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Are technological change and organizational change biased against older workers?
Firm-level evidence

Abstract:
Recent decades have been characterized by rapid technological change. In the same period, early withdrawal from the labor market has increased markedly. One particular question concerns the effects of technological change and organizational change on the labor market participation of workers of different ages. The question posed in this paper is whether technological change and organizational change are biased against age, thereby causing a shift in demand from older to younger workers. We estimate the effects of organizational change and technological change on wage bill shares for five age groups. By using panel data, we control for unobserved firm fixed effects. The results indicate that organizational change raises the wage bill share for workers in their forties but lowers the share for workers in their fifties. The wage bill shares of the youngest and oldest workers are hardly affected by organizational change and technological change. Separate estimates for men and women yield qualitatively similar results. In regressions for different educational levels, wage bill shares are positively affected by organizational change for highly educated individuals in their thirties. Technological change increases the wage bill share of highly educated workers in their sixties. For workers with intermediate and lower levels of education, the results are similar to those obtained from the whole sample.

Keywords: technological change, organizational change, age-biased labor demand

JEL classification: J23, J31, O33

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1. Introduction

In recent decades, there has been widespread technological change, particularly the increased use of information technology (IT) in most businesses; see Berman *et al*. (1994), Berman *et al*. (1998), and Autor *et al*. (1998). The introduction of new technologies in a firm may make some of the existing human capital of its workers obsolete. Along with the development and adoption of new production technologies come new ways of organizing workplaces. This is because the new technologies require new ways of organizing the workplace to operate efficiently.[1] Along with the introduction of new technologies and workplace practices, there has been a fall in the labor force participation of older men in many countries during recent decades; see OECD (2006). There are many studies of reduced labor force participation by older men. Much of this literature has focused on the supply side in analyzing reduced labor force participation by older male workers; see Gruber and Wise (2004). Far less attention has been given to the demand side.

In this paper, we examine how organizational change and technological change affect the demand for workers of different ages by using data on a sample of Norwegian manufacturing firms. More specifically, our aim is to examine whether organizational change and technological change are biased against older workers. There are few existing studies of this subject. Aubert *et al*. (2006) appear to be the only ones to analyze the effects of organizational devices and new technologies on older workers. We are able to improve on their estimation strategy because we have access to panel data, rather than just one cross section. This allows us to control for unobserved firm heterogeneity by using differences over many periods.

Why should the demand for workers of different ages differ as a result of technological change and organizational change? Older workers are more experienced and may be more skilled. Because of their extra experience, they may be better able to use new technology and cope with new workplace practices if these changes are biased in favor of the more skilled and experienced. However, new technology and workplace practices may also be detrimental for older workers. Aubert *et al*. (2006) provide two reasons for this. First, if these changes make the skills of older workers obsolete, then because their skills are less suited to the new technology and to the new organizational structures, their productivity could fall below that of younger workers. Second, older workers may be disadvantaged by the adaptability requirements of new technological and organizational innovations. Bosma *et al*. (2003) find evidence that adaptability deteriorates with age.

Our main finding is that the wage bill shares of workers who are between 40 and 50 years old rise following organizational change, whereas the wage bill share of workers in their fifties falls.

[1] See Aubert *et al*. (2006), Caroli and Van Reenen (2001), and Black and Lynch (1996, 2001, and 2004).

Demand for younger workers appears to be unaffected by organizational change and technological change. These results support the hypothesis that organizational change is biased against older workers. This is because demand shifts from workers who are between 50 and 60 to workers who are 10 years younger but not to workers who are younger by 20 years or more. This suggests that there is some age bias in the interior of the age distribution. For both the youngest and the oldest workers, factors other than age affect wage bill shares. One implication of these findings is that technological change does not seem to be biased against age. On the contrary, the wage bill share of highly educated workers in their sixties rises following technological change. However, technological change reduces the wage bill share of highly educated workers in their fifties. This indicates that the most able workers survive the longest in the labor market. For organizational change, we find similar results; that is, workers in their fifties are negatively affected, whereas those in their sixties are unaffected. This indicates that less-skilled workers in their fifties are the most vulnerable to organizational change and technological change.

The rest of this paper is organized as follows. In Section 2, we review the relevant literature. In Section 3, we describe developments in early retirement and labor force participation by age. In Section 4, we describe our econometric model. In Section 5 we describe the data used for estimation. In Section 6, we present the estimation results. Section 7 concludes the paper.

2. A review of the empirical literature on technological change and organizational change and the demand for workers by age

There are a few studies analyzing the impact of technological change on the labor market opportunities of older workers. Some authors analyze how older workers are affected by computer use. The argument is that older workers may have more problems using computers than younger workers. However, there is no unified evidence to support this view. In their study, Borghans and ter Weel (2002) find no effect of age on computer use when they control for the tasks that are performed and the wage costs that may be saved by using computers. Friedberg (2003) finds some evidence of skills obsolescence from technological change that results in less computer use but only for workers who are close to retirement.

Aubert *et al*. (2006) analyze the impact of organizational change and technological change on the demand for workers of different ages. They use a sample of French firms to examine whether there was an age bias in organizational and technological innovations in the 1990s. They use joint generalized least squares (Seemingly Unrelated Regression model) to regress wage bill shares for four age groups on variables capturing workplace innovations and computer use as well as physical capital and value added. This model can use potential correlation between age categories within the same firm at the same time period. They find that the wage bill share of older workers is lower, and that of younger workers is higher, in innovative firms. Further, these results apply to both men and women. Their results also hold for different occupations. Thus, in a general sense, skills do not seem to fully protect workers from the effects of innovations. Aubert *et al*. (2006) also analyze inflows and outflows, and find that technological change boosts the job opportunities of younger workers. On the other hand, organizational innovations reduce exits by older workers by less than they do for younger workers. They conclude from these findings that older workers suffer from either skill obsolescence or a lack of adaptability following technological change and organizational change.

Older workers may be a selected group. Estimating the effects of, for example, computer use by age is only possible for individuals still in work. Given that it is reasonable to assume that the longest surviving workers in the labor market are the most efficient, this suggests that age is correlated with computer use. This may cause an underestimation of the effect of age. This is because the workers who are omitted from the sample have withdrawn from the labor market, and thus may be the least skilled.

A related, and much larger, part of the literature is devoted to analyzing whether new technologies and new workplace practices are biased in favor of skilled workers *per se*. Skill-biased technological change shifts demand toward more highly skilled labor and away from less-skilled workers; see Bresnahan *et al*. (2002). Chennels and Van Reenen (2002) provide an overview of the literature on skill-biased technological change and Card and DiNardo (2002) present a critical view of the skill-biased technological-change hypothesis. In a recent paper analyzing how skill requirements are related to technological change, Spitz-Oener (2006) finds that current skills are more complex than those that were required in 1979. Further, she finds that the demand for skills is higher in computer-intensive companies. In a sample of Dutch establishments, Borghans and ter Weel (2006) find that productivity gains explain most of the changes in the division of labor. Further, productivity gains raise the demand for skills, while improvements in communication lead to greater specialization and reductions in skill requirements. There are a few studies that suggest that organizational change is skill biased; see Caroli and Van Reenen (2001) and Bresnahan *et al*. (2002). These organizational innovations are characterized by moves away from mass production and bureaucratic organization towards more flexible and decentralized workplace organization. In a recent paper, Mobius and Schoenle (2006) develop a model that can explain the evolution of work over time. Their model differs from standard models of skill-biased technological change because they make no assumptions about the effect of technological change on the demand for skills in different time periods. This is because their model does not incorporate any assumptions about the direct effect of technological change on skills. The production technology determines the organization of the workplace, and the product market is the transmission mechanism in their model.

3. Early retirement and labor force participation in Norway

Lower labor force participation by older workers because of early retirement is a growing concern in many countries. Consider the figures on withdrawal rates from labor in Norway. Figure 1 displays the shares of those under disability retirement, those receiving AFP pensions, and those in a residual group 'other'. The group 'other' comprises individuals who are on temporary disability pensions, in rehabilitation, unemployed, or who are not participating in the labor market for some other reason. Other nonemployed individuals could be in education (typically younger individuals) or may be staying at home (particularly older women). Some older individuals may have retired early through private retirement schemes. Figure 1 shows that the share of those on disability pensions increased slightly for individuals in their thirties and through their forties. For individuals over 50 years old, the share on disability pension increases even more. Twenty percent of 66-year-olds retired with a disability pension. Some individuals who are 62 or more retired with an AFP pension. About 12 percent have AFP pensions at the age of 62. For 66-year-old individuals, more than 32 percent retired with AFP pensions. For those in the 'other' group, the share falls as people age from their early twenties to their late fifties. Thereafter, the share in this group increases, and the share for those who are 66 years old is less than 15 percent. Thus, in total, about two-thirds of 66-year-old individuals retire before they reach the official retirement age.

