IT, Organizational Change and Wages[§]

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Abstract

In this paper we analyze the impact of information technology (IT) use and organizational changes (OC) on wages. The individual level data for 1998/1999 contain detailed information on the use of different kinds of IT as well as on different organizational changes. We find that a large part of the IT–wage premium is attributable to the use of advanced office technologies and modern applications such as the Internet and Intranet. Moreover, employees share in the gains from OC within firms in form of higher wages. We find complementary impacts of IT and OC on wages only for the case of restructured departments. The wage premiums due to changes in the management structure and outsourcing turn out to be independent of the use of IT.

JEL–classification: J30, J31
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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 Chennells and Van Reenen (2002) or by Card and DiNardo (2002).

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). In addition, the reorganization of workplaces may have a much larger impact on the occupational structure of firms than technical capital (Aguirregabiria and Alonso-Borrego, 2000), and 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 effect of information technology (IT) use *and* organizational change (OC) in a common framework using individual level data. Using the individual level has several advantages: In contrast to 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. In addition, we also know whether or not employees 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 employees were 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. In addition, detailed information in our data set both with respect to individual characteristics and firm characteristics allows to extract much of the unobserved heterogeneity that usually has sobering effects on the meaningfulness of estimation results. Finally, 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 data set used in this study contains information of around 12,000 individuals observed in 1998/1999. The empirical evidence obtained from OLS regressions suggests that even when controlling for a wide range of individual characteristics as well

as firm characteristics, there remains a positive and significant effect of IT on wages of about 9 percent. Taking account of the heterogeneity of IT by including different measures of IT instead of an aggregate measure shows, however, that only advanced office technologies are related to higher wages. In particular, the coefficient of more recent IT applications such as Internet and Intranet turn out to be important with respect to their size and their significance. IT–related manufacturing technologies, in contrast, have no significant effect on wages.

All types of organizational changes considered as measures to increase the efficiency of a firm's production process show positive and significant impacts on wages when included separately as well as when included jointly in the wage regressions. Following the literature that views IT and OC as complementary strategies we analyze, by using interaction terms, whether IT–users who work in firms that reorganized their production process are rewarded systematically different than non–IT–users. For the case of restructuring departments we find complementarities of IT and OC with respect to wages. This result seems reasonable if restructuring departments reflects a decentralizing process attributing more responsibility and decision making rights to employees. This kind of OC usually demands an efficient information flow between employees as well as between employees and management, thus needing an efficient IT system. In addition, the demand for personal skills that are hard to capture by "observable" variables may thereby be increased. As regards changes in the management structure and outsourcing, our estimation results rather suggest that sharing part of the productivity gains is a company–wide strategy in firms that changed their organizational structure. This strategy results in a wage premium for all employees in the firm independent of whether or not they use IT on–the–job. Moreover, it does not seem to play a significant role whether the employee's personal workplace situation is affected by the OC for none of the three types of OC considered.

The paper is organized as follows: Section 2 gives a short review on previous studies on the effects of IT and OC and motivates our work. Section 3 describes the data and the empirical framework. Estimation results are presented and discussed in section 4. Section 5 concludes.

2 Background Discussion

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

DiNardo and Pischke, 1997 and Entorf and Kramarz, 1997). In particular, Entorf and Kramarz (1997) show by taking individual specific fixed effects into account that new technologies are used by abler workers which 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.

Borghans and ter Weel (2002) provide a theoretical model of the adoption and diffusion of computers and the related development of the wage structure. They propose that initially the most productive and skilled workers start to use computers resulting in a wage inequality within the group of skilled workers. When unskilled workers start to use computers, owing to decreasing costs of IT, also the wage inequality between the group of skilled and the group of unskilled workers increases. Between-group and within-group wage inequality should diminish with the increasing diffusion of computers. Remaining wage inequalities are attributable to relatively higher productivity gains. The theoretical model is consistent with the empirical findings of the authors using U.S. CPS data from 1963 to 2000.

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), Eriksson (2001), 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 for example 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.

