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IT, Organizational Change and Wages

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Abstract

In this paper we analyze the impact of information technology and organizational changes on wages using individual level data for 1998/1999. The average impact of IT use on wages turns out to be five to six percent, however, the effects differ across different IT components. Unless employees use IT at the workplace, they do not share in the gains from organizational changes in form of higher wages. Outsourcing additionally requires a high qualification of employees in order to result in positive wage effects.

JEL–classification: J30, J31
Keywords: Information technology, organizational change, wage equations

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Non-Technical Summary

The effects of new technologies on labor demand and wages are an extensively discussed topic in labor market literature. Recently, however, there emerged a growing awareness about the fact that in order to result in efficiency gains the introduction of new technologies in the workplace should be accompanied by appropriate organizational changes. Using individual level data, this study investigates whether the use of IT and organizational changes affect wage outcomes, and hence, whether or not employers share part of the productivity gains associated with IT use and organizational changes with their employees.

Given that organizational changes raise a firm's productivity, there are some arguments why employers should share part of their gains with their employees. For example, firms may have to pay a wage premium in order to attenuate resistance to workplace changes and to ensure that employees actively collaborate with respect to the implementation of the organizational changes. Moreover, employers may have to pay a wage premium to indemnify employees for the increased job insecurity that may be associated with the workplace reorganization.

Three forms of organizational changes are considered in this study: restructuring of departments, changes in the management structure and outsourcing of parts of the production process. In addition, we take different IT components such as personal computers, laptops and the Internet into account rather than viewing IT as a homogeneous factor.

Controlling for a wide range of individual characteristics, workplace characteristics and firm characteristics, we find an average treatment effect of IT use of around five to six percent. The results for the different IT-components indicate that it is important to take the heterogeneity of IT into account. We interpret this positive wage effect of IT use not as causal in the sense that only the implementation and use of IT at the workplace increases individual productivity and thus wages. In line with previous research, we rather believe that employees get more productive through the experience they gain in using IT.

The average treatment effects for all three types of organizational changes considered as measures to increase the efficiency of a firm's production process turn out to be insignificant. Moreover, it does not seem to play a significant role whether or not the employee's personal workplace situation is affected by the organizational changes. IT users, however, who work in firms that restructured their departments or outsourced part of their production are systematically better rewarded than non-IT users. For the case of outsourcing, a high qualification of the employee is additionally important next to the use of IT in order to result in positive and significant wage effects.

1 Introduction

The effects of new technologies on skills and wages are an extensively discussed topic in the labor market literature, see for example the comprehensive surveys by Card and DiNardo (2002), Chennells and van Reenen (2002) or by Katz and Autor (1999).

Recent studies point out, however, that in order to result in efficiency gains on the firm-level, the use of IT should be accompanied by appropriate organizational changes, so-called high-performance-workplace-organizations (HPWO) with favorably decentralizing character such as team work, flat hierarchies, job rotation, quality circles, etc. Microeconometric evidence for this hypothesis is given for example by Bresnahan, Brynjolfsson and Hitt (2002) and by Brynjolfsson and Hitt (2000). The reorganization of workplaces may even have a larger impact on the occupational structure of firms than technical capital (Aguirregabiria and Alonso-Borrego, 2000). The skill-biasing impact of organizational changes is also discussed by Caroli and van Reenen (2001). Plant level evidence suggests that employees benefit from organizational changes in terms of higher wages (Cappelli and Carter, 2000).

The contribution of our study is that it is the first to analyze both the effects of information technology (IT) use *and* organizational change (OC) in a common framework using individual level data. Thus, the paper contributes to the discussion about the complementarities between IT and OC. Assuming that IT and OC - as strategic complements - increase the productivity of firms, we analyze whether employees profit from these productivity gains.

The analyses in this paper are related to previous studies, the most prominent starting with the question: "Do employees who use computer technology on-the-job earn higher wages as a result of their computer skills?". This question is initially addressed by the seminal study of Krueger (1993) who, in cross-section data, finds that computer use is associated with roughly 10 to 15 percent higher pay. However, in the subsequent years various studies point to the endogeneity problem associated with this question (for example Borghans and ter Weel, 2002, DiNardo and Pischke, 1997, Entorf and Kramarz, 1997, and Haisken-DeNew and Schmidt, 1999). In particular, Entorf and Kramarz (1997) show by taking individual specific fixed effects into account that new technologies are used by abler workers who were already better paid before the introduction of the new machines. They find that it is rather the experience with new technologies that makes the employees more productive and thus allows them to obtain higher wages.

More or less at the same time, studies extolling the productivity effects of workplace innovations emerge, for example by Black and Lynch (1996), Black and Lynch (2001), Caroli and van Reenen (2001), Eriksson (2003), Huselid (1995), Ichniowski, Shaw and Prennushi (1997). These studies deal with so-called high-performance workplace organizations (HPWO) or innovative human resource management (HRM) meaning work practices with decentralizing character that allocate more decision making rights as well as responsibility to employees. Studies such as Black and Lynch (2000) and Appelbaum, Bailey, Berg and Kalleberg (2000) find that firms that introduced HPWO have higher firm performance and are paying higher wages. Osterman (2000), in contrast, does not find that employees are profiting from the introduction of HPWO in terms of greater wage increases or increased job security. The results of Wolf and Zwick (2002), who found that firms with structural productivity problems are more likely to introduce organizational changes, rather lead to cautious than optimistic expectations as far as wage increases are concerned.

From the point of view of the firm, however, there are some arguments why employers should share part of the gains with their employees (Black and Lynch, 2000). Firstly, firms may have to pay a wage premium in order to attenuate resistance to workplace changes of employees and to ensure that employees actively collaborate with respect to the implementation of OC. Secondly, employers may also have to pay a wage premium in order to indemnify employees for the increased job insecurity that may be associated with the workplace reorganizations. And thirdly, employees may also acquire additional skills owing to the workplace restructuring that are valuable to outside firms, such as problem solving or interpersonal skills. Hence, employers may have an incentive to pay a wage mark-up in order to ensure that employees stay with their firm.

Another argument for a wage increase for some workers owing to OC might be, that a fraction of employees is particularly involved in the introduction of organizational changes by supporting the successful implementation from a technical point of view. Moreover, the productivity effects of OC might be more pronounced for some workers than others. As put forward for instance by Bresnahan et al. (2002) and Brynjolfsson and Hitt (2000), IT might *enable* organizational changes. Companies have to adapt their organizational structures when implementing IT in order to use these technologies efficiently. Thus, implementing IT and organizational changes as strategic complementarities may result in positive productivity effects. Empirical evidence for this hypothesis is given by Bresnahan et al. (2002) and Brynjolfsson and Hitt (2000) on the basis of different U.S. firm data sets and to some extent also by Bertschek and Kaiser (2004) who take into account the simultaneity between productivity and OC and provide evidence for firms belonging to the German business-related services sector.