We divide the population aged 20–66 according to their educational levels and calculate their labor force participation rates. Individuals are categorized according to whether they have a low, intermediate, or high educational level. The three groups are defined in the Appendix. The labor force participation rates of those with low education are remarkably stable over time, as Figure 2 shows. None of the age groups has participation rates above 80 percent. For the age group 60–66, the participation rates are slightly over 40 percent. Apart from the latter age group, all age groups experienced small reductions in participation rates between 2001 and 2003.

Labor force participation rates for those with an intermediate educational level are shown in Figure 3. The trend is quite stable, although the participation rates are higher than for the less educated. The participation rate for individuals in their sixties fell slightly from 57 percent in 1992 to 53 percent in 2003. In Figure 4, labor force participation rates for highly educated individuals are shown. Individuals in their thirties and forties had the highest labor force participation rates, at around 90 percent, in 2003. For those in the age groups 30–39, 40–49, and 50–59, the participation rates did not change much from 1992 to 2003. On the other hand, participation by individuals in their twenties increased from about 70 percent in 1992 to 73 percent in 2003. For individuals in their sixties, the participation rate decreased from about 72 percent in 1992 to 66 percent in 2003. The labor market participation of older highly educated workers probably fell, in part, because more individuals retired with an AFP pension.

4. Econometric model

We investigate how the demand for workers of different ages is affected by organizational change and technological change. The demand for labor can be derived from minimization of the firm's cost function. A frequently used cost function is the translog cost function. This function has a flexible form, which is suitable for representing choices of production technology. Thus, we assume that the firm minimizes a translog cost function of the following form:

(1)
$$lnC_{i,t}=\beta_0+\sum_{a\in(1,\dots,A)}\alpha_a lnW_{a,i,t}+\sum_{a\in(1,\dots,A)}\sum_{a'\in(1,\dots,A)}\beta_{a,a'}lnW_{a,i,t}lnW_{a',i,t}+\beta_K lnK_{i,t}$$
$$+\sum_{a\in(1,\dots,A)}\beta_{a,K}lnK_{it}lnW_{a,i,t}+\beta_y lnY_{it}+\sum_{a\in(1,\dots,A)}\beta_{a,Y}lnY_{it}lnW_{a,i,t}+\beta_Q lnY_{it}+\sum_{a\in(1,\dots,A)}\beta_{a,Q}lnY_{it}lnW_{a,i,t},$$

where $C_{i,t}$ denotes costs and $W_{a,i,t}$ is the wage for age group *a* in firm *i* in year *t* and there are *A* age groups. Further, $K_{i,t}$ is capital, $Y_{i,t}$ is value added, and $Q_{i,t}$ denotes technological and organizational capital. Using Shepard's Lemma, we can derive the conditional factor demands. However, because the factor demand system is not linear in the parameters, it is common to use the wage bill shares. These are given by:

(2)
$$S_{a,i,t}=\alpha_a+\sum_{a\in(1,\dots,A)}\beta_{a,a'}lnW_{a',i,t}+\beta_{a,K}lnK_{i,t}+\beta_{a,Y}lnY_{i,t}+\beta_{a,Q}lnQ_{i,t}+\varepsilon_{a,i,t},$$

where $S_{a,i,t}$ denotes the wage bill share of age group *a*. The cost function in (1) represents the theoretical model. In (2), we have added a stochastic error term, $\varepsilon_{i,t}$, to generate an econometric model. There are several problems related to the estimation of these wage bill share equations. We apply the estimation methods developed by Caroli and Van Reenen (2001) to deal with these problems. First, there is the problem of unobserved heterogeneity. A common way of controlling for fixed unobserved effects is to apply the difference operator to (2) and estimate differenced equations. Then, we get the following equations in (long) difference form, where long refer to a two year period:

(3)
$$S_{a,i,t}=\beta_{a,a}\quad lnW_{a,i,t}+\sum_{a',a\neq a'}\beta_{a,a'}\quad lnW_{a',i,t}+\beta_{a,K}\quad lnK_{i,t}+\beta_{a,Y}ln\quad Y_{i,t}+\beta_{a,Q}\quad lnQ_{i,t}+\quad\varepsilon_{a,i,t},$$

where   is the long-difference operator.

Another important problem is that both technological change and organizational change may be endogenous. A shock to the firm, such as a negative demand shock, may cause the firm to reorganize and downsize specific groups of workers simultaneously. A response to such a shock could also be to introduce new technologies and simultaneously change the composition of the labor force in the firm. To tackle this simultaneity problem, we use lagged values of organizational change and technological change as instruments for the instantaneous values of the same variables. The lagged values of the variables are predetermined and can thus be treated as being exogenous to changes in the wage bill shares in period *t*. Another justification for using lagged values could be that institutional regulations and other rigidities in the decision-making process cause firms to delay adjustments to labour. Data on organizational change and technological change over the period 1999–2001 are used to explain changes in the wage bill shares between 2001 and 2003. By using lagged values of the explanatory variables, any relationship between changes in wage bill shares and the variables representing organizational change and technological change may seem weaker. Thus, any effect of organizational change or technological change is an indicator of an actual effect on wage bill shares. The other explanatory variables are also lagged for the same reasons that the technological- and organizational-change variables are lagged. Further, the variables for technological change and organizational change are discrete; they do not measure the stock of technological change or organizational capital, and they convey nothing about the comprehensiveness of such changes, which is a limitation. Rather, they simply indicate whether a firm changed its production technology or whether it made any organizational change within a specified time period.

In addition, the relative-wage terms are replaced with dummy variables for regions. As noted by Schøne (2002), there are high mobility costs in the Norwegian labor market, with relatively low mobility between regions. Thus, using regional-specific dummy variables is a reasonable way of representing differences in relative wages. We estimate the following equations for age-specific wage bill shares:

$$(4) \qquad S_{a,i,j,k,t} = \beta_{a,O} OC_{i,t-1} + \beta_{a,T} TECH_{i,t-1} + \beta_{a,K} \; lnK_{i,t-1} + \beta_{a,Y} \; lnY_{i,t-1} + \alpha' X_{i,t-1} + \gamma_1' IND_{ji} + \gamma_2' REG_{ki} + \; u_{a,i,t} \, .$$

In (4), *a* indexes the age group, *i* indexes the firm, and *t* indexes the time period. Further, *j* denotes the industry and *k* denotes the region. The variable representing organizational change, *OC*, is a dummy variable that takes a value of unity for firms that implemented organizational change in the preceding two years, and zero otherwise. Similarly, *TECH* is a dummy variable that is unity if the firm changed its process technology in the preceding two years, and zero otherwise. The capital stock is denoted by *K*, and *Y* denotes value added, while *X* is a vector of firm-specific characteristics. The variables *IND* and *REG* represent industry and regional dummies, respectively. There are seven regional dummies and 14 industry dummies. In addition, in (4), we include an interaction term between organizational change and technological change.

5. Data

The data set is constructed by combining three data sources from Statistics Norway. Individual-level data from Norwegian register data (FD–TRYGD) in Statistics Norway are used to calculate wage bill shares and employment shares at the firm level.[2] These data consist of administrative register data on registered events for all individuals in the Norwegian population. The database contains information on variables such as demography, labor market status, including employer identification, education, unemployment, retirement, income, and wealth. The database has data from 1992. We use data up to 2004. The data for technological change and organizational change are taken from the innovation statistics in Statistics Norway; see Statistics Norway (2004). The innovation survey is periodic and was undertaken in 1992, 1997, and 2001. The survey for 2001 is based on the same questionnaire for all EU member countries and forms part of Eurostat's third Community Innovation Survey. The survey focuses on the introduction of new or improved products, processes, and innovation activity at the firm level. Data for tangible fixed assets and value added were collected from the capital database in Statistics Norway; see Raknerud *et al*. (2004). The capital database contains data from accounts statistics and manufacturing statistics in Statistics Norway. The data from the accounts statistics are for joint-stock companies and contain financial data from balance sheets and income statements. The data in the accounts statistics are unconsolidated. This means that they are firm-level data and imply that the parent company and its subsidiaries are treated as separate economic units. Because data on acquisitions of tangible fixed assets are not included in the accounts statistics, these data are collected from manufacturing statistics. The capital database covers firms in the manufacturing sector.

