Does Future PC Use Determine Our Wages Today? – Evidence from German Panel Data

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Abstract:

Using 1985–1999 data from the German Socio-Economic Panel Study (GSOEP) to analyze wages we confirm the hypothesis that existing computer wage premiums are determined by individual ability or other unobserved individual characteristics rather than by productivity effects. While a rather large personal computer (PC) wage premium was found in the cross-sectional regressions even after the inclusion of standard controls, the conventional longitudinal regression analysis revealed substantially lower or statistically insignificant coefficients, as have other studies. In addition, a new method of testing the two competing explanations for computer wage differentials against each other was found: future PC variables were employed in the wage regressions in order to obtain a further control for worker heterogeneity. The finding that future PC variables have a statistically significant effect on current wages leads one to conclude that computer wage differentials can be attributed to worker heterogeneity rather than to computer-induced productivity.

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1. Introduction

It is common knowledge that computer skills are remunerated well in the job market. Internships are only available for students with an excellent knowledge of word-processing and spreadsheet analysis, employers require at least one programming language, lectures are inconceivable without a video projector running a sophisticated presentation, statistics are impossible without powerful specialized programs, and informatics students can earn twice the salary of a well-paid economist. The objective of this study is to analyze why knowledge of computer applications pays so well. Of course, computer wage differentials may be justified, because computers enable workers to become more productive, which in turn makes them more valuable to their companies. On the other hand, there is much criticism of computer-related productivity improvements, and reasonable doubt that the PC wage premium is due solely to the increased productivity of computer systems. The question is, to what extent can existing PC wage differentials be attributed to computer-increased productivity, and to what extent can they be explained by individual differences in human capital investment or by unobservable individual characteristics such as ability?

Existing studies of computer wage premiums are divided about whether workers receive a computer wage premium because they are more able or because the new technology increases their productivity. According to the productivity-enhancing hypothesis, workers should be remunerated more highly as soon as they start using a computer at work, while the competing hypothesis states that PC users would already have been better-paid before the introduction of the new technology. Most existing studies of the role of computer technology in changes in the wage structure show that workers who use a computer at work earn 10 – 20% more than those who do not (see e.g., Krueger 1993, Bell 1996, Miller and Mulvey 1997, and DiNardo and Pischke 1997). One of the first studies to investigate the impact of computer use on wage differentials, by Krueger (1993), finds a computer wage premium of up to 15% using cross-section data. By contrast, Oosterbeek (1997) shows that, for the Netherlands, the computer wage premium does not vary with the intensity of computer use. He suggests that returns from computer use can be attributed to factors other than the higher productivity of PC-using workers. This might be the case because workers of high ability do the more demanding computer jobs. Gollac and Kramarz (1997) attribute this phenomenon to the frequent occurrence of changes in (computer) technology as well as in organization, where the capacity to adapt to those changes is rewarded. Furthermore, firms anticipate progress in computerization in the near future, and therefore search for a workforce that is already adapted to the new technology. DiNardo and Pischke (1997) also doubt any causal relationship between the use of computers at work and wage premiums. Using detailed information on German workers' jobs and on the tools used in those jobs, they find evidence of wage differentials ranging from 9% to 14% associated with other "white-collar" tools such as calculators, telephones, and pencils, as well as evidence of a wage penalty linked to "blue-collar" tools. These findings suggest that the tools approximate the occupational wage structure, and that workers who use computers on the job possess unobserved skills, which lead to higher wages.

Whereas cross-section studies are inadequate for capturing the individual components of wage determination, various panel studies have investigated the effect of unobserved heterogeneity on the computer wage premium. Bell (1996) analyzes the impact of computer use on earnings, using data for the United Kingdom. He finds empirical support for the productivity-enhancing explanation in the form of a wage premium for computer use of 17% after the inclusion of worker and employer characteristics, such as firm size, industry and occupation dummies, and one of 14% after adding ability test scores. His findings of a positive relation between wages and PC use at work, using cross-section data for 1991, are confirmed by the panel study and by a cross-section study for 1981, in which he uses future skills (observed in 1991) as covariates. Bell (1996) therefore refutes the suggestion that the computer wage premium simply captures unobserved heterogeneity. This interpretation is also supported by Miller and Mulvey (1997) who conduct a cross-section study for Australia.