A recent branch of the literature points out the complementarity of IT and OC. As put forward for instance by Bresnahan et al. (2002) and Brynjolfsson and Hitt (2000), IT *enables* organizational change. 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 (2001) 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 services sector for analyzing how changes in jobs may affect wage outcomes. Their results suggest that employees benefit from IT use and OC in 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 reorganizing their organizational structure.

From the point of view of the firm 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.

The data set contains information about three measures of workplace reorganization: restructuring of departments, changes in the management structure, and outsourcing.

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 fix costs by variable cost, and to increase flexibility.

3 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 observations. 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, firms in the agricultural sector are excluded.

Our basic framework closely follows Krueger (1993), using ordinary least squares (OLS) estimation techniques with heteroscedasticity-consistent standard errors. In addition to the main variables of interest, IT and OC, we include variables reflecting individual characteristics in order to account for the fact that employees may systematically differ with respect to characteristics that may again affect 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 do not have enough information on the employers to tell whether they systematically differ in ways that affect wages and OC. Our data set, in contrast, allows to take various firm characteristics into account such as firm size, industry affiliation 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 less likely to introduce OC than smaller firms. We expect "high–tech" firms to pay higher wages and that they are more likely to introduce OC than firms with less IT–intensive production processes (Osterman, 1994).

Hence, the most important variables for the analysis are: hourly wages, the IT equipment used on–the–job, the formal educational background of employees, work experience, tenure with the current employer and occupational dummies, firm size dummies, sector dummies and the IT–intensity of the industry. Summary statistics are in the Appendix. The variables are constructed as follows:

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.

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 kind of computers, scanners or computerized control devices such as e.g. 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) on–the–job.

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 kind 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 shows that 57 percent of the employees in the sample use IT on–the–job. Within the group of "IT white–collar, the use of personal computers is the largest with a percentage share of 63 percent, followed by 21 percent of employees using laptops and 10 percent using "other computers. Within the group of "IT blue–collar, scanners are used by 19 percent of the employees, and 17 percent of the employees work with computerized control devices. 33 percent of the survey participants in our sample use the Internet and 57 percent use an Intranet.

Organizational Changes: Employees are asked whether the firm they are working at has introduced one or more of the following three different kinds of measures

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

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 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. According to the summary statistics in Table A, 42 percent of the employees in the sample belong to firms that restructured departments. Management structures have been changed in case of 32 percent of the employees and 20 percent of the survey participants indicate to belong to firms in which parts of the production process has been outsourced. Owing to a high item–nonresponse, the information whether employees have been directly affected by the different kinds of organizational change is available only for a fraction of the sample. Within this sub–sample, between 31 percent of employees in the case of outsourcing and even 64 percent of employees in the case of changes in the management structure say that their workplace situation has been directly affected by the corresponding organizational change. 44 percent report that their workplace has been directly affected by a restructuring of departments.

Although there is no single generally accepted definition of HPWO or innovative HRM in the literature, most authors share the idea that these terms do not refer to single practices but rather to a bundle of complementary practices that together form a coherent system (see for example Ichniowski, Kochan, Levine, Olson and Strauss, 1996, Milgrom and Roberts, 1990, and Osterman, 1994). According to the figures in Table B, 25 percent of the survey participants indicate to belong to firms that restructured their departments and changed their management structure. 12 percent reported that the firms changed their management structure and increased their outsourcing activities. 15 percent belong to firms that intensified their outsourcing activities in addition to restructuring their departments and 11 percent of the survey participants belong to firms that implemented all three practices. Hence, although the incidence differs, each of the combinations of practices can be observed indicating that there is no single bundle of practices that is applied in all firms.

In addition, OC and IT 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 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 5 also demonstrates major differences with respect to the

educational attainment of IT–users and non–IT–users and their wage outcome.

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. As expected, 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 (Table A).

The survey participants also indicate their first year of work. Based on these answers we calculate 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.

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 "high–tech" 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.

Firm size measured as the number of employees is available in 7 size classes. Firms with one to four employee 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).

4 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 computer 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 with declining pace), as shown in the paper by DiNardo and Pischke, it remained stable or even slightly declined in the 90s.