The dependent variables are the changes in wage bill shares between 2001 and 2003. Similarly, changes in employment shares (share of workers) are changes between 2001 and 2003. The data for technological change and organizational change are taken from the innovation statistics for 2001. These two variables are discrete. They denote whether there have been any changes in process technology or organizational structures during the period 1999–2001. All other control variables relate to this same time period. Descriptive statistics for the explanatory variables are shown in Table 1.

The sample covers workers aged 20 to 66. Because few individuals under 20 are in the labor market, it is reasonable to exclude those who are younger than 20. As the official retirement age in Norway is 67, workers older than 66 years are excluded. Workers are divided into five age groups: 20–29 years; 30–39 years; 40–49 years; 50–59 years; and 60–66 years. This is similar to the classification used by Aubert *et al*. (2006), except for the 60–66-years-old age group. Further, we include in the sample firms that had workers in each age group in either 2001, 2003, or both years. This means that a firm that has workers in a particular age group in 2001 does not necessarily have

[2] Information (in Norwegian) about these data can be found at http://www.ssb.no/emner/03/fd-trygd/

workers in the same age group in 2003, or *vice versa*. Using this procedure creates a sample of 1,047 firms, 753 of which are single-plant firms.

The proportions of firms that introduced new technologies and organizational change in the period 1999–2001 are similar, at 36.5 percent and 35.8 percent, respectively. Thus, about one-third of the firms in our sample experienced either technological change or organizational change. Nearly 19 percent of firms experienced both technological change and organizational change during the period. The employment shares of the three age groups (30–39, 40–49, and 50–59) were similar in 2001. In that year, the youngest age group had the smallest employment share and the oldest age group had the smallest wage bill share. The oldest age group includes fewer age cohorts than the other groups. In addition, in this group, many individuals have access to early retirement schemes. Thus, as we explained in Section 3, their labour force participation is lower. The variables used are defined in the Appendix.

6. Results

6.1. Wage bill share estimates

For each age group, the change in the wage bill share is regressed on the variable for technological change, the variable for organizational change, and the other control variables by using ordinary least squares (OLS). The standard errors are adjusted, making them robust to arbitrary heteroskedasticity, see White (1980). The results for the total sample are given in Table 2. The changes in the average wage bill shares for all five age groups together sum to zero. According to the results, there was a reduction in the two youngest age groups' wage bill shares between 2001 and 2003. The reduction is largest for the age group 20–29. The wage bill share for this group fell by 20.7 percent. For the three oldest age groups, the increases in the wage bill shares are similar. However, the increase of 22.4 percent for the workers in their sixties is the largest. Unemployment between 2001 and 2003 increased and employment fell. This may partly explain why the wage bill share of the youngest workers is the smallest. There are two regressions for each age group. In the first regression, organizational change (OC) and technological change (TECH) are included along with estimates of the control variables. The results are shown in panel A. In the second regression, an interaction term between the organizational- and technological-change variables is included. These results are reported in panel B. In the tables, we report only the results for the OC and TECH variables and the variable corresponding to the interaction between them. The results that include the estimates of the coefficients for all the control variables included in the regressions in panel A of Table 1 are shown in Appendix Table 1. These control variables are the logarithm of the change in capital between 1999 and 2001, the logarithm of the change in value added between 1999 and 2001, the logarithm of the change in employment between 2001 and 2003, the logarithm of average employment in the period 1999 to 2001, financial performance between 1999 and 2001 (in the form of a binary variable that is unity if the operating profit margin is better than average in the manufacturing sector, and zero otherwise), the age of the firm in 2003, the wage bill share of all five age groups in 2001, seven regional dummy variables, and 14 industry dummies.

The results in panel A indicate that the wage bill share of workers in their forties increases as a result of organizational change. For 50–59-year-old individuals, on the other hand, organizational change affects the wage bill share negatively. For the other age groups, neither organizational nor technological change has any significant impact on the wage bill shares.[3] In panel B, the interaction variable between organizational change and technological change is included. Organizational change continues to positively affect the wage bill share of workers in their forties. However, the interaction variable between organizational change and technological change has a negative impact on the wage bill share for this age group. Nevertheless, the total effect of organizational change and technological change and their interaction is positive but not statistically significant, where this is tested using an F-test. The wage bill share for workers in their fifties remains negatively affected by organizational change. However, the coefficient is not statistically significant. Comparing the models in panel A and B there does not seem to be any significant differences. The explanatory power is in all cases quite similar. The results, therefore, does not give any clear indications that one of the models should be preferred.

The picture that emerges from these results is that the wage bill share of workers in their fifties falls following organizational change. However, workers in the forties, rather than younger, workers benefit. Arguably, although these workers are quite experienced, they have several years left in the labor market. This is because they are in the middle of their working careers. Workers in their fifties, on the other hand, are closer to retirement and are expected to have less time left in the labor market. This may reduce their incentives to adapt to new technologies and new organizational devices. For those in the age groups 20–29, 30–39, and 60–66, neither organizational nor technological change, nor the interaction between them, has any significant effect on the wage bill shares. Regarding the other control variables in Appendix Table 1, for 20–29-year-olds, the variable for changes in employment is positive and significant. This indicates that expansions in employment raise the wage shares of individuals in their twenties. There is no evidence that organizational change or technological change affects the wage bill shares of individuals in their thirties. There are reasons to believe that 60–66-year-olds are a highly selective group, on whom there are specific individual effects that are unobservable to the researcher. Many individuals in these age cohorts have already

[3] Results from panel-A regressions that include all the variables are reported in Appendix Table 1.

withdrawn from the labor market. Hence, those remaining in work probably have different characteristics compared to those that have already left the labor market. To be specific, those still in work may be the most able individuals in these age cohorts. In addition, many of them can take advantage of early retirement options through the AFP scheme.

The first set of regression results indicates that workers in the forties benefit from organizational change, whereas workers in their fifties are disadvantaged. Technological change has no significant effect on the wage bill share of any age group. Aubert *et al*. (2006) find that younger workers have a higher share of the wage bill in companies in which there is greater computer use and in companies that implement organizational change, whereas the opposite is the case for older workers. Unlike these authors, we control for firm-specific fixed effects, which represent unobserved characteristics that are specific to the firm. This means that the variables for organizational change and technological change do not pick up any fixed effects. That is, the coefficients on these variables represent the pure effect of these variables on changes in the wage bill share. Thus, our results may differ from those of Aubert *et al*. (2006) because their positive relationship between younger workers' share of the wage bill and organizational change and technological change is captured in our model by the fixed effects. However, the data used in this paper do not allow us to undertake the same type of analysis as that by Aubert *et al*. (2006). This is because we can only construct variables for organizational change and technological change in general; we do not have information on the specific organizational routines and technologies used at any particular point in time. Whether their analysis would have generated the same results on our sample is unclear.

There may be some uncertainty regarding the interpretation of the results in Table 2. We therefore investigate the robustness of the reported results. In each regression in Table 2, the dependent variable is the change in the wage bill share. Changes in relative wages may influence the wage bill share. To check whether this is of any importance, we run regressions in which changes in employment shares (share of workers) are the dependent variables. The results in Table 3 convey the same broad effects of organizational change and technological change as do the regressions for the wage bill shares. Thus, the results based on the regressions for wage bill shares do not seem to be driven by changes in relative wages between age groups.

A problem with our variables representing organizational change and technological change is that they only indicate whether firms made any changes to their organizational structures or introduced new process technologies between 1999 and 2001. This means the variables convey no information about the comprehensiveness of the changes. This is a weakness of the data. In this respect, Aubert *et al*. (2006) have access to richer information about the organizational routines applied by firms. In addition, firms may have one or more plants. In multiplant firms, the changes reported may apply to all the plants or only to some of them. There is no information about this.

However, in single-plant firms, we know that the changes affect that specific unit. In any case, because changes in organizational structure and technology may only affect part of the firm, relevant information is still missing. However, it may be worth running the regressions in Table 2 for single-plant firms only. Comparing these results with those in Table 2 would reveal the different effects of organizational change and technological change in multiplant and single-plant firms. This also conveys information about the robustness of the results to changes in the sample. The results from similar regressions to those in Table 2 for single-plant firms are reported in Table 4. The main results from Table 2 still apply apart from a few differences. In panel A, organizational change positively affects the wage bill share of workers aged 40–49. Although organizational change continues to have a negative impact on the wage bill share of 50–59-year-olds, the effect is not significant. On the other hand, the coefficient on organizational change for those aged 60–66 is negative and significant. The only difference between panel B in table 4 and table 2 is that the interaction variable for 40–49-year-olds is no longer statistically significant, although it remains negative, as in Table 2.