To the best of our knowledge, Cappelli and Carter (2000) is the only study that analyzes the joint effects of IT and OC on wages. They use data on around 3,300 U.S. establishments of the manufacturing industry and the service sector for analyzing how changes in jobs may affect wage outcomes. Their results suggest that employees benefit from IT use and OC in the form of higher wages, however, the effect of OC seems to be limited to the manufacturing sector.

Our study contributes to the discussion about the *joint* effects of IT and OC on wages. In contrast to the analysis by Cappelli and Carter (2000), we are in the favorable position to have individual level data to investigate this question. Assuming that IT and OC - as complementary measures - have positive impacts on firms' productivity, as suggested by several firm level studies, we will analyze whether employees share in the gains that firms obtain from using IT and from changing their organizational structure.

In contrast to Cappelli and Carter (2000) we use individual level data which has several advantages compared to using firm level data sets: we do not have to fall back upon aggregate information on employees. In particular, we know whether or not an employee uses information technology on-the-job. The data set has the distinct advantage over others that it contains detailed information on the usage of several kinds of IT, ranging from personal computers to computerized control devices and thus reflecting the heterogeneity of IT. Moreover, the data refer to a recent time period – 1998/1999 – when the diffusion of some IT components such as personal computers is already very advanced whereas other IT components such as the Internet are still less broadly used on-the-job. The educational attainment as well as other individual characteristics of the individuals are contained in the data.

A special feature of the data is that it contains detailed information about the firms the interviewed employees are working in. In particular, the employees were asked whether or not they work in firms that reorganized their organizational structure within the last two years. Three forms of organizational changes are considered: restructuring of departments, changes in the management structure and outsourcing of parts of the production process. The survey even tells us whether the single employee was personally affected by the organizational changes in the firm. This information allows us to measure IT usage, workplace reorganization, skills and wages at the individual level and to analyze the relationship between these factors more directly. Additional detailed information in our data set with respect to individual characteristics, workplace characteristics and firm characteristics allows to extract much of the unobserved heterogeneity that usually affects the meaningfulness of estimation results.

The data set used in this study contains information of around 12,000 male employees with residence in West Germany observed in 1998/1999. The empirical evidence obtained from OLS regressions suggests that even when controlling for a wide range of individual characteristics, workplace characteristics and firm characteristics, there remains a positive average treatment effect of IT use of around 5 percent. Taking account of the heterogeneity of IT by including different measures of IT instead of an aggregate measure shows, however, that rather advanced office technologies are related to higher wages. In particular, the coefficients of more recent IT applications such as Internet and Intranet turn out to be important with respect to their size and their significance. Scanners, in contrast, turn out to have a significantly negative impact on wages. In addition, for employees with a high level of education, the evidence points to saturation effects as far as the diffusion of IT use is concerned. It seems that at the end of the 90s, the degree of diffusion of IT at workplaces of highly qualified employees is so high that the use of IT is not rewarded with wage premiums anymore.

Further estimations indicate that employees do not share in the gains that firms achieve by introducing organizational changes unless they use IT on-the-job. IT-users who work in firms that restructured their departments or outsourced part of their production process are rewarded systematically better than non-IT-users. This result is in line with the hypothesis of complementarities between IT and OC for which empirical evidence has been found previously at the firm level. As far as the wage level is concerned, it does not seem to play a significant role whether or not the employee's personal workplace situation is affected by the OC, for none of the three types of OC considered. For the case of outsourcing, a high qualification of the employee is additionally important next to the use of IT in order to result in positive and significant wage effects.

The paper is organized as follows: Section 2 describes the data and the empirical framework. Estimation results are presented and discussed in section 3. Section 4 concludes.

2 Data and Empirical Framework

The analysis is based on the so-called BIBB/IAB-data set which is a survey among employees. This data set contains four cross-sections of the *Qualification and Career Survey* carried out by the German Federal Institute for Vocational Training ("Bundesinstitut für Berufsbildung (BIBB)") and the Research Institute of the Federal Employment Service ("Institut für Arbeitsmarkt- und Berufsforschung (IAB)"). It is a rich source of information on the qualification and occupational career trends of German employees. We use the most recent cross-section which was launched in 1998-1999 because it is the only one that contains both information on the diffusion of IT at workplaces and information on organizational changes in firms.

The complete sample contains more than 34,000 observations. For the purpose of the analysis at hand we restrict the sample to male employees with residence in West-Germany and German nationality. Self-employed were also withdrawn from the sample. This reduces the sample to around 12,300 individuals. The persons in the sample are between 18 and 65 years old. The firms employing these employees cover a wide range of industries both manufacturing and services, however firms in the agricultural sector are excluded.

Our basic framework closely follows Krueger (1993) who estimates extended income functions originating from Mincer (1974) by ordinary least squares (OLS). Moreover, we use the large number of covariates available in the data set in order to identify the average treatment effects (ATE) of IT use and of organizational changes. (Rosenbaum and Rubin, 1983; Wooldridge, 2002, ch. 18.3). In short, this strategy involves the inclusion of level effects and interaction terms in the regression specification, where the treatment is interacted with various covariates that were previously demeaned (using the sample averages). This procedure attempts to separate the correlation of wages with IT and OC from potential correlations of IT and OC with other covariates and to reduce unobserved heterogeneity as far as possible.

In addition to the main variables of interest, IT and OC, three types of variables are considered in the analyses: individual characteristics, firm characteristics and workplace characteristics. We include variables reflecting individual characteristics in order to account for the fact that employees may systematically differ with respect to characteristics that may affect both computer use and wages. As more highly skilled workers are more likely to use computers at work and earn higher wages, we control for the level of formal education of employees, work experience and tenure with the current employer. As wages of civil servants are determined in another process than wages of employees in private firms we also include a dummy variable for civil servants into the regressions.

One drawback of most estimations on individual-level data is that they generally do not have enough information on the employers. Employer information may however be important if they determine systematic effects on wages, IT-use and OC. Our data set allows to take various firm characteristics into account such as firm size, industry affiliation, innovation strategy and IT intensity of the sector. Based on previous empirical research, we expect for example that larger firms pay higher wages and that they are more likely to introduce OC than smaller firms. Furthermore, we expect “IT-intensive” firms to pay higher wages and that they are more likely to introduce OC than firms with less IT-intensive production processes (Osterman, 1994). Another feature that distinguishes our data set from others is that it includes information on the task composition of occupations. This information on occupational skill requirements allows us to further reduce unobserved heterogeneity.