However, the studies that use matched employee-employer data, by Doms, Dunne, and Troske (1997) for the U.S., and by Entorf and Kramarz (1994, 1997) for France, demonstrate that new technology workers received a wage premium before the introduction of this technology. These studies find that controlling for firm heterogeneity attenuates the wage premium received by workers for using computer-related new technology. In the longitudinal studies by Entorf and Kramarz (1994, 1997), the significance of the computer variables almost completely disappears, whereas the coefficients of computer experience remain significant. They show that the wage premium is due to computer-based new technologies being used by more able workers, which suggests that "firms select their best employees when they need someone to work using computer-based new technology with high autonomy" (Entorf and Kramarz 1994, P. 24). The preceding results are confirmed by Entorf, Gollac, and Kramarz (1999), who find that the introduction of individual fixed effects into the longitudinal model leads to a substantially lower computer wage premium than that obtained in the cross-section study. Therefore, they demonstrate that PC users were already better paid before the new technology was introduced in their jobs, and suggest that “unobserved but compensated characteristics of the workers matter” (Entorf, Gollac, and Kramarz 1999, P. 464). Haisken-DeNew and Schmidt (1999) doubt that there are computer-use wage differentials worth speaking of in Germany. They find that the significance of coefficients for PC use almost completely disappears in the longitudinal study, and conclude that “for Germany, unobserved individual heterogeneity or ability plays the key role in effectively explaining away the apparent wage premium for using a computer at work” (Haisken-DeNew and Schmidt 1999, P. 10). In this study we extend the model of Haisken-DeNew and Schmidt (1999) by using future information of computer use as a further control for ability. Our findings reject the productivity hypothesis: the higher pay of PC users cannot be traced back to computer-related productivity increases.

2. Data

The data used in this study were made available by the German Socio-Economic Panel Study (GSOEP) at the German Institute for Economic Research (DIW) in Berlin. The GSOEP is a representative longitudinal micro-database that provides a wide range of socio-economic information on private households in Germany. Data were first collected from about 12,200 randomly selected adult respondents (in 6,000 families) in the former West Germany in 1984. After German reunification in 1989, the GSOEP was extended by about 4,500 persons (in 2,200 families) from the former East Germany. In the most recent wave, for 1999, about 13,000 respondents were still participating in the panel study. The GSOEP data is available as a public-use file containing 95% of the GSOEP sample, with some variables omitted for reasons of data protection (see Wagner et al. 1993, or for more detailed information, Haisken-DeNew and Frick 2000).

We use GSOEP data from 1985 to 1999 for male and female West German full-time employees aged between 20 and 65, excluding foreigners and civil servants. The first wave was excluded, since some questions that are important for this study were not included in 1984. We used an unbalanced panel, and included only those respondents who participated in at least two waves of the survey so that we could control for individual unobserved heterogeneity. In addition, we had to exclude all respondents who had not participated in the survey in 1997, because this is the year in which the information required to construct a variable that indicates PC use was obtained from respondents. In total, the sub-sample consists of 22,361 respondents, while 1,527 observations for 1999 are available for the cross-section study.

The GSOEP provides detailed information on earnings. Our dependent variable is monthly gross earnings including extra payments, such as the Christmas bonus, holiday pay, income from profit sharing, and other bonuses. Extra payments have become increasingly important in recent years, and Pierce (1999) found that excluding extra payments from earnings tends to understate wage differentials. Since monthly labor income overstates the remuneration of workers whose weekly hours of work exceed 40, it would be appropriate to use the hourly wage rate by dividing earnings by working hours. However, hourly wages as used by Haisken-DeNew and Schmidt (1999) might understate the earnings of managers and other workers who work long hours. Therefore, this study uses total monthly compensation as used by Entorf and Kramarz (1994), and uses working time as a control variable to prevent differences in working hours from distorting the estimates.

All earnings regressions are run separately for men and women and include control variables such as education, experience, age, marital status, five firm size bands, and dummies for six occupations, nine regions, 14 time periods, and 14 industries. The GSOEP also provides information on PC use, which is the central variable in this study, on which a question was only included in the 1997 survey. For that year, the survey indicates whether a respondent used a PC, and identifies the year in which he or she first used a PC at work. The same information was collected on the use of a PC at home.[1] It is relatively easy to trace back PC use retrospectively for the years before 1997 from the information on when a respondent first used a computer (see Haisken-DeNew and Schmidt 1999, P. 4). The underlying assumption is that once a person uses a computer, he uses one in all subsequent years. In 1998, only information on the frequency of private PC use was collected, whereas in 1999 respondents were asked only about professional PC use. To obtain dummy variables for PC use at work and PC use at home for each wave, we overcame the problem of missing information as follows. If a person used a PC at work in 1997, the dummy variable is set equal to unity in the

[1] The information on computer use was obtained from the 1997 GSOEP personal questionnaire from the following question: *"Do you use a computer at home/at work, and if so, since what year at home/at work?"* The original German text reads as follows: *"Benutzen Sie privat oder beruflich (bzw. in Ihrer Ausbildung) einen Computer? Gemeint sind hier Personal-Computer (PC) aber auch Grossrechneranlagen, jedoch nicht reine Spielcomputer! [Ja/Nein], ich benutze [einen/keinen] Computer [privat/beruflich] und zwar seit ..."*.

two subsequent years. [2] The same is done for PChome.[3] If the respondent did not use a PC at work in 1997, the PC dummy is set equal to zero in 1998, and is set equal to unity in 1999 provided the respondent was using a PC at work according to the 1999 survey. If the respondent did not use a PC at home in 1997, but there is evidence of private PC use in 1998, then the PC dummy is set equal to unity in the two subsequent years. If there is no evidence of private PC use in 1997 and 1998, then the PChome dummy is set to zero in 1998 and 1999. The PChome variable provides a complete picture of a person's computer utilization, and its inclusion reduces bias in the coefficient of PC use at work "due to omitted factors which are associated with computer-use more generally"(Krueger 1993, P. 43).