The demand responses to organizational change and technological change may differ for firms in which employment fell between 2001 and 2003 compared to firms in which employment increased over the same period. There were 552 firms that reduced employment and 495 firms that increased employment between 2001 and 2003. The results of separate regressions for each age group by employment change are given in Table 5. Changes in wage bill shares are larger in firms that lowered employment than in firms that raised employment, although the structure of the changes is similar. Both in expanding and in contracting firms, the wage bill shares of workers in the age groups 20–29 and 30–39 fell between 2001 and 2003. The largest reduction was for the lowest age group. Wage bill shares for the three other age groups increased over the same period. Hence, we would not expect running separate regressions for expanding and contracting firms to greatly affect the results. Let us consider these estimates.

First, we consider firms that reduced employment. In panel A, the coefficient for organizational change is positive and significant for the age group 30–39 but is negative for those aged 50–59. None of the other coefficients for organizational change and technological change are significant. Organizational change seems to improve opportunities for workers who have some experience of the labor market. However, these changes do not seem to benefit workers in their fifties, who have had a long working career. This suggests an age bias in organizational change. However, workers in their twenties are negatively affected by organizational change but not significantly. In panel B, the interaction variable between organizational change and technological change is included. The coefficient on the variable for organizational change for those in the 30–39 age group is positive but not significant. For the 40–49 age group, both organizational change and technological change have positive and significant effects on the wage bill share. The interaction variable also has a significant impact on the wage bill share for this age group but the effect is negative. For 50–59-year-olds, the wage bill share falls following organizational change. These results represent weak evidence of an age bias in organizational change by indicating that workers in the forties benefit from organizational change and technological change, whereas, as shown by panel A, workers in their fifties experience a fall in their wage bill shares as a result of these changes.

Turning next to firms that increased employment, in panel A, the coefficient on the variable for technological change is positive and significant for 30–39-year-olds, whereas technological change has a negative impact on the wage bill share for those in their forties. However, for the latter age group, organizational change has a negative and significant impact on the wage bill share. From panel B, the coefficient on technological change for those in their thirties is no longer significant, and the same is true for 40–49-year-olds. However, the effect of organizational change for the latter age group remains positive. The interaction variable between organizational change and technological change has a negative impact on the wage bill share for those in the 50–59 age group and a positive impact on the wage bill share for those aged 60–66. For the 60–66 age group, the effect of organizational change is negative and significant when the interaction variable between organizational change and technological change is included. The aggregate effect of organizational change and technological change and their interaction is not significantly different from zero for both age groups, where this is tested using an F-test. There is no clear evidence of any age bias in either organizational change or technological change. Technological change increases the wage bill share of workers in the thirties and has the opposite effect on workers in their forties. That means technological change is beneficial for workers who have a few years of work experience, whereas workers in the middle of their careers are negatively affected. However, workers in the latter age group are positively affected by organizational change, although these effects are not stable. When the interaction variable between organizational change and technological change is included, only the positive effect of organizational change for the 40–49 age group is still significant, although the directions of the effects are the same as those in panel A. In addition, the interaction variable has a negative effect on the wage bill share of workers in their fifties. By contrast, this effect is positive for the highest age group included. These effects could be driven by the selection of workers remaining in the labor market. Workers in their sixties are probably more likely to be selected than workers in their fifties. Simultaneous organizational change and technological change may disadvantage less-able workers in their fifties but may benefit workers in their sixties, since the latter group, having survived for so long in the labor market, have high ability. However, there is evidence of such an effect only among firms that increased employment.

6.2. Wage bill share estimates by gender

Organizational change and technological change may affect men and women differently. This could be because men and women have different occupations within firms, and these jobs may differ in how they are affected by organizational change and technological change. Therefore, we run separate regressions for men and women. In Table 6, results from these regressions are reported. In panel A, for men, the only significant coefficient estimate is the positive one on technological change for the 50–59 age group. When the interaction variable between organizational change and technological change is included, the coefficient on technological change for those aged 50–59 remains negative but is not significant. On the other hand, the coefficient on organizational change is positive for those aged 40–49. That is, the wage bill shares of men are not greatly affected by organizational change and technological change. The wage bill shares of those in different age groups changed little between 2001 and 2003. The largest change applies to individuals in their twenties, for whom there is a reduction of 0.014. In the regressions that include only men, those in this age cohort are positively affected by employment changes, as is the case according to the regressions for all workers.

In the regressions for women, the results are similar to those for the whole sample. Female workers in their forties experience an increase in their wage bill share, while women in their fifties experience a decrease. Many of these women probably engage in administrative work that may be affected by the introduction of both IT and new workplace practices. The results show that women in their forties are positively affected by organizational change, whereas those in their fifties are negatively affected. Thus, workers in their forties may be better able to adapt to new workplace practices than workers who are closer to retirement. On the other hand, the wage bill share of female workers in the forties are negatively affected by technological change. This may be because IT affects job requirements or makes some jobs redundant.

6.3. Wage bill share estimates by educational level

In the preceding regressions, workers with different educational levels were grouped together. This was done to investigate if there is an age bias without taking into account differences in education. There are potentially several ways of dividing the sample according to education. One way is to use information on the educational level, meaning the length of education. Another way is to divide the sample according to educational field. One could also try to construct a measure of skills, which may take into account factors other than educational level such as educational field, work experience, and the wage. We limit our analysis to investigating differences by years of education. There is evidence in the literature that better educated workers are more able to cope with changing technology and workplace changes; see, for example, Chennels and Van Reenen (2002), who investigate the effects of technological change on the demand for skills, and Caroli and Van Reenen (2001), who investigate the effects of organizational change.

We divide the sample into three according to educational level. Those with a low educational level comprise individuals with not more than 12 years of schooling. Individuals with unspecified education and those for whom no information on their education is available are included in the low educational-level group. Those with an intermediate educational level comprise individuals with 13 or 14 years of schooling. Those with high education comprise persons with a college or university degree. Definitions of the three educational groups are given in the Appendix. The regression results for the three educational levels are reported in Table 7.

As before, the wage bill share is defined as the share of wages relative to the total wage bill in the firm. For workers with high education, the impact of organizational change on 30–39-year-olds is positive; see panel A. Those in the 50–59 age group are negatively affected by technological change. The effect is positive for the 60–66 age group. When an interaction variable between organizational change and technological change is included, these estimates are no longer significant, although their signs are the same as in panel A. The coefficients for technological change and organizational change and the interaction variable for 40–49-year-olds are significant. Technological change and organizational change have positive effects on the wage bill share. The interaction variable negatively affects the wage bill share of 40–49-year-olds. According to the regressions without the interaction variable, technological change has a negative impact on those in their fifties but has a positive effect on workers in their sixties. The positive effect for the highest age group might be because of selection effects since this group may include the most able persons. They may be highly motivated to adapt to new technology. However, organizational change has no such effect. Because a large proportion of workers in their fifties are still working, the introduction of new technology may shift labor demand away from workers who find it difficult to adapt to the new technology. For this group, the estimated effect of organizational change is negative but not significant. Results change when the interaction variable is introduced. Technological change and organizational change raise the wage bill share of workers in their forties. Thus, simultaneous organizational change and technological change imply that workers in the forties benefit from changes in both organization and process technology. On the other hand, workers in the forties in firms that implement both organizational change and technological change suffer a fall in their wage bill share. This shows that our results for highly educated workers are unstable and sensitive to the model specification.

For those with an intermediate educational level, organizational change has a positive and significant effect on the wage bill share of those in their forties; see panels A and B. In panel A, when there is no interaction variable, technological change negatively affects the wage bill share of those who are 50–59 years old. When the interaction variable is included, the estimated coefficient is negative but not significant. Thus, as in the whole sample, workers in the forties are positively affected by organizational change, and this effect is stable in different model specifications. On the other hand, unlike in the whole sample, organizational change does not have a significantly negative impact on the wage bill share of workers in their fifties, although the estimated coefficient is negative.