The variables used in the estimations are constructed as follows (Summary statistics are in Table A in the Appendix):

Hourly Wages: The survey contains information on monthly earnings, according to 18 categories. To each category midpoints are assigned. These midpoints are then divided by the number of hours an individual usually spends at work.[1] Compared to other data sets that are usually used in comparable analyses such as CPS for the U.S. or the IAB-S for Germany, this data set has the advantage that earnings of highly paid workers are not censored from above. In all estimations, the logarithm of wages is used as dependent variable.

IT equipment: We use different variables to capture the IT equipment used on-the-job. The survey participants indicate whether or not they use one or more of the following devices: personal computers, laptops, other kinds of computers, scanners or computerized control devices such as computer numerical control machines. The data set also contains information whether or not employees are using special applications such as the Internet or an intra-firm network (Intranet) at the workplace.

In addition to implementing dummy variables for all different kinds of devices in the regressions, we also use variables measuring IT usage on a more aggregate level. “IT white-collar” is a dummy variable taking the value one if an employee uses personal computers, laptops, or other kinds of computers. “IT blue-collar” is a dummy variable taking the value one if an employee uses scanners or other computerized control devices. “IT” is a dummy variable taking the value one if one of the above noted white-collar or blue-collar devices or the Internet/Intranet is used on-the-job. The summary statistics in Table A show that 57 percent of the employees in the sample use IT at their workplace. Within the group of “IT white-collar”, the use of personal computers is the largest with a percentage share of 35 percent, followed by 12 percent of employees using laptops and 6 percent using “other computers”. Within the group of “IT blue-collar”, scanners are used by 11 percent of the employees, and 10 percent of the employees work with computerized control devices. 18 percent of the survey participants in our sample use the Internet and 32 percent use an Intranet.

Organizational Changes: The data set contains information about three measures of workplace reorganization. Employees are asked whether the firm for which they are working

[1] Comparable procedures are often used in the literature, for example by DiNardo and Pischke (1997) and by Entorf and Kramarz (1997).

has introduced one or more of the following three different kinds of measures of organizational change in the last two years: restructuring or reorganization of departments, changes in the management structure, and outsourcing of a part or parts of the production process. These different measures are used in the analysis as dummy variables that indicate whether or not the respective measure has been implemented. In addition, we construct a dummy variable "organizational change" that takes the value one if firms introduced at least one of the above measures. The use of this variable in the estimation also attempts to take account of potential collinearity between the OC variables.[2]

Restructuring of departments is a quite heterogenous measure of OC. It might represent a regrouping of employees into smaller groups or a change in the number of employees per supervisor. It might also stand for enhanced team work or for establishing profit centers or self-managed teams, etc. Since the organizational changes in the data set have taken place within the years 1997 to 1999, it seems, however, to be justified to consider the restructuring of departments as an organizational change with decentralizing character.

Changes in the management structure are supposed to reflect flattening of hierarchies and thus reducing the number of managerial employees. This may have an inverse effect on those employees who loose power and potentially their job owing to the abolishment of hierarchy levels. However, for the individual employee this measure enhances his or her decision-making authority and enriches the range of tasks that he or she usually performs, resulting in employees who are highly motivated and who identify themselves with their firm.

Outsourcing means that firms externalize certain tasks that were previously performed by their employees in order to reduce costs. They then buy these products and services from firms that are specialized in those tasks. Outsourcing allows the firms to concentrate on their core competencies, to replace fixed costs by variable costs, and to increase flexibility.

According to the summary statistics in Table A, 42 percent of the employees in the sample belong to firms that restructured departments. Management structures were changed in the case of 32 percent of survey participants and 19 percent of them indicate to belong to firms in which parts of the production process has been outsourced. Table D indicates that the frequencies of all three types of OC increase with firm size. The data moreover contain information on whether or not the interviewed employee has been directly affected by an organizational change. Thus, analogously, we construct dummy variables for whether or not employees have been directly affected by these measures. Six percent of survey participants indicate that they have been directly affected by outsourcing activities by their firm. 19 percent report that their workplace has been directly affected by a restructuring of departments. Changes in the management structure directly affected 21 percent of employees.

IT and OC are often viewed as strategic complements. As Table C displays, IT users are more likely to work in firms that reorganized their production processes. The higher

[2]The correlation between the restructuring of departments and outsourcing (changes in the management structure) is 0.359 (0.464). The correlation between changes in the management structure and outsourcing is 0.309.

incidence holds for all three practices. However, the difference is most pronounced for the restructuring of departments. 54 percent of the IT-users reported to work in firms that restructured their department compared to 26 percent for non-IT-users. Table C also demonstrates major differences with respect to the educational attainment of IT-users and non-IT-users and their wage outcome indicating that IT-users have a higher educational attainment and earn higher wages.

Individual characteristics: We distinguish three levels of formal educational attainment of employees. Employees with a low level of education are those with no further vocational training. Employees with medium levels of education have a vocational qualification either from an apprenticeship or they are graduated from a vocational college. Employees holding a degree from a university or a technical college are classified as having a high level of educational attainment. This categorization corresponds to the German education system, see for example Bellmann, Reinberg and Tessaring (1994) or Fitzenberger (1999). In contrast, U.S. studies usually use the number of schooling years as a measure of education (see also Card (1999) for a further discussion.) As shown in Table A in the Appendix, the largest part of the survey participants, 70 percent, has a medium qualification level whereas 19 percent are highly qualified and only 10 percent have a low education level.

The survey participants also indicate their first year of work. Based on these answers we calculate (potential) work experience (1999-first year of work). In addition, employees indicate the year in which they start to work with the current employer. This information is used to calculate firm tenure (1999-first year with current employer). The data set also contains information about the current occupation of the employees. Occupations are grouped according to the (2-digit-level) classification of occupational titles by the Federal Employment Bureau, 1999, leading to 78 occupational groups.

Workplace Characteristics: Survey participants are asked what kind of activities they perform at the workplace. Based on these activities six categories are constructed that classify the occupational skill requirements: analytic tasks, interactive tasks, repetitive cognitive tasks, repetitive manual tasks, non-repetitive manual tasks and computing tasks. On the individual level, each of these categories is an intensity. For example, the variable for analytical task intensities is the fraction of analytical activities in all activities an employee has to perform. Spitz (2003) includes details on the concept of skill requirements of occupations and a list of activities that employees perform ot their place of work. On average, 17 percent of the activities of employees are analytical in nature, whereas 3 percent are repetitive cognitive (Table A in the Appendix).

Firm characteristics: Firms are classified according to nearly 50 detailed industry codes. Based on these codes we group firms into three sectors: manufacturing, trade, and services. In order to identify firms operating in "IT-intensive" industries, we construct a dummy variable that takes the value one if the IT intensity of the industry is higher than the average IT intensity of the sector to which it belongs. In addition, the survey participants were asked whether or not their firm introduced new modes of production within the last two years and whether or not it put new products or new services on the market. Based on these answers two dummy variables for "process innovation" and "product innovation" were constructed.

