**$: 5% $***$: 1% heteroscedasticity-robust standard errors

Table A.5: Results of Probit estimation (3)

dependent variable: dummy for adoption of new technologies					
Variable	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**
share of employees below 30 years	1.281***				reference
	(0.465)				(categorie)
share of employees between 30 and 40 years		0.046			-1.003*
		(0.422)			(0.577)
share of employees between 40 and 55 years			-0.621*		-1.266***
			(0.355)		(0.490)
share of employees above 55 years				-1.048	-1.755**
				(0.656)	(0.734)
share of highly qualified employees	0.266	0.090	0.123	0.082	0.229
	(0.318)	(0.313)	(0.320)	(0.314)	(0.321)
firm size (dummy variable=1 if 1-9 employees)			reference categorie		
firm size (dummy variable=1 if 10-19 employees)	0.504**	0.548**	0.509**	0.508**	0.416**
	(0.231)	(0.227)	(0.230)	(0.232)	(0.233)
firm size (dummy variable=1 if 20-49 employees)	0.458*	0.584**	0.516**	0.557**	0.432*
	(0.250)	(0.243)	(0.246)	(0.245)	(0.252)
firm size (dummy variable=1 if 50 or more employees)	0.210	0.298	0.230	0.260	0.167
	(0.242)	(0.235)	(0.240)	(0.235)	(0.246)
firm age	-0.002	-0.002	-0.001	-0.001	-0.002
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
exporter	-0.115	-0.098	-0.096	-0.130	-0.134
	(0.190)	(0.188)	(0.188)	(0.190)	(0.191)
foreign competitors	0.203	0.237	0.210	0.238	0.197
	(0.178)	(0.176)	(0.178)	(0.176)	(0.179)
flat hierarchies	-0.142	-0.168	-0.160	-0.174	-0.151
	(0.210)	(0.204)	(0.206)	(0.203)	(0.209)
teamwork	0.441**	0.488**	0.473**	0.515***	0.467**
	(0.192)	(0.192)	(0.190)	(0.188)	(0.193)
customer requirement	0.809***	0.783***	0.777***	0.777***	0.793***
	(0.178)	(0.177)	(0.177)	(0.177)	(0.179)
East Germany	-0.166	-0.189	-0.183	-0.181	-0.161
	(0.203)	(0.203)	(0.203)	(0.205)	(0.204)
industry dummies jointly significant	no	no	no	no	no
Intercept	-1.565***	-1.209***	-0.949**	-1.078***	0.282
	(0.440)	(0.441)	(0.473)	(0.415)	(0.572)
N	297	297	297	297	297
Log-likelihood	-172.281	-176.141	-174.853	-175.025	-171.777
$\chi^2_{(20)}$	67.05	56.092	57.499	59.168	
$\chi^2_{(22)}$					67.039

Significance levels : $*$: 10% $**$: 5% $***$: 1% heteroscedasticity-robust standard errors

Table A.6: Results of Probit estimation (4)