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

Dependent Variable: Log(Hourly Wages)				
	(1)	(2)	(3)	(4)
IT	0.282***	0.087***		
	(0.007)	(0.008)		
Personal Computer			0.017**	
			(0.009)	
Laptop			0.071***	
			(0.011)	
Other Computer			0.021	
			(0.013)	
Scanner			-0.017	
			(0.013)	
Computerized Control Devices			0.006	
			(0.012)	
Internet			0.038***	0.046***
			(0.010)	(0.009)
Intranet			0.048***	0.053***
			(0.009)	(0.009)
IT white–collar				0.042***
				(0.009)
IT blue–collar				0.005
				(0.010)
Individual Characteristics				
highly educated		0.265***	0.241***	0.244***
		(0.018)	(0.026)	(0.026)
medium educated		0.099***	0.064***	0.065***
		(0.012)	(0.023)	(0.024)
experience		0.021***	0.025***	0.024***
		(0.001)	(0.002)	(0.002)
experience^2 *(1/100)		-0.037***	-0.042***	-0.042***
		(0.002)	(0.003)	(0.003)
Firm Characteristics				
IT intensive industry		0.020***	0.028***	0.027***
		(0.007)	(0.010)	(0.010)
77 occupation dummies	No	Yes	Yes	Yes
Pseudo-R^2	0.12	0.42	0.37	0.36
Number of observations	10501	10234	5766	5766

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. Standard errors are in parentheses ***,**,*–indicate significance on the 1, 5, 10 percent level.

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 was already explained in section 3. 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, and IT–intensity is displayed in column (2) of Table 1. This specification also contains 77 two–digit occupation dummies. As expected, the computer–use wage differential drops considerably compared to specification (1). The results still indicate that employees who use IT on the job earn about 9 percent more than employees who do not use computers on the job, holding education, occupation, and firm characteristics constant. However, a large part of the IT wage premium is captured by the educational attainment of employees. Firms operating in an IT–intensive environment, i.e. that belong to an IT-intensive industry are also found to pay higher wages.

The data allow to have a closer look at different kinds of IT tools. In column (3) of Table 1, we can see that only the coefficients for advanced office technologies, PCs and laptops, as well as for the Internet and for Intranet are significantly positive. Other computers as well as the tools that are best classified as IT–related manufacturing technologies (scanners and computer controlled devices) do not have a significant impact. These results show that IT is a quite heterogenous production factor the decomposition of which reveals interesting insights into the effects of different IT components. Although Internet and Intranet are already widely diffused across firms, their use within firms is probably restricted to employees with managerial, administrative or research tasks thus having a relatively high level of skills and thus earning higher wages.

The results do not change considerably when aggregating the different 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 (3), only the IT white–collar dummy has a significantly positive sign, the coefficient of the IT–blue–collar dummy is, as expected, insignificant. Since the coefficients of the other regressors in specification (4) do not vary considerably compared to those in specification (3), it seems to be justified to aggregate the IT variables in this way.

As outlined in section 2, 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. The estimation results

taking account of organizational changes are displayed in Table 2. 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 reorganized their organizational structures are payed higher wages. This result is robust with respect to various specifications. For example, the regression in column (4) contains a dummy variable taking the value one if at least one of the three kinds of organizational change has been carried out. The results in column (5) correspond to a regression including 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. A comparison of the coefficients of the IT dummy in Tables 1 and 2 shows only a slight reduction when taking account of organizational change.

These results are confirmed when IT usage is measured by the dummy variables "IT white–collar" and "IT blue–collar" as shown in Table 3. It is also interesting to note that the coefficients of the IT usage variables only drop slightly owing to the inclusion of the OC–variables.

Up until now, we analyzed the effects of computer 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 change and IT in order to see whether IT-users who work in firms that reorganized their structures earn higher pay than non–users.