Firm size measured as the number of employees is captured by 7 size classes. Firms with one to four employees are classified to belong to the first size bracket and firms with more than 1,000 employees to the last one. Based on these size classes, 7 dummy variables are formed. Most of the survey participants, 27 percent, belong to firms with a size class from 10 up to 49 employees, followed by the size class from 100 up to 499 employees. Firms with more than 1000 employees are represented by 16 percent of the survey participants. Less than 14 percent of the interviewed employees belong to small firms with less than ten employees (see Table D in the Appendix).

3 Empirical Results

Table 1 displays the estimation results of the basic wage regressions. The result in the first column shows that the raw log wage differential for IT use in Germany is 0.282 (about 32 percent) in 1998-1999. This is slightly smaller than the raw log wage differential of 0.288 that DiNardo and Pischke (1997) report for Germany based on the 1991-1992 cross-section of the BIBB/IAB data. Thus, in contrast to the period between 1979 and 1991-1992, where the raw log wage differentials for computer use increased steadily (although at a declining pace), as shown in the paper by DiNardo and Pischke, it remained stable or even slightly declined in the 90s.

Taking account of the fact that IT may be a very heterogenous factor, specification (2) in Table 1 includes the different types of IT devices available in the data set. The results show that the effects of these IT components differ considerably with respect to their size and significance. Personal computers, laptops and computerized control devices show positive and significant effects whereas the coefficients of other computers and scanners turn out to be insignificant. The measures of networking technologies, Internet and Intranet, have positive and highly significant effects.

Having only a cross-section at hand, we are not able to control for unobserved heterogeneity by taking individual-specific fixed effects into account. However, this caveat is to some extent outweighed by the fact that the data set contains many variables that are potentially correlated with IT use and hourly wages. These variables are included in the regressions as additional controls as explained in section 2. The results of the richer specification that controls for both, individual-specific characteristics such as formal educational attainment, work experience, tenure with the current employer and firm-specific characteristics such as firm size, sector affiliation, IT-intensity and innovative activity are displayed in column (3) of Table 1. As expected, the computer-use wage differential drops considerably compared to specification (1). Specification (4) additionally includes 77 two-digit occupation dummies which reduces the IT effect by more than 50 percent. Also, the effects of other covariates are reduced, however, without changing the qualitative results.

Table 1: OLS Regressions for the Effect of IT on Wages

Dependent Variable: Log(Hourly Wages)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
IT	0.282***		0.150***	0.072***	0.064***		
	(0.007)		(0.008)	(0.009)	(0.009)		
Personal Computer		0.112***				0.018**	
		(0.009)				(0.008)	
Laptop		0.106***				0.070***	
		(0.013)				(0.011)	
Other Computer		0.014				0.027**	
		(0.016)				(0.013)	
Scanner		0.005				-0.023**	
		(0.015)				(0.012)	
Comp. Control Devices		0.040***				0.032***	
		(0.011)				(0.011)	
Internet		0.117***				0.030***	0.035***
		(0.011)				(0.010)	(0.009)
Intranet		0.144***				0.050***	0.051***
		(0.009)				(0.009)	(0.009)
IT white-collar							0.039***
							(0.008)
IT blue-collar							0.016*
							(0.009)
Individ. Characteristics							
high educ. level			0.414***	0.253***	0.243***	0.240***	0.240***
			(0.016)	(0.018)	(0.018)	(0.018)	(0.018)
medium educ. level			0.119***	0.086***	0.085***	0.086***	0.086***
			(0.012)	(0.013)	(0.013)	(0.013)	(0.013)
experience			0.019***	0.021***	0.021***	0.021***	0.021***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
experience^2 *(1/100)			-0.033***	-0.036***	-0.036***	-0.036***	-0.036***
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm Characteristics							
IT intensive industry			0.041***	0.022***	0.020***	0.021***	0.020***
			(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Product Innovation			0.023***	0.021***	0.021***	0.017**	0.018***
			(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Process Innovation			0.046***	0.037***	0.035***	0.033***	0.031***
			(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Workplace Characteristics: Intensity of...							
analytic tasks					0.234***	0.240***	0.232***
					(0.038)	(0.038)	(0.038)
interactive tasks					0.188***	0.189***	0.180***
					(0.031)	(0.031)	(0.031)
routine cognitive tasks					0.381***	0.374***	0.344***
					(0.075)	(0.075)	(0.075)
routine manual tasks					0.024	0.037	0.026
					(0.063)	(0.063)	(0.063)
computer tasks					0.156***	0.087	0.084
					(0.057)	(0.058)	(0.058)
77 occupation dummies	No	No	No	Yes	Yes	Yes	Yes
R^2	0.12	0.14	0.36	0.41	0.42	0.42	0.42
Number of observations	10501	10491	9683	9683	9471	9661	9661

Control variables are: Dummy variable for civil servants, tenure with the current employer, sector dummies, dummies for 8 firm size categories. Employees with low levels of education working in large firms in the services sector are the base category. Heteroscedasticity-consistent standard errors are in parentheses. ***,**,*-indicate significance at the 1, 5, 10 percent level.

Specification (5) additionally includes information on workplace characteristics. The results still indicate that employees who use IT on-the-job earn about 7 percent more than employees who do not use computers on-the-job, holding education, occupation, firm characteristics and workplace characteristics constant. The results for the different specifications show that a large part of the raw log wage differential for IT use is captured by the educational attainment of employees. Firms operating in an IT-intensive environment are found to pay higher wages. The same holds for firms that are innovative with respect to new products as well as processes.

Column (6) of Table 1 reveals that the coefficients for advanced office technologies, PCs and laptops, as well as for the Internet and for Intranet drop considerably with respect to size after the inclusion of the controls. The coefficient for "other computers" now turns out to be significant at the five percent level and the coefficient for scanner use turns out to have a significantly negative impact on wages. This might reflect the fact that scanners are usually used by rather low-skilled employees such as cashiers, for example. In line with specification (2), these results underpin that IT is a quite heterogenous production factor the decomposition of which reveals interesting insights into the effects of different IT components. In particular, the effects of laptop use and Intranet use are relatively high compared to the other IT components. Although these devices are already widely diffused across firms, their use is probably restricted to employees with managerial, administrative or research tasks thus having a relatively high level of skills and thus earning higher wages. However, since various variables in this specification control for the educational attainment and the skill requirements of occupations, the positively estimated effects of some of the IT components might hint at heterogeneity within the group of highly qualified employees.