Results for individuals with a low educational level are similar to those with an intermediate level. The effect of organizational change on the wage bill share of workers in their forties is positive and significant, whether the interaction variable is included or not. For those who are 50–59, organizational change has a negative and significant impact on the wage bill share; see panel A. When the interaction variable is included, the coefficient on organizational change is negative but not significant. Organizational change has a larger positive effect on workers in the forties, with a low educational level than on those with an intermediate level. We also find that the coefficients on organizational change and technological change for workers in their fifties are negative, although they are only significant in some regressions. Thus, as in the aggregate regressions, most of the significant effects relate to those in the age groups 40–49 and 50–59. The effects on the wage bill shares are positive for workers in their forties and negative for workers in their fifties.

7. Conclusions

In this paper, we found that organizational change increases the wage bill share of workers in the forties but reduces the wage bill share of workers in their fifties. However, organizational change or technological change does not shift demand from the oldest to the youngest workers. In separate regressions for men and women, the main results broadly apply to women. For men, the qualitative effects are similar, but most of the effects are not statistically significant. Dividing the sample by educational level does not greatly affect the estimated effects of organizational change and technological change on wage bill shares for persons with a low or intermediate level of education. For higher educated individuals organizational change increases the wage bill share of workers in their thirties, while technological change raises the wage bill share of workers in their sixties. However, workers in their fifties suffer a fall in their wage bill share following technological change. The findings do not constitute unambiguous evidence of an age bias in either organizational change or technological change. However, workers in the forties benefit through a higher wage bill share following organizational change. By contrast, organizational change is detrimental to workers in their fifties.

An advantage of our analysis over that of Aubert *et al*. (2006) is that we can control for firm-specific fixed effects. Hence, our estimated effects of the explanatory variables are not a mixture of the variables' effects and the fixed effects. The estimated effects are the true effects of the right-hand-side variables. However, a weakness of our data is that the variables for organizational change and technological change are binary. They only convey information whether changes have taken place. They reveal nothing about the comprehensiveness of the changes. In that respect, Aubert *et al*. (2006) are in a better situation since they have access to richer information about the intensity of the use of computers and about organizational routines. Thus, data that incorporate information about the intensity of changes could be useful in capturing the comprehensiveness of changes. Another useful extension might be to create a multi-dimensional measure of skills that utilize information on other variables beside the level of education. Hence, in addition to information on educational levels, information on educational fields, experience and wage levels may be useful for creating a measure of skills.

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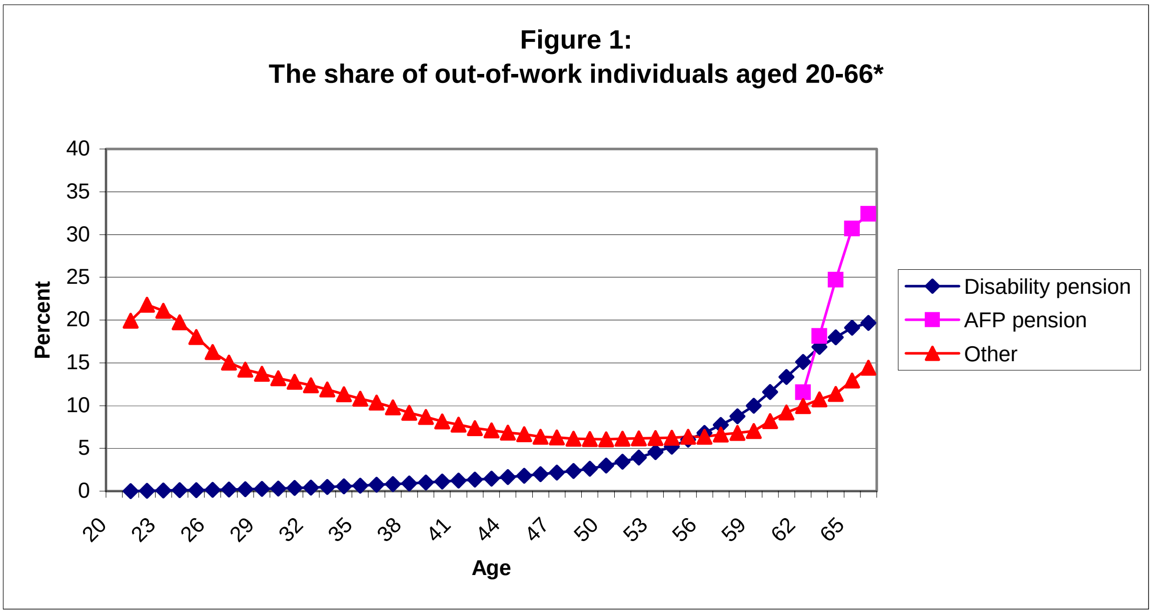
Figures and tables



* The group 'other' includes those with a temporary disability, those in rehabilitation, the unemployed, and others who have no specified reason for being out of work.

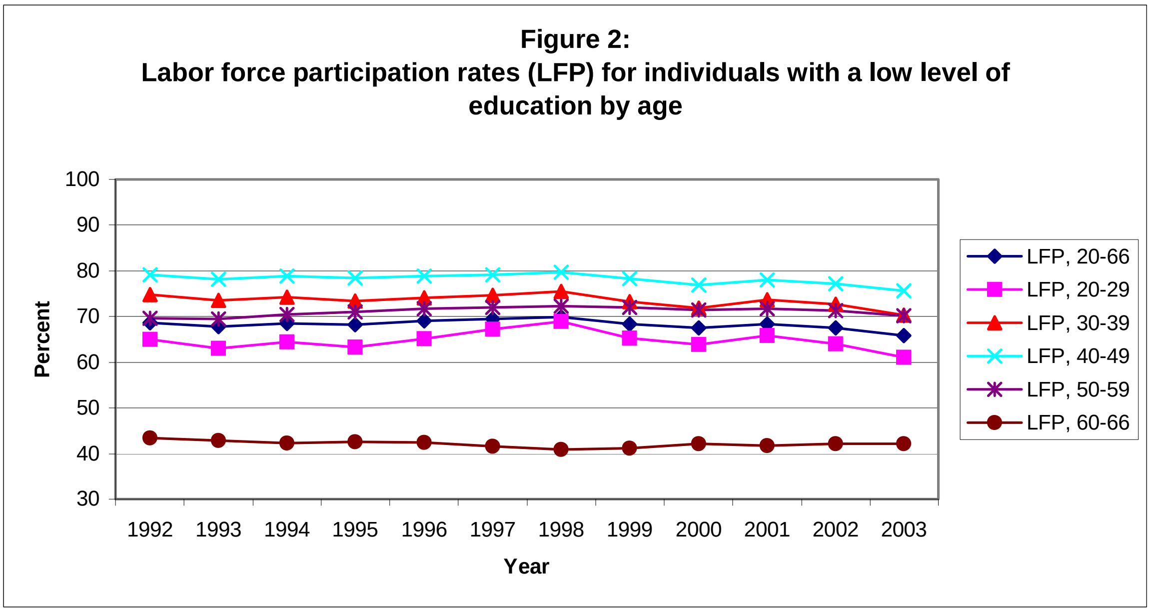


Figure 3:
Labor force participation rates for individuals with an intermediate level of education by age

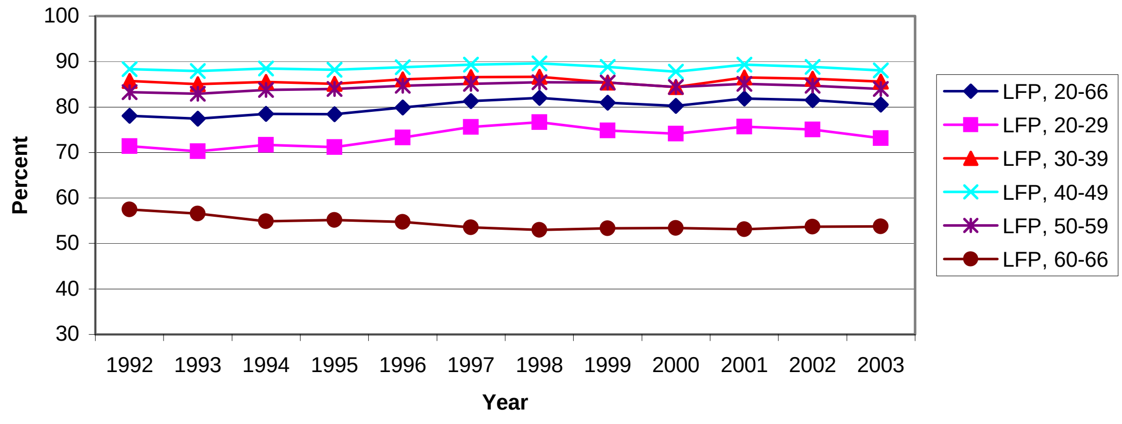


Figure 4:
Labor force participation rates for individuals with high level of education by age