Table 4 displays the estimation results. For the case of restructured departments, specification (1), the coefficient of the restructuring dummy drops considerably with respect to size compared to specification (1) in Table 3 and turns to be insignificant. However, the interaction term between IT and restructuring is positive and significant at the five percent level. For the other two cases, changes in the management structure and outsourcing, specifications (2) and (3), the reverse outcome can be found. The effect of the organizational change variable remains positive and significant whereas the interaction terms turn out to be insignificant. The latter effects dominate in the last specification (4) of Table 4 where organizational change and its interaction with IT are measured on a more aggregate level. These results imply that the restructuring of departments seems to go hand in hand with the use of IT or, put differently, that IT use seems to be complemented by the appropriate organizational measures such as enforcement of team work, self–managing teams or other kinds of organizational change that demand an efficient information flow between employees which is again supported by IT usage. The other two kinds of organizational change considered in the estimations are obviously not related to the use of IT. A change in a firm's management structure or outsourcing of parts of

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

Dependent Variable: Log(Hourly Wages)					
	(1)	(2)	(3)	(4)	(5)
IT	0.084***	0.079***	0.085***	0.080***	0.079***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Workplace Reorganization					
restructuring of dept.	0.033***				0.017**
	(0.007)				(0.008)
chg. in management structure		0.048***			0.037***
		(0.007)			(0.008)
outsourcing			0.043***		0.027***
			(0.008)		(0.008)
organizational change				0.051***	
				(0.007)	
Individual Characteristics					
highly educated	0.256***	0.260***	0.261***	0.252***	0.253***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
medium educated	0.093***	0.094***	0.098***	0.090***	0.091***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
experience	0.021***	0.021***	0.022***	0.021***	0.022***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
experience^2 *(1/100)	-0.036***	-0.037***	-0.037***	-0.037***	-0.037***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm Characteristics					
IT intensive industry	0.021***	0.023***	0.024***	0.025***	0.025***
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Pseudo-R^2	0.42	0.42	0.41	0.42	0.42
Number of observations	9808	9836	9655	9431	9431

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. Standard errors are in parentheses ***,**,*–indicate significance on the 1, 5, 10 percent level.

the production process do not necessarily reflect a change in the information flow among employees and are thus not necessarily related to the use of IT. However, these variables are positively and significantly related to hourly wages independent of whether or not employees use IT and thus reflect a wage compensating effect for example due to the necessity to adapt to new working conditions or to restrict the content of work to certain tasks.

While 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 change resulting in productivity gains, our results support the complementarity hypothesis only for the case of restructuring departments. However, this result seems to be reasonable in the sense that work efficiency of a restructured department might be enhanced by the appropriate use of IT and vice versa. However, a wage premium due to productivity gains resulting from outsourcing is independent of the employees' IT usage. Potential productivity gains resulting from these measures are passed on to employees rather as a company–wide strategy

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 white–collar	0.038***	0.038***	0.038***	0.039***	0.038***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
IT blue–collar	0.005	0.001	0.002	0.002	0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Internet	0.041***	0.045***	0.046***	0.042***	0.040***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Intranet	0.051***	0.052***	0.054***	0.054***	0.053***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)
Workplace Reorganization					
restructuring	0.034***				0.021**
	(0.009)				(0.010)
chg. in management structure		0.046***			0.035***
		(0.009)			(0.009)
outsourcing			0.034***		0.017*
			(0.010)		(0.011)
organizational change				0.048***	
				(0.010)	
Individual Characteristics					
highly educated	0.225***	0.234***	0.232***	0.220***	0.222***
	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)
medium educated	0.049***	0.057***	0.056**	0.045***	0.047**
	(0.023)	(0.023)	(0.024)	(0.023)	(0.023)
experience	0.025***	0.025***	0.025***	0.025***	0.025***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
experience^2 *(1/100)	-0.041***	-0.041***	-0.041***	-0.041***	-0.041***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm Characteristics					
IT intensive industry	0.030***	0.029***	0.031***	0.033***	0.034***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Pseudo-R^2	0.36	0.37	0.36	0.37	0.37
Number of observations	5634	5638	5561	5468	5468

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

independent of the *individual* IT usage within the firm.