Specification (7), lastly, presents the results when aggregating the different IT tools to a dummy variable "IT white-collar" that takes the value one if the employee uses one of the advanced office technologies, and a dummy variable "IT blue-collar" that takes the value one if the employee uses one of the IT-related manufacturing tools. While these variables represent IT hardware components, Internet and Intranet are kept as single factors representing rather the degree of (internal and external) networking. In line with the results of specification (6), the IT white-collar dummy has a significantly positive sign. The coefficient of the IT-blue-collar dummy turns out to be positive but it is only weakly significant.

As outlined in Section 2, one of the aims of the paper is to identify the average treatment effect of IT use. Therefore, we estimate additional specifications that include various interaction terms between IT use (or the different components of IT) and covariates that were previously demeaned using the sample averages. In particular, IT use is interacted with qualification and experience as well as with workplace characteristics. Table 2 displays the results. The results in column (1) indicate that the ATE of IT use is around 6 percent for employees with low or medium levels of education. The ATE for employees with high levels of education is slightly negative.[3]

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[3]The average treatment effect of an educational level is $A\hat{T}E(x) = \hat{\alpha} + (x - \bar{x})\hat{\delta}$ where $\hat{\alpha}$ is the estimated average treatment effect, $\bar{x}$ is the sample mean of regressor x and $\hat{\delta}$ is the estimated coefficient of the interaction terms (see Wooldridge, p. 613 for further details). The estimated coefficient of IT use, 0.059,

We interpret the negative wage effect found for employees with high educational attainment to reflect saturation effects with respect to the diffusion of IT at the workplace. In the years 1998/1999, 88 percent of the employees with high educational attainment use IT at the workplace, thus IT use is a well established working tool for highly qualified employees such that its use is not rewarded anymore with wage premiums. A further approach to explain this result is that due to an increasing supply of highly qualified employees, the tasks that this group of workers has to accomplish are more and more those that were previously performed by employees with a medium educational level. Several studies discuss this under the heading "over-qualification".

It is also interesting that the IT effect changes sign with work experience. For employees with years of work experience below the average ($\underline{\text{experience}} < 0$) IT use has a negative impact on wages and this negative effect is reinforced by the quadratic term. For employees with above average years of work experience, the linear effect and quadratic effect jointly lead to an inverted U-relationship.

In specification (2), the different IT components are interacted with the (demeaned) levels of educational attainment of employees. Although not reported, this specification also includes interaction terms between the different IT components and the demeaned variables experience, experience^2 and tenure. The ATE for the white-collar IT components are significantly positive, whereas the ATE for scanner use is significantly negative. For employees with a high level of education, PC use is associated with lower wages and for employees with medium levels of education, the wage effect of PC use is zero. Analogous results are found with respect to laptops, although in this case the effect for employees with medium levels of education is also negative. This implies that the positive wage effect of the use of IT white-collar components are mainly driven by the wage effects found for employees with low levels of education.

Scanner use is on average associated with 4 percent wage decrease. However, employees with high levels of education who use scanners at the workplace earn around 10 percent higher wages. This result indicates that scanners are not only used to substitute for the routine tasks of cashiers at the bottom end of the wage structure but that they are also used by employees with high levels of education, for example employees framing advertisements and using scanners for creative work. The ATE for the Internet use is found to be nearly 4 percent and for Intranet use it is found to be slightly higher than 5 percent.

Specification (3) additionally includes interaction terms between IT and the demeaned task intensities of workplaces. The ATE for IT use drops slightly to around 5.5 percent. We find complementary relationships between non-repetitive cognitive tasks and IT use in the sense that IT users with above average intensities of analytical and interactive tasks

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reflects the average treatment effect of IT use. It refers to the employees with low educational level, thus for the reference group. However, it also refers to employees with medium educational level since the corresponding interaction term (medium educational level * IT) is insignificant. For employees with high educational level $ATE = (0.059 + (0.808 * (-0.082)) = -0.007$, where 0.808 corresponds to $(1 - 0.192)$ with 0.192 equal to the percentage share of employees with high educational level and -0.082 equal to the estimated interaction term for (high educational level *IT).

earn significantly higher wages. With respect to repetitive cognitive tasks, the results point to a substitutive relationship as IT users with above average intensities of repetitive cognitive tasks earn significantly less.

In what follows, the analysis is extended by including variables measuring organizational changes. As outlined in section 1, firms reorganize workplaces in order to increase the efficiency of the production process which might result in firm productivity gains and thus, if employees participate in these gains, in higher wages.

Basic bivariate regressions (not reported here) show that employees that work in firms that restructured their departments earn around 20 percent higher wages (t-statistic: 23.67). Employees working in firms that introduced changes in the management structure earn around 18 percent higher wages (t-statistic: 20.84) and employees working in firms that outsourced part of their production process witness a wage mark-up of more than 15 percent (t-statistic: 15.46). However, as these results are not conditional on other variables, they might be driven by composition effects.

The estimation results that take additional controls into account are displayed in Table 3. In columns (1)-(3) the different measures of organizational change, restructuring of the department, change in the management structure and outsourcing, are introduced separately in the regressions. The three coefficients are significantly positive indicating that employees working in firms that changed their organizational structures are payed higher wages even after controlling for various characteristics. Compared to the size of the coefficient of the bivariate regressions, however, the wage mark-up drops considerably. This result is robust with respect to various specifications. For example, the regression in specification (4) includes a dummy variable taking the value one if at least one of the three kinds of organizational change has been carried out. Specification (5) includes all three dummy variables measuring organizational change together. Although decreasing in size, these variables still turn out to have a positive and significant impact on hourly wages with the exception of the restructuring dummy the coefficient of which turns to be insignificant. The coefficients of the IT dummy have changed only slightly after the inclusion of the variables of organizational change compared to the results in Table 1.

These results are confirmed when IT usage is measured by the dummy variables "IT white-collar" and "IT blue-collar".[4]

[4]For efficiency reasons these results are not presented in this paper, however, they are available on request from the authors.