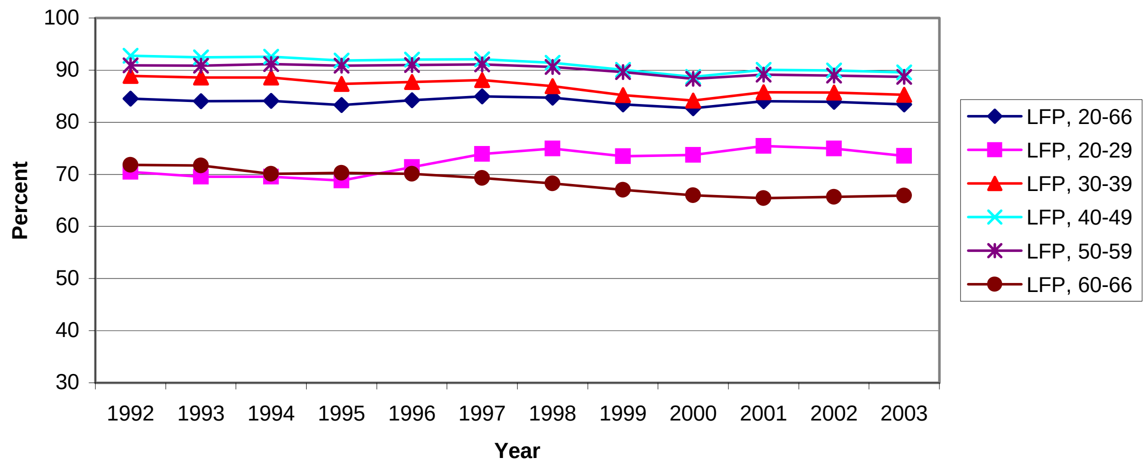


Table 1. Descriptive statistics for explanatory variables*

Variable	N	Mean	Std. dev.	Minimum	Maximum
New process technology$_{1999–2001}$	1,047	0.365	0.481	0	1
Organizational change$_{1999–2001}$	1,047	0.358	0.480	0	1
(Organizational change*technological change)$_{1999–2001}$	1,047	0.189	0.392	0	1
log capital$_{2001}$–log capital$_{1999}$	1,047	0.067	0.623	–5.320	3.951
log value added$_{2001}$–log value added$_{1999}$	1,047	0.015	0.481	–7.072	5.192
log(average employment 1999–2001)	1,047	4.119	1.096	1.540	8.411
log employment$_{2003}$–Log employment$_{2001}$	1,047	–0.050	0.319	–4.021	1.484
Financial performance 1999–2001	1,047	0.877	0.329	0	1
Age of firm in 2003	1,047	23.809	20.693	4	130
Wage bill share for 20–29-year-olds in 2001	1,047	0.150	0.088	0	0.563
Wage bill share for 30–39-year-olds in 2001	1,047	0.288	0.096	0	0.683
Wage bill share for 40–49-year-olds in 2001	1,047	0.269	0.095	0	0.606
Wage bill share for 50–59-year-olds in 2001	1,047	0.235	0.102	0	0.663
Wage bill share for 60–66-year-olds in 2001	1,047	0.058	0.047	0	0.297
Employment share for 20–29-year-olds in 2001	1,047	0.177	0.100	0	0.563
Employment share for 30–39-year-olds in 2001	1,047	0.284	0.092	0	0.636
Employment share for 40–49-year-olds in 2001	1,047	0.252	0.086	0	0.579
Employment share for 50–59-year-olds in 2001	1,047	0.225	0.097	0	0.600
Employment share for 60–66-year-olds in 2001	1,047	0.062	0.046	0	0.364
Regional dummies:					
Oslo and Akershus	1,047	0.120	0.325	0	1
Hedmark and Oppland	1,047	0.086	0.280	0	1
Østfold, Vestfold, Buskerud, and Telemark	1,047	0.255	0.436	0	1
Agder and Rogaland	1,047	0.155	0.362	0	1
Hordaland, Sogn og Fjordane, and Møre og Romsdal	1,047	0.236	0.425	0	1
Trøndelag	1,047	0.080	0.272	0	1
Nordland, Troms, and Finnmark	1,047	0.067	0.250	0	1

Table 1 (cont.)

Variable	N	Mean	Std. dev.	Minimum	Maximum
Industry dummies:					
Manufacture of food products, beverages, and tobacco	1,047	0.157	0.363	0	1
Manufacture of textile and textile products	1,047	0.051	0.219	0	1
Manufacture of wood and products of wood and cork	1,047	0.079	0.270	0	1
Manufacture of pulp, paper, and paper products	1,047	0.027	0.161	0	1
Publishing, printing, and reproduction of recorded media	1,047	0.105	0.307	0	1
Manufacture of chemicals and chemical products	1,047	0.036	0.187	0	1
Manufacture of rubber and plastic products	1,047	0.032	0.177	0	1
Manufacture of other nonmetallic mineral products	1,047	0.041	0.198	0	1
Manufacture of basic metals	1,047	0.038	0.192	0	1
Manufacture of fabricated metal products	1,047	0.103	0.304	0	1
Manufacture of machinery and equipment n.e.c.	1,047	0.091	0.287	0	1
Manufacture of electrical and optical equipment	1,047	0.064	0.245	0	1
Manufacture of transport equipment	1,047	0.119	0.324	0	1
Manufacture of furniture. manufacturing n.e.c.	1,047	0.056	0.231	0	1

* Complete names of industries are given in the Appendix.

Table 2. Changes in wage bill shares: the effects of organizational change and technological change

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
Mean of dependent variable	-0.031	-0.0006	0.012	0.013	0.013
A. Controls and					
OC	-0.003 (0.004)	0.001 (0.005)	0.014* (0.005)	-0.009* (0.004)	-0.003 (0.003)
TECH	0.001 (0.004)	0.006 (0.005)	-0.001 (0.006)	-0.006 (0.004)	0.000 (0.003)
B. Controls and					
OC	-0.005 (0.005)	-0.004 (0.007)	0.022* (0.006)	-0.007 (0.006)	-0.006 (0.003)
TECH	-0.001 (0.005)	0.001 (0.007)	0.006 (0.008)	-0.004 (0.006)	-0.003 (0.004)
OC * TECH	0.005 (0.007)	0.012 (0.011)	-0.019** (0.011)	-0.005 (0.008)	0.007 (0.006)

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies. For each regression, 1,047 observations were used.

* denotes significant at 5%; ** denotes significant at 10%.

Table 3. Changes in employment shares: the effects of organizational change and technological change

Dependent variable: Change in employment share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
Mean of dependent variable	-0.035	-0.004	0.013	0.014	0.012
A. Controls and					
OC	-0.001 (0.004)	-0.003 (0.005)	0.011* (0.005)	-0.007** (0.004)	-0.000 (0.003)
TECH	0.003 (0.004)	0.006 (0.005)	-0.002 (0.006)	-0.007** (0.004)	0.001 (0.003)
B. Controls and					
OC	-0.003 (0.005)	-0.008 (0.007)	-0.017* (0.006)	-0.005 (0.005)	-0.002 (0.004)
TECH	0.001 (0.005)	0.001 (0.007)	0.004 (0.008)	-0.005 (0.005)	0.000 (0.004)
OC * TECH	0.005 (0.008)	0.011 (0.011)	-0.014 (0.011)	-0.005 (0.008)	0.003 (0.007)

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2002) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies. For each regression, 1,047 observations were used.

* denotes significant at 5%; ** denotes significant at 10%.

Table 4. Changes in wage bill shares: the effects of organizational change and technological change for single-plant firms

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
Mean of dependent variable	-0.033	-0.004	0.013	0.011	0.013
A. Controls and					
OC	-0.002 (0.005)	-0.000 (0.007)	0.018* (0.007)	-0.008 (0.006)	-0.006** (0.004)
TECH	0.002 (0.005)	0.004 (0.007)	0.002 (0.007)	-0.006 (0.006)	-0.002 (0.004)
B. Controls and					
OC	-0.005 (0.006)	-0.010 (0.009)	0.025* (0.009)	-0.005 (0.007)	-0.006 (0.004)
TECH	-0.000 (0.006)	-0.004 (0.009)	0.009 (0.009)	-0.003 (0.007)	-0.001 (0.005)
OC * TECH	0.005 (0.010)	0.020 (0.014)	-0.017 (0.014)	-0.008 (0.011)	-0.002 (0.007)

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies. For each regression, 753 observations were used.