3. Estimation Methods

The first model (I) in this study adopts a simple approach to replicate the cross-sectional findings of most studies on PC wage differentials. For 1999, the standard cross-sectional earnings equation is augmented by a dummy variable indicating whether a worker uses a computer at work. In addition, as well as the use of other control variables, a variable for PC use at home is used to capture some of the unobserved individual characteristics. Let w_i be individual *i*'s monthly wage.[4] The Mincer-type specification of the earnings regression is:

(1) $$\ln w_i = X_i'b + PC_i'c + u_i$$ model (I)

where X_i are standard control variables and PC_i is a vector of dummy variables, which are equal to unity if the individual uses a computer at work, at home, or both, *b* and *c* are vectors of parameters to be estimated, and u_i denotes the unobservable effects. At this point, unobserved individual characteristics will be only partially captured, at best, by adding the PChome variable to the regression for computer wage differentials. Model (II) is very similar to model (I) except that, as in the study by Haisken-DeNew and Schmidt (1999), panel data is used to run a pooled regression as well as random effects and fixed effects estimations in order to control for unobservable individual characteristics:

(2) $$\ln w_{it} = X_{it}'b + PC_{it}'c + u_{it}$$ model (II)

[2] In what follows, the dummy variables for using a PC at work, at home, and at work and at home are referred to as PCwork, PChome and PCboth.

[3] We admit that in this way we wasted some of the information of 1998 and 1999 in order to have a consistent way of dealing with the PC use information, since we wanted to keep the assumption that PC use in one year means also PC use in all subsequent years. However, only a low percentage of workers who used a PC in 1997 did not use one in 1998 and 1999, which supports our assumption.

[4] In what follows, the wage refers to the total monthly compensation of a worker.

An alternative approach to test the productivity-enhancing hypothesis is to include information on future PC use at work in a longitudinal analysis, which might capture unobserved worker characteristics. This approach is similar to that of Bell (1996) who, in a cross-section study, regressed the log of hourly wages, not only on standard control variables but also on variables for skills that were measured in a subsequent survey conducted ten years later. The use of the future PC variable is possible given the relatively long panel data period, which can be split into two sub-periods: one from 1985 to 1987, the other post-1987. The first period is used as a sub-sample on which the longitudinal wage regressions are run. The second period is only used to provide information on whether a PC has been used at work after 1987.[5] In what follows, this information is referred to as future PC use, as observed from the perspective of the first period. The model can be represented as follows:

(3) $$\ln w_{i,85-87} = X'_{i,85-87}b + PC'_{i,85-87}c + PC'_{i,88-99}e + u_{i,85-87}$$ model (III)

where dummy variables for computer-use at work after 1987, $PC_{i,88-99}$, are included. The variables for PC use indicate whether a survey respondent uses a computer at work today (1985-1987) and/or in the future (after 1987). With regard to future PC use, we distinguish in the first version of model (III) between: no PC use at work in either the first or second period; no PC use at work in the first period, but some in the second period; and PC use at work in both the first and second periods. In addition to these dummy variables, more detailed information on future PC use is added to another version of model (III); that is, information on when the future PC use at work transpires. A distinction is made between different future PC variables, since PC use in the near future might have a different effect on wages than PC use in the distant future. In the early years of the second period, working with computers at work was evidently rather exceptional given that until 1989 less than 20% of workers were PC users. However, from 1995 onwards, the proportion of PC users was above 50%, and rose even more until 1999, when more than two-thirds of those surveyed used a computer at work, and PC use at work was rather common. Therefore, in the second version of model (III) instead of one future PC variable we use four dummy variables to distinguish between future PC use occurring before 1988[6], between 1988 and 1990, between 1991 and 1994, and after 1994. Consequently, the following variables relating to PC use at work are incorporated into the panel study: no PC use today or in the future; no PC use today but some in the immediate

[5] This dividing line was drawn in order to obtain future information relating to the longest possible time period (1988-1999) whilst still being able to control for unobserved worker heterogeneity with panel data (1985-1987).
[6] PC use before 1988 would be future PC use for workers who did not use a PC at work in 1985 (1986) but did so in 1986 (1987).

future (before 1988); no PC use today but some in the near future (between 1988 and 1990); no PC use today but some in the medium future (between 1991 and 1994); no PC use today but some in the distant future (after 1994); and PC use today and in the future.

Since the future PC-use variables cannot have a causal effect on current wage determination, one might suppose that the coefficients of the future PC variables will not be significant in the regression analysis. However, wages might be statistically affected by these variables. If PC use at work in the future has a statistical influence on wages today, this suggests that the future PC-use variables capture unobserved worker characteristics such as ability, which does affect earnings. If so, the same might be true of current PC variables. If variables on future PC use are closely related to worker ability, then so too probably are variables on current PC use, which thus capture worker ability rather than productivity effects. This would imply that computer wage differentials merely indicate a wage premium due to unobserved worker characteristics rather than to productivity improvements attributable to computers.