Table 2: OLS Regressions for the Effect of IT on Wages

Dependent Variable: Log(Hourly Wages)			
	(1)	(2)	(3)
IT	0.059***		0.055***
	(0.010)		(0.011)
Personal Computer		0.022***	
		(0.008)	
Laptop		0.082***	
		(0.013)	
Other Computer		0.022*	
		(0.013)	
Scanner		-0.041***	
		(0.014)	
Comp. Control Devices		0.027**	
		(0.012)	
Internet		0.039***	
		(0.011)	
Intranet		0.052***	
		(0.009)	
Individ. Characteristics			
high educ. level	0.302***	0.280***	0.291***
	(0.031)	(0.024)	(0.032)
medium educ. level	0.097***	0.101***	0.092***
	(0.015)	(0.014)	(0.015)
Workplace Characteristics: Intensity of...			
analytical tasks	0.232***	0.234***	0.185***
	(0.038)	(0.038)	(0.048)
interactive tasks	0.189***	0.184***	0.117***
	(0.031)	(0.032)	(0.038)
routine cognitive tasks	0.380***	0.346***	0.809***
	(0.075)	(0.075)	(0.152)
routine manual tasks	0.020	0.033	-0.021
	(0.063)	(0.063)	(0.070)
computer tasks	0.157***	0.085	0.178
	(0.057)	(0.057)	(0.165)
Interaction Terms			
high educ. level*IT	-0.082**		-0.071*
	(0.037)		(0.038)
medium educ. level*IT	-0.034		-0.027
	(0.027)		(0.027)
high educ. level*PC		-0.085**	
		(0.040)	
medium educ. level*PC		-0.076**	
		(0.037)	
high educ. level*Laptop		-0.137**	
		(0.064)	
medium educ. level*Laptop		-0.154***	
		(0.063)	
high educ. level*other Comp.		0.092	
		(0.065)	
medium educ. level*other Comp.		0.022	
		(0.059)	

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Dependent Variable: Log(Hourly Wages)			
high educ. level*Scanner		0.172**	
		(0.074)	
medium educ. level*Scanner		0.154**	
		(0.073)	
high educ. level*Comp. Control Dev.		-0.050	
		(0.069)	
medium educ. level*Comp. Control Dev.		-0.015	
		(0.066)	
high educ. level*Internet		-0.064	
		(0.069)	
medium educ. level*Internet		-0.033	
		(0.067)	
high educ. level* Intranet		-0.014	
		(0.041)	
medium educ. level*Intranet		0.011	
		(0.037)	
analytic * IT			0.136*
			(0.078)
interactive *IT			0.202***
			(0.064)
routine cognitive*IT			-0.461***
			(0.172)
routine manual * IT			0.157
			(0.132)
computer tasks * IT			0.076
			(0.178)
experience*IT	0.009***		0.009***
	(0.002)		(0.002)
$experience^2$ *(1/100) * IT	-0.015***		-0.016***
	(0.005)		(0.005)
R^2	0.41	0.42	0.42
Number of observations	9671	9661	9671

Control variables are: Dummy variable for civil servants, formal educational attainment, work experience, tenure with the current employer, sector dummies, dummies for 8 firm size categories, dummy for IT intensive firms, dummies for product and process innovations, 77 occupation dummies. x means that the sample average was subtracted from the regressor x. Specification (2) also includes the interaction terms between the different IT components and experience, $experience^2$ and tenure. Heteroscedasticity-consistent standard errors are in parentheses. ***,**,*-indicate significance at the 1, 5, 10 percent level.

Up until now, we analyzed the effects of IT use and organizational changes separately. However, since there is empirical evidence at the firm-level hinting at a complementary relationship between IT and organizational change we consider in the next set of regressions the interaction terms of the various types of organizational changes and IT in order to see whether IT users who work in firms that reorganized their production processes earn higher pay than non-IT-users. As the educational background of employees is also important for the productivity effects of IT use and organizational changes on the firm level, we additionally included threefold interaction terms to analyze whether employees with different educational background that use IT and work in firms that introduced organizational changes are rewarded systematically differently. In order to be able to identify average treatment effects, further interaction terms (with demeaned variables) are included into the specification.

Table 4 shows the estimation results. Each of the specifications focuses on one measure of organizational change: (1) restructuring of departments, (2) change in the management structure and (3) outsourcing. The ATE for each measure of organizational change is not significantly different from zero. Thus, it seems that, on average, employees do not share in the gains that firms achieve from reorganizing their production processes. The ATE for IT use, however, is still significantly positive and the size of 5 percent is compatible with the previous results. For the case of restructured departments and outsourcing, the interaction terms with IT use are positive and significant at the five percent level hinting at a complementary relationship.

From the results of the various interaction terms in specification (1), we conclude that firms reward employees with different educational attainment systematically differently, however, this payment strategy is independent from the fact whether or not firms have restructured their departments. The threefold interaction terms do not reveal significant effects, either. Only the interaction terms with work experience are significantly different from zero. Analogously to the interaction term between IT and experience the restructuring of departments has a negative impact for employees with experience below average which is reinforced by the quadratic term. For employees with experience above average restructured departments have a positive wage effect implying – together with the quadratic term – an inverted U-relationship. Thus, experience seems to enhance the wage premium that employees gain from the restructuring of departments, for example because they have to take more responsibilities.

The results for changes in the management structure, shown in column (2), are slightly different. Employees with a high level of education working in firms that changed their management structure earn significantly (at the 5 percent level) lower wages. The same holds for employees with a medium level of education, however, the coefficient is only significant at the 10 percent level. This result is intriguing because employees with high levels of education who are expected to have management duties in firms are likeliest to be affected by changes in the management structure. The same may be true for employees with a medium level of education, although to a lesser extent.

Looking at the threefold interaction term, we find weak evidence for complementarities between educational attainment, IT use and the introduction of changes in the management by firms.

With respect to the level of statistical significance, the results for outsourcing activities of firms (column 3) are most convincing. Employees with a high level of education who work in firms that outsourced part of their production process earn significantly lower wages than employees with equal educational attainment who work in firms without outsourcing. However, as the threefold interaction term shows, this negative effect turns out to be positive for those who use IT at the workplace.

Former empirical studies at the firm-level, for example Bresnahan et al. (2002) and Brynjolfsson and Hitt (2000) find evidence for complementarities between IT use and organizational changes resulting in productivity gains. Our results support the complementarity hypothesis for the case of restructuring of departments and outsourcing. Furthermore the threefold complementarity between qualification of employees, IT use and organizational changes is confirmed for outsourcing and (with only weak significance) for changes in the management structure.

One might suspect that only the wages of employees who are directly concerned by an organizational change differ systematically. In the survey the employees were asked whether or not their personal working situation has been directly affected by a workplace reorganization. This information is included in further regressions, the results of which are depicted in Table 5.

According to the estimation results, it does not seem to matter whether or not employees' working situations are directly affected by organizational change. None of the OC variables is significant. However, for the case of restructuring, we find a complementary relationship with IT resulting in significantly positive wage effects.

The interpretation of our results might be encumbered with an important caveat: although the coefficients for the different OCs are insignificant, they might be upward biased because those employees that have been mostly affected by the OCs have been dismissed. The survey on which our analyses are based, however, only includes employees, but not unemployed persons. Thus, we are not able to take account of persons who are affected by organizational changes in the sense that they lose their jobs. Using matched employer-employee data Jacobsen, LaLonde and Sullivan (1993), for example, find that high-tenure workers that are displaced and then rehired end up with considerable wage losses. Rationalizing production processes in order to save costs might be involved with the dismissal of employees – an effect that cannot be captured by our data base. This argument applies in particular to the case of outsourcing when firms not only source out certain tasks but whole workplaces.