* denotes significant at 5%; ** denotes significant at 10%.

Table 5. Changes in wage bill shares: the effects of organizational change and technological change by the sign of the employment change in the firm

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
			Employment reduction		
Mean of dependent variable	-0.038	-0.010	0.016	0.017	0.015
A. Controls and					
OC	-0.003 (0.005)	0.014** (0.007)	0.009 (0.008)	-0.018* (0.006)	-0.003 (0.005)
TECH	0.003 (0.005)	-0.006 (0.008)	0.009 (0.009)	-0.008 (0.006)	0.002 (0.005)
B. Controls and					
OC	-0.007 (0.007)	0.010 (0.009)	0.024* (0.009)	-0.021* (0.008)	-0.006 (0.005)
TECH	-0.002 (0.007)	-0.010 (0.011)	0.024** (0.013)	-0.011 (0.008)	-0.001 (0.007)
OC * TECH	0.010 (0.010)	0.011 (0.015)	-0.035* (0.017)	0.007 (0.012)	0.007 (0.011)
			Employment increase		
Mean of dependent variable	-0.024	-0.002	0.007	0.008	0.012
A. Controls and					
OC	-0.005 (0.005)	-0.010 (0.007)	0.019* (0.007)	-0.001 (0.006)	-0.003 (0.004)
TECH	0.000 (0.006)	0.013** (0.007)	-0.013* (0.008)	-0.000 (0.006)	-0.001 (0.004)
B. Controls and					
OC	-0.006 (0.007)	-0.012 (0.007)	0.020* (0.007)	0.007 (0.007)	-0.009** (0.005)
TECH	-0.001 (0.007)	0.011 (0.009)	-0.012 (0.009)	0.007 (0.008)	-0.006 (0.005)
OC * TECH	0.003 (0.011)	0.005 (0.011)	-0.002 (0.015)	-0.020** (0.011)	0.015* (0.007)

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies. For each regression with employment reductions, there are 552 observations. For each regression with employment increases, there are 495 observations.

* denotes significant at 5%; ** denotes significant at 10%.

Table 6. Changes in wage bill shares: the effects of organizational change and technological change by gender

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
			Men		
Mean of dependent variable	-0.014	-0.003	0.001	0.006	0.007
A. Controls and					
OC	-0.002 (0.003)	-0.003 (0.005)	0.007 (0.005)	-0.005 (0.004)	-0.001 (0.003)
TECH	-0.001 (0.003)	0.004 (0.005)	0.003 (0.006)	-0.008* (0.004)	0.000 (0.003)
B. Controls and					
OC	-0.004 (0.005)	-0.006 (0.006)	0.014* (0.006)	-0.001 (0.005)	-0.004 (0.003)
TECH	-0.003 (0.004)	0.001 (0.006)	0.010 (0.008)	-0.004 (0.005)	-0.003 (0.004)
OC * TECH	0.005 (0.007)	0.008 (0.010)	-0.017 (0.011)	-0.009 (0.008)	0.007 (0.006)
Obervations	1 035	1 038	1 037	1 027	981
			Women		
Mean of dependent variable	-0.003	0.000	0.001	0.001	0.001
A. Controls and					
OC	-0.001 (0.002)	0.003 (0.003)	0.008* (0.002)	-0.005* (0.002)	-0.002 (0.001)
TECH	0.003 (0.002)	0.002 (0.003)	-0.005* (0.002)	0.002 (0.002)	0.001 (0.002)
B. Controls and					
OC	-0.001 (0.002)	0.001 (0.004)	0.008* (0.003)	-0.006* (0.002)	-0.001 (0.002)
TECH	0.004 (0.003)	-0.000 (0.004)	-0.005 (0.003)	0.001 (0.003)	0.002 (0.002)
OC * TECH	-0.001 (0.004)	0.006 (0.008)	-0.001 (0.005)	0.003 (0.004)	-0.001 (0.003)
Observations	830	923	928	908	691

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies.
* denotes significant at 5%; ** denotes significant at 10%.

Table 7. Changes in wage bill shares: the effects of organizational change and technological change by educational level

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
			High education (more than 14 years)		
Mean of dependent variable	-0.001	0.002	0.002	0.002	0.002
A. Controls and					
OC	0.001 (0.002)	0.007** (0.003)	-0.000 (0.003)	-0.002 (0.003)	-0.003 (0.003)
TECH	-0.002 (0.002)	0.004 (0.004)	0.003 (0.004)	-0.006* (0.003)	0.007** (0.004)
B. Controls and					
OC	-0.000 (0.002)	0.002 (0.005)	0.007** (0.004)	-0.002 (0.004)	-0.002 (0.003)
TECH	-0.003 (0.002)	-0.000 (0.004)	0.010** (0.006)	-0.005 (0.004)	-0.002 (0.008)
OC * TECH	0.003 (0.003)	0.10 (0.008)	-0.017* (0.008)	-0.001 (0.006)	-0.002 (0.008)
Obervations	695	837	782	707	445
			Intermediate education (13 or 14 years)		
Mean of dependent variable	-0.006	0.001	0.006	0.003	0.001
A. Controls and					
OC	-0.004 (0.003)	-0.002 (0.004)	0.009* (0.004)	-0.003 (0.002)	0.001 (0.002)
TECH	0.001 (0.003)	-0.000 (0.004)	-0.002 (0.004)	-0.006* (0.002)	0.002 (0.002)
B. Controls and					
OC	-0.005 (0.004)	-0.001 (0.005)	0.011* (0.005)	-0.002 (0.003)	0.003 (0.003)
TECH	-0.001 (0.004)	0.001 (0.004)	-0.000 (0.006)	-0.005 (0.003)	0.004 (0.003)
OC * TECH	0.004 (0.006)	-0.002 (0.007)	-0.003 (0.008)	-0.004 (0.005)	-0.004 (0.004)
Observations	1 016	1 033	991	910	639

Table 7 (cont.)

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
		Low education (less than 13 years)			
Mean of dependent variable	-0.005	-0.004	-0.003	0.001	0.004
A. Controls and					
OC	-0.003 (0.003)	-0.006 (0.004)	0.014* (0.005)	-0.007** (0.004)	-0.001 (0.002)
TECH	0.004 (0.003)	0.001 (0.005)	-0.003 (0.005)	-0.001 (0.004)	-0.003 (0.003)
B. Controls and					
OC	-0.004 (0.005)	-0.006 (0.006)	0.016* (0.006)	-0.005 (0.005)	-0.003 (0.003)
TECH	0.002 (0.004)	0.001 (0.006)	-0.001 (0.007)	0.000 (0.005)	-0.005 (0.004)
OC * TECH	0.003 (0.007)	0.001 (0.009)	-0.006 (0.010)	-0.003 (0.008)	0.005 (0.005)
Obervations	1 044	1 047	1 045	1 046	1 029

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies.

* denotes significant at 5%; ** denotes significant at 10%.

Variable definitions

Wage bill share
The wage bill share for each age group is the group's share of the total wage bill in the firm. The sum of the wage bill shares for all age groups is unity.

Employment share
The employment share for each age group is the group's share of total employment in the firm. The sum of the employment shares for all age groups is unity.

Organizational change$_{1999–2001}$ (OC)
The variable for organizational change is a discrete variable indicating whether the firm has implemented any organizational change in the period 1999–2001. For firms that have answered a questionnaire, the variable is constructed from the innovation statistics.

New process technology$_{1999–2001}$ (TECH)
The variable for technological change is a discrete variable indicating whether the firm has introduced new process technology in the period 1999–2001. For firms that have answered a questionnaire, the variable is constructed from the innovation statistics.

(Organizational change*New process technology)$_{1999–2001}$
Interaction between organizational change and technological change.

Log (capital$_{2001}$–capital$_{1999}$)
The logarithm of the change in capital (tangible fixed assets) between 1999 and 2001.

Log (value added$_{2001}$–value added$_{1999}$)
The logarithm of the change in value added between 1999 and 2001.

Log(average employment 1999–2001)
The logarithm of average employment in the firm during the period 1999–2001.

Log employment$_{2003}$–Log employment$_{2001}$
Change in the logarithm of employment between 2001 and 2003.