One might suspect that only employees who are directly concerned by an organizational change have higher wage rates. 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. The number of observations decreases considerably due to a high item–non–response with respect to these variables. 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.

The results in Table 4 and Table 5 indicate that firms that implement organizational

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

Dependent Variable: Log(Hourly Wages)				
	(1)	(2)	(3)	(4)
IT	0.074***	0.075***	0.083***	0.070***
	(0.10)	(0.010)	(0.009)	(0.012)
Workplace Reorganization				
restructuring	0.016			
	(0.011)			
chg. in management structure		0.041***		
		(0.011)		
outsourcing			0.036***	
			(0.012)	
organizational change				0.040***
				(0.010)
Interaction Terms				
IT*restructuring	0.026*			
	(0.014)			
IT*chg. in management structure		0.011		
		(0.014)		
IT*outsourcing			0.011	
			(0.015)	
IT*organiz. change				0.019
				(0.013)
Pseudo-R^2	0.42	0.42	0.41	0.42
Number of observations	9808	9836	9655	9431

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, 77 occupation dummies. Employees with low levels of education working in large firms in the services sector are the base category. Standard errors are in parentheses ***,**,*–indicate significance on the 1, 5, 10 percent level.

changes do this as part of their corporate strategy. This strategy goes along with paying higher wages to employees no matter whether or not the employee's personal workplace situation has been directly concerned.

To sum up the empirical results: Although our data set allows to control for a wide range of individual–specific and firm–specific characteristics IT use is related to significantly higher wages for employees. Taking different kinds of IT into account reveals significantly positive effects only for PCs, laptops, the Internet and Intranet whereas the coefficients of IT rather related to blue–collar occupations, i.e. scanners and computerized control devices, remain insignificant. Organizational change as a measure to increase the efficiency of a firm's production process shows a positive and significant impact on wages. These cross–section results may be driven by the fact that abler employees who already earned higher wages before the introduction of IT are more likely to use IT on–the–job and highly productive firms that already paid higher wages before the introduction of organizational changes are more likely to introduce measures of OC as outlined in section 2. Unfortunately, our data set is lacking valuable instruments that could be informative of this question. In

order to include additional information on the ability of employees, we also estimate regressions that contain variables reflecting the skill requirements of jobs such as for example the intensity of analytical tasks and interactive tasks.[2] However, this proceeding does not change our estimation results.

The hypothesis that IT and organizational change have to be seen as complementary strategies going hand in hand in order to result in positive productivity effects and thus in higher wages is supported only for the case of restructuring departments. No complementary effects are found for changes in the management structure and outsourcing although there might be complementary effects on the firm level with respect to productivity — what we cannot analyze with our data. The wage premiums of IT use and OC rather turn out to be independent of each other for these two types of OC. In addition, we find for all three kinds of OC considered, that it does not seem to play a significant role whether or not the employee's personal workplace situation is affected by the organizational change .

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

Dependent Variable: Log(Hourly Wages)			
	(1)	(2)	(3)
IT white–collar	0.034***	0.018	0.022
	(0.012)	(0.013)	(0.019)
IT blue–collar	0.016	0.013	-0.004
	(0.013)	(0.014)	(0.019)
Internet	0.040***	0.054***	0.046***
	(0.012)	(0.014)	(0.019)
Intranet	0.045***	0.036***	0.050***
	(0.012)	(0.014)	(0.018)
Being directly affected by...			
...restructuring	0.009		
	(0.010)		
...chg. in management structure		-0.007	
		(0.012)	
...outsourcing			0.002
			(0.016)
Pseudo-R^2	0.38	0.38	0.43
Number of observations	3124	2370	1303

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, 77 occupation dummies. Employees with low levels of education working in large firms in the services sector are the base category. Standard errors are in parentheses ***,**,*–indicate significance on the 1, 5, 10 percent level.

[2]See Spitz (2003) for details on the concept of skill requirements of jobs.

5 Conclusions

Our paper analyzes whether the use of IT on–the–job and organizational changes are positively related to individual wages taking into account possible complementarities between IT and OC. We use data at the individual level referring to the time period 1998/1999.