4. Results

Compared to the cross-sectional study, in which the wage premium from using a PC at work is around 6,5% for men when control variables are included, the computer wage premium estimated by the pooled regression is much smaller, as can be seen in Table 1. When looking at the random effects estimator, it is striking that all coefficients for, and explanatory power of, the PC-use variables are considerably reduced. In the regressions for men, the dummy variable for PC use at work shrinks to around 1% and loses some of its significance in all three versions of model (II). When the wage equation for female workers is estimated with random effects, all coefficients for the PC use at work variables remain statistically significant, but are substantially reduced to around 2%. The fixed effects estimator applied to model (II) reveals even more sobering results concerning the wage premium from using a computer at work. The PCwork variable is not statistically significant in the regressions for either men or women. Furthermore, the fixed effects model has significantly negative wage premiums for the PChome variable for men, and a significantly positive coefficient for PCboth.[7]

[7] Using the Hausman test to test the fixed effects model against the random effects model indicates evidence of a correlation between the individual effects and the regressors, which supports the fixed effects assumption. However, the random effects model is superior to the pooled OLS estimator, which is revealed by the Breusch and Pagan Lagrange multiplier test for random effects.

Table 1: Model (I) and (II): Regressions with Standard Control Variables

	Cross-Section 1999		Longitudinal Regressions 1985 – 1999					
			Pooled OLS		Random Effects		Fixed Effects	
Variable	Men	Women	Men	Women	Men	Women	Men	Women
PCwork	0.0641**	0.0533**	0.0253**	0.0629**	0.0118*	0.0268**	-0.0008	0.0130
	(0.0194)	(0.0311)	(0.0048)	(0.0065)	(0.0048)	(0.0067)	(0.0050)	(0.0072)
χ^2-LM-Test			Men: 17195.2; Women: 5995.6					
Hausman-Test					Men: 2973.3 Women: 3330.1			
PCwork	0.0564**	0.0488	0.0141**	0.0576**	0.0112*	0.0237**	0.0007	0.0110
	(0.0197)	(0.0313)	(0.0050)	(0.0065)	(0.0050)	(0.0067)	(0.0052)	(0.0072)
PChome	0.0335	0.0289	0.0403**	0.0439**	0.0026	0.0304**	-0.0137**	0.0209*
	(0.0157)	(0.0237)	(0.0050)	(0.0081)	(0.0049)	(0.0079)	(0.0051)	(0.0083)
χ^2-LM-Test			Men: 16816.3; Women: 5936.4					
Hausman-Test					Men: 1839.5; Women: 8803.8			
PCwork	0.0566*	0.0726*	0.0122*	0.0564**	0.0046	0.0204**	-0.0078	0.0070
	(0.0233)	(0.0336)	(0.0056)	(0.0068)	(0.0055)	(0.0069)	(0.0057)	(0.0074)
PChome	0.0338	0.1254*	0.0340**	0.0345*	-0.0121	0.0059	-0.0234**	-0.0106
	(0.0256)	(0.0558)	(0.0079)	(0.0166)	(0.0072)	(0.0148)	(0.0074)	(0.0156)
PCboth	-0.0005	-0.1156	0.0102	0.0119	0.0242**	0.0309*	0.0274**	0.0393*
	(0.0318)	(0.0606)	(0.0098)	(0.0186)	(0.0086)	(0.0159)	(0.0088)	(0.0165)
χ^2-LM-Test			Men: 16814.3; Women: 5338.1					
Hausman-Test					Men: 1233.2; Women: 9632.6			
Observations	1070	457	Men: 15536; Women: 6825					

Source: GSOEP, 1985-1999.
Notes: * Statistically significant at the 5% level, ** at the 1% level. Standard errors in parentheses.

It is well to pause at this point and reflect on the preliminary findings. Controlling for unobserved heterogeneity the wage premiums for computer usage were substantially reduced in the random effects model. In the fixed effects model, all the variables indicating PC use at work were statistically insignificant. These results indicate that it is not computer-induced productivity, but unobserved yet compensated worker characteristics, that matter.

This can be tested further by model (III), where variables for future PC use at work are included in the longitudinal regressions for the years from 1985 to 1987. Information from surveys after 1987 enables analysis of how computer wage premiums may be affected by those future variables which, though unable to have a causal effect on wage determination, may be statistically significant, perhaps because they capture unobserved worker heterogeneity. The drawback of this approach is that we cannot use the fixed effects estimator because the future PC variables do not vary over time. However, since we put future PC variables as indicator for ability directly in our model, we can test our hypothesis that unobserved heterogeneity is captured by future PC use. The advantage is therefore that we can measure actual ability.

The regression analysis reveals that not all wage differentials implied by the future PC-use dummies are statistically significant when standard control variables are included (see Table 2). The initial estimates of the first version of model (III) show that both men and women receive a wage premium if they do not use a PC today, but will do so in the future (PC01). The future wage premium for men is around 3% in the pooled OLS regression and 5% in the random effects model, whereas women receive a future PC-use premium of around 4% according to both regressions. An even higher premium is obtained from using a PC today and in the future (PC11). As can be expected, the coefficients and explanatory power of this dummy variable remain virtually unchanged in both the pooled OLS and random effects specifications when more detailed information on future PC use is added to model (III) by including variables that indicate when a computer would be used for the first time in the future (second version). The division of the future PC-use variable PC01 into four different dummies, PC0, PC1, PC2, and PC3, which indicate how far into the future is the first use of a PC at work, reveals that the point in time does indeed matter.