Financial performance 1999–2001
This variable is a binary variable that takes a value of unity if the firm has an operating profit margin that exceeds the average for manufacturing joint-stock companies and is zero otherwise. The operating profit margin is defined as operating profit as a percentage of operating income.

Age of firm in 2003
The number of years since the firm was founded, in 2003.

Classification of regions (by counties)

Region 1	Oslo and Akershus
Region 2	Hedmark and Oppland
Region 3	Østfold, Vestfold, Buskerud, and Telemark
Region 4	Agder and Rogaland
Region 5	Hordaland, Sogn og Fjordane, and Møre og Romsdal
Region 6	Trøndelag
Region	7 Nordland, Troms, and Finnmark

Classification of industries (by two-digit NACE code)

Industry 1	Manufacture of food products, beverages, and tobacco (15, 16)
Industry 2	Manufacture of textiles and textile products, tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harnesses, and footwear (17, 18,19)
Industry 3	Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20)
Industry 4	Manufacture of pulp, paper, and paper products (21)
Industry 5	Publishing, printing, and reproduction of recorded media (22)
Industry 6	Manufacture of chemicals and chemical products (24)
Industry 7	Manufacture of rubber and plastic products (25)
Industry 8	Manufacture of other nonmetallic mineral products (26)
Industry 9	Manufacture of basic metals (27)
Industry 10	Manufacture of fabricated metal products, except machinery and equipment (28)
Industry 11	Manufacture of machinery and equipment n.e.c. (29)
Industry 12	Manufacture of electrical and optical equipment (30, 31, 32, 33)
Industry 13	Manufacture of transport equipment (34, 35)
Industry 14	Manufacture of furniture, manufacturing n.e.c. (36)

Definition of educational groups

Low educational level	Primary education	1^{st} – 7^{th} class level
	Lower secondary education	8^{th} – 10^{th} class level
	Upper secondary education	11^{th} – 12^{th} class level
	Unspecified	
Intermediate educational level	Upper secondary, final year	13^{th} class level +
	Postsecondary nontertiary education	14^{th} class level +
High educational level	First stage of tertiary education: undergraduate level	14^{th} – 17^{th} class level
	First stage of tertiary education: graduate level	18^{th} – 19^{th} class level
	Second stage of tertiary education: (postgraduate education)	20^{th} class level

Table A.1. Changes in wage bill shares: the effects of organizational change and technological change

Dependent variable: Change in wage bill share between 2001 and 2003					
Age group	20-29	30-39	40-49	50-59	60-66
Mean of dependent variable	-0.031	-0.0006	0.012	0.013	0.013
A					
OC	-0.003 (0.004)	0.001 (0.005)	0.014* (0.005)	-0.009* (0.004)	-0.003 (0.003)
TECH	0.001 (0.004)	0.006 (0.005)	-0.001 (0.006)	-0.006 (0.004)	0.000 (0.003)
log capital (2001) – log capital (1999)	-0.007* (0.003)	0.007 (0.005)	-0.000 (0.004)	-0.004 (0.003)	0.004** (0.003)
log value added (2001) – log value added (1999)	0.001 (0.003)	-0.007 (0.004)	0.002 (0.006)	0.008** (0.005)	-0.004 (0.004)
log (average employment 1999-2001)	-0.002 (0.002)	0.005** (0.003)	-0.001 (0.003)	0.003 (0.002)	-0.005* (0.002)
log employment (2003) – log employment (2001)	0.039* (0.006)	-0.022 (0.018)	-0.012 (0.014)	0.010 (0.013)	-0.016 (0.012)
Financial performance 1999–2001	-0.004 (0.006)	0.013 (0.009)	0.007 (0.008)	-0.003 (0.007)	0.013* (0.006)
Age of firm in 2003	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Wage bill share for 20–29 year-olds in 2001	-0.273* (0.028)	0.256* (0.036)	-0.042 (0.030)	0.008 (0.026)	0.051* (0.016)
Wage bill share for 30–39 year-olds in 2001	0.070* (0.021)	-0.294* (0.032)	0.276* (0.031)	-0.062* (0.024)	0.009 (0.017)
Wage bill share for 40–49 year-olds in 2001	0.069* (0.021)	0.014 (0.029)	-0.310* (0.031)	0.191* (0.026)	0.036** (0.019)
Wage bill share for 50–59 year-olds in 2001	0.035** 0.021)	-0.032 (0.033)	0.029 (0.030)	-0.217* (0.032)	0.186* (0.024)
Wage bill share for 60–66 year-olds in 2001	0.021 (0.041)	-0.104** (0.059)	0.117** (0.065)	0.186* (0.059)	-0.427* (0.045)
Hedmark and Oppland	-0.014* (0.007)	0.022* (0.011)	-0.014 (0.010)	0.008 (0.009)	-0.001 (0.007)
Østfold, Vestfold, Buskerud, and Telemark	0.003 (0.006)	-0.003 (0.009)	-0.004 (0.009)	0.007 (0.007)	-0.003 (0.006)
Agder and Rogaland	-0.004 (0.007)	0.013 (0.010)	-0.015** (0.009)	0.013 (0.009)	-0.006 (0.006)
Hordaland, Sogn og Fjordane, and Møre og Romsdal	0.002 (0.007)	0.006 (0.010)	-0.013 (0.009)	0.005 (0.008)	0.001 (0.006)
Trøndelag	0.000 (0.008)	-0.002 (0.011)	-0.007 (0.010)	0.014 (0.009)	-0.005 (0.006)
Nordland, Troms, and Finnmark	-0.003 (0.010)	0.015 (0.012)	-0.010 (0.011)	-0.003 (0.009)	0.001 (0.006)

Table A.1 (cont.)

Age group	20-29	30-39	40-49	50-59	60-66
Manufacture of textiles	-0.036* (0.009)	0.015 (0.016)	0.034** (0.018)	-0.008 (0.012)	-0.005 (0.008)
Manufacture of wood	-0.016** (0.009)	-0.005 (0.010)	0.009 (0.010)	0.005 (0.009)	0.008 (0.006)
Manufacture of pulp, paper and paper products	-0.033* (0.009)	-0.001 (0.013)	0.023** (0.013)	0.005 (0.011)	0.006 (0.009)
Publishing, printing	-0.033* (0.007)	0.015** 0.009)	0.011 (0.008)	0.011 (0.008)	-0.004 (0.005)
Manufacture of chemicals	-0.042* (0.009)	0.004 (0.011)	0.036* (0.017)	0.015 (0.010)	-0.013** (0.007)
Manufacture of rubber and plastic products	-0.028* (0.012)	0.030** (0.018)	-0.023 (0.014)	-0.003 (0.013)	0.023* (0.010)
Manufacture of other nonmetallic mineral products	-0.019* (0.009)	-0.015 (0.012)	0.022* (0.012)	-0.009 (0.010)	0.021* (0.007)
Manufacture of basic metals	-0.035* (0.009)	-0.029* (0.013)	0.032* (0.010)	0.019** (0.010)	0.013 (0.008)
Manufacture of fabricated metal products	-0.031* (0.007)	-0.009 (0.009)	0.015** (0.009)	0.014 (0.009)	0.011* (0.005)
Manufacture of machinery and equipment	-0.015 (0.009)	-0.007 (0.010)	0.004 (0.011)	0.017** (0.009)	-0.000 (0.005)
Manufacture of electrical and optical equipment	-0.034* (0.008)	-0.001 (0.012)	0.015 (0.012)	0.003 (0.010)	0.017** (0.010)
Manufacture of transport equipment	-0.024* (0.007)	-0.012 (0.010)	0.020* (0.009)	0.001 (0.008)	0.016* (0.006)
Manufacture of furniture	-0.034* (0.009)	-0.010 0.015)	0.012 (0.012)	0.026* (0.011)	0.005 (0.006)

OLS regressions with heteroskedasticity-robust standard errors in parentheses. OC (organizational change) and TECH (new process technology). Control variables are: the log of capital (2001)–the log of capital(1999); the log of value added (2001)–the log of value added (1999); the log of employment (2003) – the log of employment (2001); the log of average employment (1999–2001); financial performance (1999–2001); the age of the firm in 2003; the wage bill share of all five age groups in 2001; seven regional dummy variables; and 14 industry dummies. For each regression, 1,047 observations were used. Akershus and Oslo is the reference region, and manufacture of food products is the reference industry.

* denotes significant at 5%; ** denotes significant at 10%.