The empirical evidence obtained from OLS regressions suggests that even when controlling for a wide range of individual characteristics as well as firm characteristics, there remains a positive and significant effect of IT on wages of about 9 percent. A large part of the effect is attributable to the use of advanced office technologies. In addition, the coefficients of more recent IT applications such as the Internet and Intranet turn out to be important with respect to their size and their significance. IT–related manufacturing technologies, in contrast, have no significant effects on wages.

All types of organizational changes considered as measures to increase the efficiency of a firm's production process show positive and significant impacts on wages when included separately as well as when included jointly in the wage regressions.

Although recent studies find that IT and OC are complementary strategies with respect to promoting productivity, we find these complementarities with respect to wages only for the exceptional case of restructuring departments – a result that makes sense if restructuring departments reflects a decentralizing process attributing more responsibility and decision making rights to employees and demanding more personal skills that are hard to capture by "observable" variables. However, as regards the other two kinds of OC considered in this study, changes in the management structure and outsourcing, our estimation results rather suggest that sharing part of the productivity gains is a company–wide strategy in firms that reorganized their production. This strategy results in a wage premium for all employees in the firm independent of whether or not they use IT on–the–job. Moreover, it does not seem to play a significant role whether the employee's personal workplace situation is affected by the OC.

The results found in our study are consistent with previous empirical findings in the literature on the wage premium of IT use such as those by DiNardo and Pischke (1997) or Krueger (1993). Some authors such as for example Entorf and Kramarz (1997) point out the importance of unobserved individual heterogeneity and apply fixed effects estimation on panel data in order to control for it. Due to the fact that our data set is a cross-section we are not able to include fixed effects. Thus, although our data set contains a vast variety of individual–specific and firm–specific regressors included in the estimations, there might be some unobserved characteristics such as "soft skills" that might not be captured by these controls and hence,

the wage premiums of IT and OC found in our estimations might further be reduced when using panel data. Nevertheless, our results provide useful insights in the relationship between wages and IT and OC showing in particular that not only individual heterogeneity might be of importance in determining these wage effects but that also the heterogeneity of IT and OC are of importance.

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	0.71	0.45	0	1	6971
IT blue–collar	0.31	0.46	0	1	6971
Personal Computer	0.63	0.48	0	1	6971
Laptop	0.21	0.41	0	1	6971
PC general	0.10	0.30	0	1	6971
Internet	0.33	0.47	0	1	6971
Intranet	0.57	0.50	0	1	6971
Scanner	0.19	0.39	0	1	6971
Computerized Control Devices	0.17	0.38	0	1	6971
Qualification					
highly educated	0.19	0.39	0	1	12340
medium educated	0.70	0.46	0	1	12340
low educated	0.10	0.30	0	1	12340
experience	21.42	11.65	0	47	12340
tenure	12.98	10.49	0	47	12340
wage	29.72	12.24	3.19	98.68	10506
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.	0.44	0.50	0	1	4923
...change in management struct.	0.64	0.48	0	1	3803
...outsourcing	0.31	0.46	0	1	2236

Table B Organizational Change

Organizational Change		
Type of Organizational Change	Number of Employees	Percentage share*
restructuring of departments	4941	43.82
change in management structure	3820	33.88
outsourcing	2246	19.92
restructuring & chg. in management structure	2827	25.07
restructuring & outsourcing	1727	15.32
chg. in management structure & outsourcing	1360	12.06
restructuring, chg. in management structure & outsourcing	1187	10.53

*The denominator of this share is the total number of respondents with non-missing answers to these questions, 11275.

Table C Summary Statistics for IT–users and non–users

	Sample Means by IT–use			
	IT–user		non–IT–user	
	Mean	Std. Deviation	Mean	Std. Deviation
highly educated	0.30	0.46	0.05	0.22
medium educated	0.65	0.48	0.77	0.42
low educated	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

Table D Firm Size Distribution

Firm Size Distribution		
Number of employees	Freq.	Percent
1 to 4	581	4.79
5 to 9	1088	8.97
10 to 49	3266	26.93
50 to 99	1609	13.27
100 to 499	2697	22.24
500 to 999	963	7.72
1000 and more	1950	16.08
Total	12127	100.00

References

Aguirregabiria, V. and Alonso-Borrego, C. (2000). Occupational structure, technological innovation, and reorganization of production, *Labor Economics* **8**: 43–73.