Table 2: Model (III): Longitudinal Regressions with PC Future Variables and Standard Controls

	Estimates for men		Estimates for women	
Variable	Pooled OLS	Random Effects	Pooled OLS	Random Effects
First Version				
PC01: Did not use a computer today (1985-1987), but in the future (after 1987)	0.0307**	0.0461**	0.0414*	0.0424
	(0.0116)	(0.0169)	(0.0165)	(0.0227)
PC11: Used a computer today and in future	0.0499**	0.0762**	0.0816**	0.1025**
	(0.0157)	(0.0215)	(0.0220)	(0.0277)
χ^2-LM-Test	691.0		323.5	
Second Version				
PC0: Did not use a computer today, but in the immediate future (before 1988)	-0.0194	0.0282	0.0324	0.0357
	(0.0372)	(0.0348)	(0.0495)	(0.0412)
PC1: Did not use a computer today, but in the near future (between 1988 and 1990)	0.0423*	0.0541*	0.1020**	0.1060**
	(0.0174)	(0.0254)	(0.0257)	(0.0372)
PC2: Did not use a computer today, but in the medium future (between 1991 and 1994)	0.0319*	0.0550*	0.0452*	0.0380
	(0.0161)	(0.0241)	(0.0231)	(0.0340)
PC3: Did not use a computer today, but in the distant future (after 1994)	0.0273	0.0350	-0.0311	-0.0125
	(0.0180)	(0.0279)	(0.0272)	(0.0379)
PC11: Used a computer today and in future	0.0506**	0.0728**	0.0821**	0.0996**
	(0.0158)	(0.0227)	(0.0219)	(0.0308)
χ^2-LM-Test	689.7		317.0	
Observations	2,617		1,048	

Source: GSOEP, 1985-1999.
Notes: * Statistically significant at the 5% level, ** at the 1% level. Standard errors in parentheses.

Of the individuals who had not used a PC at work when they were originally surveyed, those who would be using a computer in the near future (PC1) had the highest wage premium on average. The wage equations for male workers reveal coefficients of up to 6% for future PC use PC1 and PC2, while PC use in the immediate future (PC0) or distant future (PC3) has no explanatory power. Women who would be using a PC in the near future receive a premium of 11% relative to those who would not be using a PC at all. In comparison with the wage premiums from the pooled OLS regression, those from the random effects model were slightly higher.

The estimates show that future computer use seems to have an important statistical effect on wage determination, and one that is more than half as strong as that of current computer use. This is evidence against the productivity-enhancing explanation of PC wage differentials, since the statistical influence of future PC use at work on wages today is an indication that future PC-use variables capture worker heterogeneity. Therefore, wages are determined not by future PC use at work (which is impossible anyway), but by unobserved worker characteristics, with future PC use perhaps serving as a proxy for ability.[8] Due to the close association between future PC-use variables and individual characteristics, which are well-remunerated in the labor market, it is quite probable that current PC use at work, instead of generating productivity effects, captures these same characteristics. This is not to deny that workers who use a computer on the job may indeed be more productive. However, according to the findings of this study, higher productivity is not attributable to the use of computers, but rather to individual worker characteristics. Therefore, computer wage differentials are not due to productivity-enhancing computer technology, but arise rather because more able individuals are more likely to use a computer at work, and these individuals would earn a wage premium even in the absence of computer technology.

5. Conclusion

Having used data from the German Socio-Economic Panel Study (GSOEP) to analyze wages, we confirm that international evidence for wage differentials also applies to Germany. As other studies have found, computer wage differentials were substantial in the cross-section study for 1999, after including many worker and firm characteristics. However, cross-section results can be spurious, and greatly influenced by worker heterogeneity, and since the GSOEP does not provide information on measured ability, several types of panel study have been carried out to reduce the influence of unobserved worker characteristics and to increase the reliability of the results. The first approach was the conventional method of making use of panel data for the years from 1985 to 1999 provided by the GSOEP. It was found that computer wage premiums were reduced in the pooled OLS and in the random effects specifications, but did not vanish completely. However, in the fixed effects model, all the variables indicating PC use at work were statistically insignificant. Another approach

[8] If a person’s future PC use does capture his or her ability, one could get real returns to education by including this variable in the Mincer equation, in which case, the effect of ability and other unobservable individual characteristics on the schooling coefficient would be diminished. The inclusion of future PC use in the wage equation would reduce bias by controlling for the self-selection effect, which enables one to measure the purged education effect.

involved the inclusion of dummy variables indicating future PC use in the longitudinal regression. Since future PC-use variables had a statistical influence on the determination of wages, it can be concluded that current PC-use variables also capture those unobserved worker characteristics that affect earnings. The indications from the applied models are that it is not computer-induced productivity, but unobserved yet compensated worker characteristics, that matter. Although we acknowledge the increasing importance of computer skills in the job market, our labor-market policy implication is not to neglect general human capital accumulation. Since it is not sufficient to focus on computer training of workers, more weight should be put on general investments to promote workers' education and their soft skills.