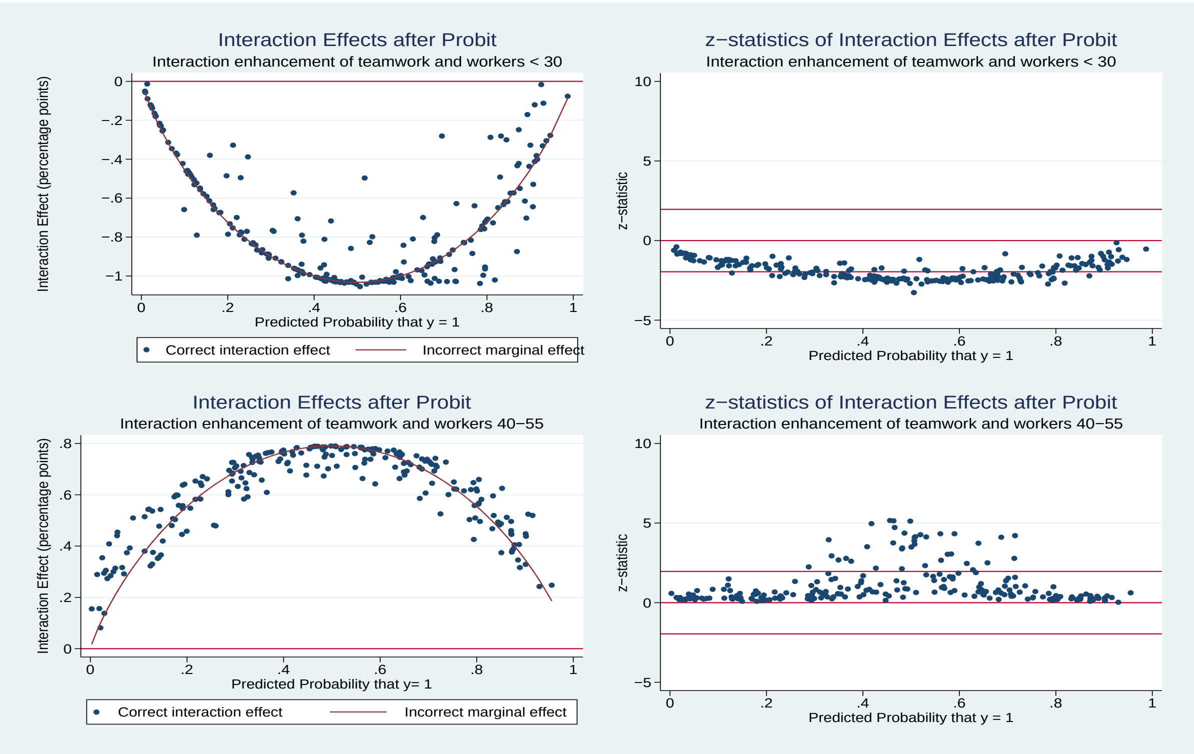
dependent variable: dummy for adoption of new technologies					
Variable	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**	**coefficient (Std. Err.)**
share of employees below 30 years	1.637***				reference
	(0.563)				(categorie)
share of employees between 30 and 40 years		0.021			-1.345*
		(0.500)			(0.712)
share of employees between 40 and 55 years			-0.701*		-1.624***
			(0.401)		(0.584)
share of employees above 55 years				-1.098	-2.014**
				(0.803)	(0.394)
share of highly qualified employees	0.247	-0.008	0.063	-0.029	0.215
	(0.388)	(0.374)	(0.388)	(0.378)	(0.394)
firm size (dummy variable=1 if 1-9 employees)			reference categorie		
firm size (dummy variable=1 if 10-19 employees)	0.424	0.488*	0.453*	0.436	0.385
	(0.270)	(0.264)	(0.265)	(0.271)	(0.273)
firm size (dummy variable=1 if 20-49 employees)	0.582**	0.724**	0.671**	0.695**	0.566*
	(0.292)	(0.282)	(0.285)	(0.285)	(0.294)
firm size (dummy variable=1 if 50 or more employees)	0.196	0.309	0.253	0.271	0.168
	(0.296)	(0.290)	(0.293)	(0.290)	(0.299)
firm age	0.006	0.004	0.006	0.005	0.006
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
exporter	-0.062	-0.032	-0.039	-0.073	-0.087
	(0.217)	(0.214)	(0.214)	(0.217)	(0.218)
foreign competitors	0.013	0.057	0.041	0.059	0.016
	(0.215)	(0.208)	(0.211)	(0.208)	(0.215)
flat hierarchies	-0.131	-0.133	-0.158	-0.151	-0.154
	(0.244)	(0.241)	(0.242)	(0.240)	(0.246)
teamwork	0.101	0.161	0.157	0.198	0.134
	(0.226)	(0.229)	(0.224)	(0.223)	(0.232)
customer requirement	0.761***	0.687***	0.694***	0.677***	0.743***
	(0.215)	(0.214)	(0.215)	(0.217)	(0.216)
product innovation	0.865***	0.858***	0.853***	0.842***	0.852***
	(0.208)	(0.206)	(0.207)	(0.206)	(0.209)
IT-intensity	0.119	0.224	0.154	0.217	0.104
	(0.370)	(0.355)	(0.354)	(0.360)	(0.368)
East Germany	-0.003	-0.093	-0.058	-0.074	0.010
	(0.252)	(0.247)	(0.249)	(0.249)	(0.254)
industry dummies jointly significant	no	no	no	no	no
Intercept	-1.986***	-1.555***	-1.248**	-1.383**	-0.334
	(0.567)	(0.546)	(0.559)	(0.558)	(0.720)
N	234	234	234	234	234
Log-likelihood	-125.127	-129.043	-127.87	-128.186	-124.846
$\chi^2_{(22)}$	80.698	61.081	66.98	64.162	
$\chi^2_{(24)}$					80.900