Table 3: OLS Regressions for the Effect of IT and Organizational Change on Wages

Dependent Variable: Log(Hourly Wages)					
	(1)	(2)	(3)	(4)	(5)
IT	0.067***	0.061***	0.064***	0.063***	0.063***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Workplace Reorganization					
restructuring of dept.	0.016**				0.004
	(0.007)				(0.008)
chg. in management structure		0.036***			0.031***
		(0.007)			(0.008)
outsourcing			0.032***		0.023***
			(0.008)		(0.008)
organizational change				0.034***	
				(0.008)	
Individ. Characteristics					
high educ. level	0.241***	0.241***	0.241***	0.236***	0.237***
	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)
medium educ. level	0.085***	0.083***	0.087***	0.083***	0.083***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
experience	0.021***	0.021***	0.021***	0.021***	0.021***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
experience^2 *(1/100)	-0.035***	-0.036***	-0.036***	-0.035***	-0.035***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Workplace Characteristics: Intensity of...					
analytical tasks	0.224***	0.222***	0.245***	0.220***	0.222***
	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)
interactive tasks	0.171***	0.179***	0.179***	0.175***	0.176***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
routine cognitive tasks	0.352***	0.380***	0.365***	0.365***	0.369***
	(0.075)	(0.075)	(0.076)	(0.076)	(0.076)
routine manual tasks	0.005	0.009	0.028	0.014	0.017
	(0.064)	(0.065)	(0.066)	(0.068)	(0.068)
computer tasks	0.127**	0.133**	0.149***	0.132**	0.129**
	(0.057)	(0.057)	(0.058)	(0.058)	(0.058)
Firm Characteristics					
IT intensive industry	0.020***	0.021***	0.022***	0.024***	0.024***
	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Product Innovation	0.017**	0.017**	0.018**	0.016**	0.016**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Process Innovation	0.033***	0.031***	0.034***	0.029***	0.029***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
R^2	0.42	0.42	0.42	0.42	0.42
Number of observations	9496	9466	9345	9190	9190

Control variables are: Dummy variable for civil servants, tenure with the current employer, sector dummies, dummies for 8 firm size categories, 77 occupation dummies. Employees with low levels of education working in large firms in the services sector are the base category. Heteroscedasticity-consistent standard errors are in parentheses. ***,**,*-indicate significance at the 1, 5, 10 percent level.

Table 4: OLS Regressions for the Effect of IT, Organizational Changes, and Interactions on Wages

Dependent Variable: Log(Hourly Wages)			
	(1)	(2)	(3)
IT	0.048***	0.049***	0.054***
	(0.012)	(0.011)	(0.011)
Workplace Reorganization			
restructuring	-0.008		
	(0.015)		
chg. in management structure		0.018	
		(0.015)	
outsourcing			-0.013
			(0.020)
Individ. Characteristics			
high educ. level	0.314***	0.334***	0.328***
	(0.035)	(0.035)	(0.033)
medium educ. level	0.107***	0.105***	0.104***
	(0.018)	(0.017)	(0.017)
Interaction Terms			
IT * restructuring	0.040**		
	(0.018)		
IT * chg. in management structure		0.025	
		(0.016)	
IT * outsourcing			0.051**
			(0.024)
Interaction Terms w/ Demeaned Variables			
high educ. level * IT	-0.076*	-0.112**	-0.128***
	(0.046)	(0.047)	(0.041)
medium educ. level * IT	-0.002	-0.044	-0.053*
	(0.036)	(0.037)	(0.032)
high educ. level * restructuring	-0.064		
	(0.062)		
medium educ. level * restructuring	-0.049		
	(0.034)		
high educ. level * chg. management		-0.137**	
		(0.063)	
medium educ. level * chg. management		-0.064*	
		(0.039)	
high educ. level * outsourcing			-0.266***
			(0.090)
medium educ. level * outsourcing			-0.028
			(0.045)

<*Table continues on next page*>

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Dependent Variable: Log(Hourly Wages)			
	(1)	(2)	(3)
experience * IT	0.007***	0.009***	0.010***
	(0.003)	(0.003)	(0.002)
experience^2 *(1/100) * IT	-0.011***	-0.014***	-0.016***
	(0.005)	(0.005)	(0.005)
experience * restructuring	0.005**		
	(0.003)		
experience^2 *(1/100) * restructuring	-0.009*		
	(0.005)		
tenure * restructuring	-0.001		
	(0.001)		
experience * chg. in management		0.003	
		(0.003)	
experience^2 *(1/100) * chg. in management		-0.005	
		(0.005)	
tenure * chg. in management		-0.002*	
		(0.001)	
experience * outsourcing			0.001
			(0.003)
experience^2 *(1/100) * outsourcing			0.003
			(0.006)
tenure * outsourcing			-0.002**
			(0.001)
Threefold Interaction Terms			
high educ. level * IT * restructuring	0.009		
	(0.078)		
medium educ. level * IT * restructuring	-0.040		
	(0.057)		
high educ. level * IT * chg. management		0.129*	
		(0.079)	
medium educ. level * IT * chg. management		0.064	
		(0.060)	
high educ. level * IT * outsourcing			0.339***
			(0.103)
medium educ. level * IT * outsourcing			0.071
			(0.070)
R^2	0.42	0.42	0.42
Number of observations	9496	9466	9345

Control variables are: Dummy variable for civil servants, work experience, tenure with the current employer, workplace characteristics, sector dummies, dummies for 8 firm size categories, dummy for IT intensive firms, dummy for product and process innovations, 77 occupation dummies, interaction terms between demeaned workplace characteristics and measures of organizational change. Heteroscedasticity-consistent standard errors are in parentheses. ***,**,*-indicate significance at the 1, 5, 10 percent level.

According to a survey by the ZEW (Centre for European Economic Research) among more than 4,000 firms in the year 2000, the most important reasons for outsourcing of IT-related tasks have been the higher competency and quality of specialized firms, the possibility to save costs and the lack of time to do certain IT-tasks internally. In these firm-level data, no significant correlation between outsourcing and the expected development of employment can be found.