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Appendix

Table A1: Description and Descriptive Statistics of Variables Used in the Regression Models

Variable	Description	Mean (SD)	
	Dependent variable	Men	Women
lnminc	Log monthly compensation rate, Deutsche Mark	8.43 (0.38)	8.14 (0.36)
	Socio-demographic variables		
Age	Age in years	39.88 (10.74)	36.04 (11.12)
Married	Marital status: 1 = married couple, else = 0	0.71	0.45
Region0	Regional Dummy: 1=Berlin, else=0; Reference category	0.03	0.05
Region1	Regional Dummy: 1=Schleswig-Holstein, else = 0	0.04	0.03
Region2	Regional Dummy: 1=Hamburg, else = 0	0.02	0.02
Region3	Regional Dummy: 1= Lower Saxony, else = 0	0.11	0.11
Region4	Regional Dummy: 1=Bremen, else = 0	0.01	0.01
Region5	Regional Dummy: 1= North Rhine-Westphalia, else = 0	0.28	0.28
Region6	Regional Dummy: 1=Hesse, else = 0	0.09	0.08
Region7	Regional Dummy: 1= Rhineland-Palatinate/Saarland, else = 0	0.08	0.08
Region8	Regional Dummy: 1=Baden-Württemberg, else = 0	0.16	0.16
Region9	Regional Dummy: 1=Bavaria, else = 0	0.18	0.19
	Education and work experience		
Edu	Length of education in years	11.62 (2.27)	11.35 (2.02)
Senior	Work experience at the same employer in years (seniority)	12.24 (10.07)	8.57 (7.77)
Expfull	Previous work experience as full-time employee in years	18.50 (11.49)	12.66 (9.61)
Exppart	Previous work experience as part-time employee in years	0.26 (1.33)	1.39 (3.43)
	Job characteristics		
Hours	Actual working hours	43.01 (6.20)	40.90 (4.03)
Public	Work in the public sector: 1=yes, else=0	0.17	0.31
Change	Change of job: 1=yes, else=0	0.11	0.15
Job0	No training necessary for the job: 1=yes, else=0; Reference category	0.02	0.04
Job1	Briefing or courses necessary for the job: 1=yes, else=0	0.27	0.29
Job2	Vocational training necessary for the job: 1=yes, else=0	0.57	0.62
Job3	College/University necessary for the job: 1=yes, else=0	0.13	0.05
Jobcat0	Job category: 1=Manufacturing, else=0; Reference category	0.50	0.14
Jobcat1	Job category: 1=Science, else=0	0.19	0.18
Jobcat2	Job category: 1=Management, else=0	0.04	0.02
Jobcat3	Job category: 1=Office/Administration, else=0	0.16	0.46
Jobcat4	Job category: 1=Commerce, else=0	0.05	0.10
Jobcat5	Job category: 1=Services, else=0	0.04	0.08
Jobcat6	Job category: 1=Plants/Animals, else=0	0.01	0.01
Bluecol	Blue collar worker=1, else=0	0.49	0.20
Bluecol0	Blue collar worker: 1=unskilled, else=0; Reference category	0.01	0.03
Bluecol1	Blue collar worker: 1=skilled, else=0	0.13	0.11
Bluecol2	Blue collar worker: 1=semiskilled, else=0	0.28	0.05
Bluecol3	Blue collar worker: 1=foreman, else=0	0.05	0.01
Bluecol4	Blue collar worker: 1=master, else=0	0.02	0.00
Whiteco0	White collar worker: 1=foreman, else=0; Reference category	0.03	0.00