Appelbaum, E., Bailey, T., Berg, P. and Kalleberg, A. (2000). *Manufacturing Advantage: Why High Performance Work Systems Pay Off*, Cornell University Press.

Bertschek, I. and Kaiser, U. (2001). Productivity effects of organizational change: Microeconometric evidence, *mimeo*, ZEW Mannheim.

Black, S. E. and Lynch, L. M. (1996). Human-capital investments and productivity, *American Economic Review* **86**(2): 263–267.

Black, S. E. and Lynch, L. M. (2000). What's driving the new economy: The benefits of workplace innovation, *Mimeo*.

Black, S. E. and Lynch, L. M. (2001). How to compete: The impact of workplace practices and information technology on productivity, *Review of Economics and Statistics* **83**(3): 434–445.

Borghans, L. and ter Weel, B. (2002). The diffusion of computers and the distribution of wages, *Mimeo*, ROA and MERIT.

Bresnahan, T. F., Brynjolfsson, E. and Hitt, L. M. (2002). Information technology, workplace organization and the demand for skilled labor: Firm-level evidence, *Quarterly Journal of Economics* **117**(1): 339–376.

Brynjolfsson, E. and Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance, *Journal of Economic Perspectives* **14**(4): 23–48.

Cappelli, P. and Carter, W. (2000). Computers, work organization, and wage outcomes, *Working Paper 7987*, National Bureau of Economic Research, Cambridge, MA.

Card, D. and DiNardo, J. E. (2002). Skill-biased technological change and rising wage inequality: Some problems and puzzles, *Journal of Labor Economics* **20**(4): 733–783.

Chennells, L. and Van Reenen, J. (2002). Technical change and the structure of employment and wages: A survey of the microeconometric evidence, *in* N. Greenan, Y. L'Horty and J. Mairesse (eds), *Productivity, Inequality and the Digital Economy*, MIT Press, Cambridge, MA, pp. 175–223.

DiNardo, J. E. and Pischke, J. S. (1997). The returns to computer use revisited: Have pencils changed the wage structure too?, *Quarterly Journal of Economics* **CXII**: 291–303.

Entorf, H. and Kramarz, F. (1997). Does unmeasured ability explain the higher wages of new technology workers?, *European Economic Review* **41**: 1489–1509.

Eriksson, T. (2001). The effects of new work practices — evidence from employer-employee data, *Mimeo*. International Conference on Organisational Design, Management Styles and Firm Performance.

Huselid, M. A. (1995). The impact of human resource management practices on turnover, productivity, and corporate financial performance, *Academy of Management Journal* **38**(3): 635–672.

Ichniowski, C., Kochan, T., Levine, D., Olson, C. and Strauss, G. (1996). What works at work: Overview and assessment, *Industrial Relation* **35**(3): 299–333.

Ichniowski, C., Shaw, K. and Prennushi, G. (1997). The effects of human resource management practices on productivity: A study of steel finishing lines, *American Economic Review* **87**(3): 291–313.

Krueger, A. B. (1993). How computers have changed the wage structure: Evidence from microdata, 1984–1989, *Quarterly Journal of Economics* **CVIII**(1): 33–60.

Milgrom, P. and Roberts, J. (1990). The economics of modern manufacturing: Technology, strategy, and organization, *American Economic Review* **80**(3): 511–528.

Osterman, P. (1994). How common is workplace transformation and who adopts it, *Industrial and Labor Relations Review* **47**(2): 173–188.

Osterman, P. (2000). Work reorganization in an era of restructuring: Trends in diffusion and effects on employee welfare, *Industrial and Labor Relations Review* **53**(2): 179–196.

Spitz, A. (2003). IT capital, job content and educational attainment, *Discussion Paper 03-04*, ZEW Mannheim.