Table 5: OLS Regressions for the Effect of IT and of Organizational Changes that affect employees directly on Wages

Dependent Variable: Log(Hourly Wages)			
	(1)	(2)	(3)
IT	0.058***	0.054***	0.063***
	(0.010)	(0.010)	(0.010)
Being directly affected by...			
...restructuring	-0.018		
	(0.017)		
...restructuring * IT	0.035*		
	(0.019)		
...chg. in management structure		0.003	
		(0.015)	
...chg. in management * IT		0.021	
		(0.018)	
...outsourcing			-0.008
			(0.023)
...outsourcing * IT			0.029
			(0.027)
R^2	0.42	0.42	0.42
Number of observations	9496	9466	9345

Control variables are: Dummy variable for civil servants, formal educational attainment, work experience, tenure with the current employer, sector dummies, dummies for 7 firm size categories, dummy for IT intensive firms, dummy for product and process innovations, 77 occupation dummies and interaction terms between demeaned workplace characteristics (demeaned educational attainment) and measures of organizational change, demeaned educational attainment and IT use. The threefold interaction terms are also included. Heteroscedasticity-consistent standard errors are in parentheses. ***,**,*-indicate significance at the 1, 5, 10 percent level.

Several studies name the concentration on core competencies, cost reductions and lack of qualified personnel as the most important reasons for outsourcing decisions, see for example Henkel and Kaiser (2002, p.13) for the case of IT-outsourcing. The results by Falk and Koebel (2002) suggest that rather output growth than input substitution drives the increasing use of imported materials and purchased services. There seems to be no significant relationship between outsourcing and labor demand. The study by Heshmati (2003) gives a comprehensive overview on the effects of general outsourcing. The decision to source out might differ across firm size. For instance, large firms might source out whole departments which will lead to dismissals if the corresponding tasks are not done within the company anymore. On the other hand, the employees working in the outsourced department might continue their work within a new enterprise as it is for example the case for the Deutsche Bank that outsourced its IT-department to IBM, thus about 900 former Deutsche Bank employees are now working for IBM (Lamberti, 2003). Small firms, in contrast, will probably outsource single tasks rather than whole departments. In our data set, the percentage share of employees working in firms with organizational changes increases with firm size for all three types of OC considered as shown in Table D in the Appendix.

4 Conclusions

In this study we analyze whether the use of IT at the workplace and organizational changes are positively related to individual wages taking possible complementarities between IT and OC into account. We use data at the individual level referring to the time period 1998/1999.

Controlling for a wide range of individual characteristics, workplace characteristics and firm characteristics, we find an average treatment effect of IT use of around five to six percent. The results for the different IT-components indicate that it is important to take the heterogeneity of IT into account. We interpret this positive wage effect of IT use not as causal in the sense that only the implementation and use of IT at the workplace increases individual productivity and thus wages. In line with previous research, we rather believe that employees get more productive through their experience they gain with using IT (Entorf and Kramarz, 1997).

The average treatment effects for all three types of organizational changes considered as measures to increase the efficiency of a firm's production process turn out to be insignificant. Moreover, it does not seem to play a significant role whether or not the employee's personal workplace situation is affected by the OC.

IT users, however, who work in firms that restructured their departments or outsourced part of their production are systematically better rewarded. These findings are in line with recent studies based on firm-level data such as Bresnahan et al. (2002) who find that IT and OC are complementary strategies with respect to increasing productivity. In the case of outsourcing, a high level of educational attainment additionally is of significant importance. Moreover, analogously to the studies by Autor, Levy and Murnane (2003) and Spitz (2003), our analysis hints at complementarities between analytical as well as interactive tasks and IT.

The analyses we have to date lead to an open question that will be investigated in future research. Our finding that the log wage differential for IT use slightly dropped in the 1990s, together with the result that IT use for employees with high educational qualification is associated with a wage loss, is indicative of saturation effects as far as the diffusion of IT is concerned. The aspect of saturation was initially raised by Machin (2002) on the industry level. However, detailed analyses are still lacking.

Appendix

Table A: Summary Statistic

Summary Statistic					
	Mean	Std. Deviation	Min.	Max.	Observations
Information Technology					
IT	0.57	0.50	0	1	12334
IT white-collar	0.40	0.49	0	1	12322
IT blue-collar	0.18	0.38	0	1	12322
Personal Computer	0.35	0.48	0	1	12322
Laptop	0.12	0.32	0	1	12322
PC general	0.06	0.23	0	1	12322
Internet	0.18	0.39	0	1	12322
Intranet	0.32	0.47	0	1	12322
Scanner	0.11	0.31	0	1	12322
Computerized Control Devices	0.10	0.30	0	1	12322
Qualification					
high education level	0.19	0.39	0	1	12340
medium education level	0.70	0.46	0	1	12340
low education level	0.10	0.30	0	1	12340
experience	21.42	11.65	0	47	12340
tenure	12.98	10.49	0	47	12340
(hourly) wages (in DM)	29.72	12.24	3.19	98.68	10506
Workplace Characteristics:					
analytic task intensities	0.17	0.13	0	0.75	12319
interactive task intensities	0.60	0.18	0.13	1.00	12319
repetitive cognitive task int.	0.03	0.50	0	0.33	12319
repetitive manual task int.	0.28	0.68	0	0.50	12319
non-repetitive manual task int.	0.12	0.12	0	0.75	12319
computing task intensities	0.05	0.78	0	0.60	12319
Organizational Change					
restructuring of departments	0.42	0.49	0	1	11751
change in management structure	0.32	0.47	0	1	11785
outsourcing	0.19	0.40	0	1	11575
being directly affected by...					
...restructuring of departm.	0.19	0.39	0	1	11751
...change in management struct.	0.21	0.41	0	1	11785
...outsourcing	0.06	0.24	0	1	11575
Firm Characteristics					
IT intensive industry	0.56	0.50	0	1	12340
Product innovation	0.42	0.49	0	1	11803
Process innovation	0.57	0.49	0	1	11859

Table B: Firm Size Distribution

Firm Size Distribution					
			Perc. share of firms with		
Number of employees	Freq.	Percent	OC	MS	OUT
1 to 4	581	4.79	14.95	10.42	8.16
5 to 9	1088	8.97	15.24	12.64	5.94
10 to 49	3266	26.93	25.29	20.86	10.24
50 to 99	1609	13.27	36.29	28.68	13.38
100 to 499	2697	22.24	54.44	39.88	24.83
500 to 999	963	7.72	62.74	48.04	29.15
1000 and more	1950	16.08	71.13	56.05	39.94
Total	12127	100.00			

The three categories 1 employee, 2 employees, 3-4 employees are summarized in this table.

Table C: Summary Statistics for IT-users and non-IT-users

	Sample Means by IT-use			
	IT-user		non-IT-user	
	Mean	Std. Deviation	Mean	Std. Deviation
high education level	0.30	0.46	0.05	0.22
medium education level	0.65	0.48	0.77	0.42
low education level	0.05	0.22	0.17	0.38
experience	20.85	11.38	22.18	11.95
tenure	13.82	10.59	11.87	10.26
wage	33.41	12.85	25.01	9.54
restructuring of departments	0.54	0.50	0.26	0.44
change in management structure	0.41	0.49	0.21	0.41
outsourcing	0.23	0.42	0.15	0.36

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