Whiteco1	White collar worker: 1=without vocational training, else=0	0.02	0.10
Whiteco2	White collar worker: 1=with vocational training, else=0	0.11	0.26
Whiteco3	White collar worker: 1=qualified occupation, else=0	0.20	0.37
Whiteco4	White collar worker: 1=highly qualified occupation, else=0	0.14	0.07
Whiteco5	White collar worker: 1=executive function, else=0	0.01	0.01
	Industry (Reference category: all other branches)		
Branch1	Branch: 1=Energy/Water, else=0	0.03	0.01
Branch2	Branch: 1=Chemicals, else=0	0.06	0.04
Branch3	Branch: 1=Plastics, else=0	0.01	0.01
Branch4	Branch: 1=Stone, else=0	0.01	0.01
Branch5	Branch: 1=Metal, else=0	0.10	0.05
Branch6	Branch: 1=Wood, else=0	0.04	0.02
Branch7	Branch: 1=Textiles, else=0	0.01	0.04
Branch8	Branch: 1=Food, else=0	0.03	0.02
Branch9	Branch: 1=Construction, else=0	0.11	0.02
Branch10	Branch: 1=Wholesale/Retail, else=0	0.08	0.14
Branch11	Branch: 1=Transport, else=0	0.05	0.02
Branch12	Branch: 1=Banking/Insurance, else=0	0.05	0.09
Branch13	Branch: 1=Other services, else=0	0.08	0.25
Branch14	Branch: 1=Non-Profit, else=0	0.02	0.05
	Firm size		
Size1	Firm size < 5 employees	0.08	0.10
Size2	Firm size > 5 and <20 employees	0.08	0.09
Size3	Firm size > 20 and < 200 employees	0.26	0.28
Size4	Firm size > 200 and < 2000 employees	0.27	0.28
Size0	Firm size > 2000 employees; Reference category	0.31	0.25
	PC variables		
NoPC	Did not use a computer at all: 1=yes, else=0; Reference category	0.60	0.57
PChome	Used a computer at home only: 1=yes, else=0	0.06	0.02
PCwork	Used a computer at work only: 1=yes, else=0	0.17	0.30
PCboth	Used a computer at home and at work: 1=yes, else=0	0.17	0.11
	Future PC variables		
PC00	Did not use a computer at work neither today nor in the future; Reference category	0.68	0.63
PC01	Did not use a computer today (1985-1987), but in the future (after 1987)	0.30	0.35
PC11	Used a computer today and in future	0.02	0.02
PC0	Did not use a computer today, but in the immediate future (before 1988)	0.01	0.01
PC1	Did not use a computer today, but in the near future (between 1988 and 1990)	0.10	0.14
PC2	Did not use a computer today, but in the medium future (between 1991 and 1994)	0.11	0.13
PC3	Did not use a computer today, but in the distant future (after 1994)	0.08	0.07

Source: GSOEP, 1985–1999.

Table A2: Model (II): Longitudinal Regressions With PCwork for men

Variable	Pooled OLS		Random Effects		Fixed Effects	
	Parameter		Parameter		Parameter	
Intercept	7.3160**	(0.0303)	7.1026**	(0.9507)	6.6204**	(0.0914)
Year86	0.0378**	(0.0104)	0.0342**	(0.0067)	-0.0000	(0.0064)
Year87	0.0756**	(0.0102)	0.0724**	(0.0066)	0.0075	(0.0061)
Year88	0.1170**	(0.0102)	0.1059**	(0.0067)	0.0069	(0.0059)
Year89	0.1566**	(0.0010)	0.1466**	(0.0066)	0.0160**	(0.0057)
Year90	0.2047**	(0.0101)	0.1960**	(0.0067)	0.0354**	(0.0057)
Year91	0.1868**	(0.0102)	0.2059**	(0.0070)	0.0217**	(0.0057)
Year92	0.2467**	(0.0102)	0.2653**	(0.0071)	0.0507**	(0.0057)
Year93	0.2843**	(0.0101)	0.3049**	(0.0072)	0.0586**	(0.0056)
Year94	0.3054**	(0.0102)	0.3285**	(0.0073)	0.0526**	(0.0057)
Year95	0.3281**	(0.0101)	0.3489**	(0.0075)	0.0410**	(0.0058)
Year96	0.3635**	(0.0102)	0.3941**	(0.0077)	0.0573**	(0.0060)
Year97	0.3727**	(0.0102)	0.3978**	(0.0078)	0.0285**	(0.0061)
Year98	0.3692**	(0.0104)	0.4034**	(0.0081)	0.0068	(0.0064)
Year99	0.3782**	(0.0105)	0.4161**	(0.0084)	-	-
Age	0.0054**	(0.0006)	0.0075**	(0.0012)	0.0291**	(0.0032)
Married	0.0530**	(0.0045)	0.0514**	(0.0048)	0.0474**	(0.0051)
Region1	-0.0325*	(0.0136)	-0.0349	(0.0278)	-0.0863	(0.0495)
Region2	0.0139	(0.0166)	0.0056	(0.0309)	-0.0853	(0.0501)
Region3	-0.0340**	(0.0113)	-0.0622**	(0.0240)	-0.1590**	(0.0443)
Region4	-0.0486*	(0.0192)	-0.0618	(0.0358)	-0.1135*	(0.0576)
Region5	-0.0083	(0.0106)	-0.0355	(0.0227)	-0.1563**	(0.0430)
Region6	-0.0027	(0.0116)	-0.0103	(0.0249)	-0.0981*	(0.0486)
Region7	-0.0291*	(0.0118)	-0.0735**	(0.0255)	-0.2042**	(0.0510)
Region8	0.0144	(0.0110)	0.0197	(0.0237)	0.0370	(0.0476)
Region9	-0.0121	(0.0109)	-0.0082	(0.0231)	-0.0505	(0.0427)
Edu	0.0219**	(0.0013)	0.0366**	(0.0022)	0.0144**	(0.0045)
Senior	0.0035**	(0.0007)	0.0023**	(0.0006)	0.0014*	(0.0007)
Senior^2	-0.0000	(0.0000)	0.0000	(0.0000)	0.0000	(0.0000)
Expfull	0.0149**	(0.0009)	0.0165**	(0.0014)	0.0281**	(0.0036)
Expfull^2	-0.0004**	(0.0000)	-0.0004**	(0.0000)	-0.0004**	(0.0000)
Exppart	-0.0256**	(0.0026)	-0.0295**	(0.0050)	-0.0099	(0.0104)
Exppart^2	0.0009**	(0.0001)	0.0010**	(0.0003)	0.0000	(0.0018)
Hours	0.0098**	(0.0003)	0.0066**	(0.0003)	0.0062**	(0.0003)
Public	-0.0560**	(0.0055)	-0.0401**	(0.0066)	-0.0317**	(0.0073)
Change	-0.0565**	(0.0062)	-0.0494**	(0.0043)	-0.0456**	(0.0043)
Job1	0.0119	(0.0119)	0.0017	(0.0089)	-0.0033	(0.0089)
Job2	0.0332**	(0.0122)	0.0078	(0.0094)	-0.0067	(0.0095)
Job3	0.1695**	(0.0143)	0.0821**	(0.0120)	0.0406**	(0.0124)
Jobcat1	-0.0086	(0.0077)	0.0141	(0.0078)	-0.0065	(0.0084)
Jobcat2	0.1195**	(0.0108)	0.0610**	(0.0097)	0.0267**	(0.0100)