Significance levels : $*$: 10% $**$: 5% $***$: 1% heteroscedasticity-robust standard errors

Table A.7: Interaction effects

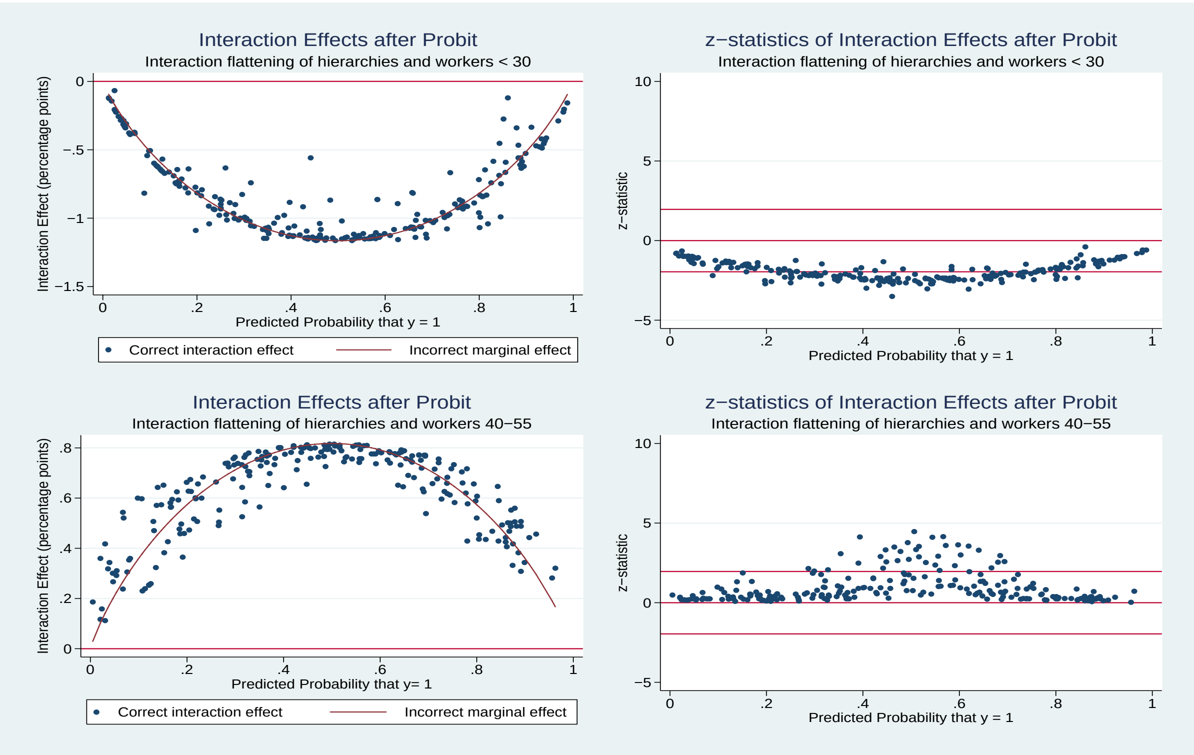
Variable	mean interaction effect	mean std. error	mean z-statistic
interaction with teamwork			
share of employees below 30 years	-0.732	0.375	-1.864
share of employees between 30 and 40 years	0.124	0.308	0.529
share of employees between 40 and 55 years	0.612	1.280	1.073
share of employees above 55 years	-0.405	1.020	-0.702
interaction with flat hierarchies			
share of employees below 30 years	-0.843	0.429	-1.921
share of employees between 30 and 40 years	0.004	0.118	0.030
share of employees between 40 and 55 years	0.625	1.348	0.965
share of employees above 55 years	0.258	0.610	0.687

Figure A.3: Interaction effects: enhancement of teamwork



Source: Own calculations based on estimation of specification (4), 234 observations

Figure A.4: Interaction effects: flattening of hierarchies



Source: Own calculations based on estimation of specification (4), 234 observations