Jobcat3	-0.0253**	(0.0073)	0.0024	(0.0075)	-0.0080	(0.0081)
Jobcat4	-0.0189	(0.0102)	0.0133	(0.0102)	0.0078	(0.0109)
Jobcat5	-0.1133**	(0.0103)	-0.0828**	(0.0126)	-0.0496**	(0.0143)
Jobcat6	-0.0610**	(0.0189)	-0.0301	(0.0274)	0.0020	(0.0333)
Bluecol	-0.3019**	(0.0206)	-0.1660**	(0.0169)	-0.1073**	(0.0173)
Bluecol1	0.0457*	(0.0180)	0.0345**	(0.0133)	0.0234	(0.0134)
Bluecol2	0.0904**	(0.0180)	0.0570**	(0.0140)	0.0346*	(0.0142)
Bluecol3	0.1567**	(0.0193)	0.1021**	(0.0153)	0.0746**	(0.0155)
Bluecol4	0.2719**	(0.0215)	0.1292**	(0.0174)	0.0812**	(0.0177)
Whiteco1	-0.2233**	(0.0163)	-0.1019**	(0.0134)	-0.0742**	(0.0135)
Whiteco2	-0.1196**	(0.0122)	-0.0629**	(0.0103)	-0.0560**	(0.0104)
Whiteco3	-0.0191	(0.0117)	-0.0115	(0.0100)	-0.0144	(0.0101)
Whiteco4	0.0743**	(0.0127)	0.0443**	(0.0108)	0.0313**	(0.0109)
Whiteco5	0.1768**	(0.0198)	0.0848**	(0.0159)	0.0540**	(0.0159)
Branch1	0.0344**	(0.0112)	0.0220	(0.0133)	0.0135	(0.0142)
Branch2	0.0502**	(0.0079)	0.0257**	(0.0099)	0.0069	(0.0109)
Branch3	-0.0192	(0.0152)	0.0053	(0.0149)	-0.0013	(0.0155)
Branch4	-0.0423**	(0.0149)	-0.0511**	(0.0158)	-0.0616**	(0.0165)
Branch5	-0.0199**	(0.0065)	0.0037	(0.0061)	0.0099	(0.0063)
Branch6	0.0157	(0.0097)	0.0008	(0.0119)	-0.0033	(0.0130)
Branch7	-0.1673**	(0.0159)	-0.0132	(0.0178)	0.0279	(0.0187)
Branch8	-0.0638**	(0.0106)	-0.0121	(0.0123)	0.0136	(0.0132)
Branch9	0.0114	(0.0066)	0.0125	(0.0073)	0.0172*	(0.0078)
Branch10	-0.1316**	(0.0079)	-0.0493**	(0.0074)	-0.0284**	(0.0077)
Branch11	-0.0264**	(0.0085)	-0.0064	(0.0100)	0.0047	(0.0109)
Branch12	0.0221*	(0.0093)	0.0196	(0.0137)	-0.0066	(0.0162)
Branch13	-0.0480**	(0.0076)	-0.0302**	(0.0082)	-0.0209*	(0.0088)
Branch14	-0.0768**	(0.0145)	-0.0409**	(0.0151)	-0.0457**	(0.0159)
Size1	-0.2174**	(0.0075)	-0.1212**	(0.0075)	-0.0788**	(0.0081)
Size2	-0.1682**	(0.0075)	-0.0995**	(0.0074)	-0.0689**	(0.0078)
Size3	-0.1086**	(0.0049)	-0.0517**	(0.0053)	-0.0283**	(0.0057)
Size4	-0.0558**	(0.0047)	-0.0240**	(0.0047)	-0.0122*	(0.0048)
PCwork	0.0253**	(0.0048)	0.0118*	(0.0048)	-0.0008	(0.0050)
Observations	15,536		15,536		15,536	
R^2	0.6814		0.6524		0.1524	

Source: GSOEP, 1985–1999.
Notes: * Statistically significant at the 5% level, ** at the 1% level. Standard errors in parentheses.