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ABSTRACT

Flexible Workplace Practices and Labor Productivity*

Using a German employer-employee matched panel data set this paper examines the effects of High Performance Workplace Systems (HPWSs) on labor productivity (defined as sales per worker) and labor efficiency (defined as the inverse of unit labor costs). The estimation results indicate that simple cross-sectional estimates of the effects of implementing HPWSs on labor productivity are biased downward due to unobserved time-invariant establishment effects and the endogeneity of the used measure for innovative workplace practices. The latter bias appears to be quantitatively more important. Results from estimating a correlated random coefficient model further suggest that a potential bias in the 2SLS-estimates due to self-selection seems to be negligible. The estimated effects of HPWSs on labor productivity are economically important and rising over time. However, corresponding positive effects of HPWSs on labor efficiency occur only in the long run. Finally, due to rising wages associated with the adoption of HPWSs, the effects of these systems on labor efficiency are smaller than the corresponding effects on labor productivity.

JEL Classification: J24, J5, L23, M11

Keywords: linked-employer-employee data set, high performance workplace organization, instrumental variables, correlated random coefficient model

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1. Introduction

Over the past decade, a growing literature is concerned with the determinants of the implementation of innovative human resource practices and their effects on establishment performance.[1] Even though the majority of these studies suggest that the use or introduction of these so-called High Performance Workplace Systems(HPWSs) has positive effects on the performance of an establishment, the findings of the literature as a group remain inconclusive (Capelli and Neumark 2001).

Several reasons have been put forward to explain the variety of results on the performance effects of HPWSs. First, almost every empirical contribution in this area uses a different measure of flexible workplace systems. In some studies, the measurement of these practices is based on the judgement or the preference of a researcher, others may use a definition of HPWSs that is specific to the particular industry they analyze, use one particular practice as a proxy for the use of HPWSs, or derive an index using some statistical procedures such as factor analysis (Godard and Delaney 2000).

Second, existing studies are based on very different data sources. Most contributions in the relevant literature employ cross-sectional data creating problems of potentially biased results due to omitted variables as well as causality issues, which creates some doubts on the conclusions drawn from these studies. In addition, the data sets used by previous studies are in many cases non-representative. They either use surveys from a very narrow industry, information on different plants of a single firm, or even information on different work areas within a single plant (see, for example, Appelbaum and Batt 1994, Ichniowski, Shaw, and Prennushi 1997, MacDuffie 1995, and Cutcher-Gershenfeld 1991). These studies often suffer from small sample sizes. Furthermore, it is doubtful whether their results can be generalized. An advantage of the analysis of particular industries or even single firms is, however, the avoidance of heterogeneity problems inherent in studies using more representative data.

[1] Surveys of this literature are provided by Appelbaum and Batt (1994), Capelli and Neumark (2001), Godard and Delaney (2000), Ichniowski, Shaw, and Prennushi (1997) and Ichniowski, Kochan, Levine, Olson, and Strauss (2000). A more recent literature is concerned with the question whether changes in the organization of work are skill-biased and could add to the existing explanations of rising earnings inequality in the U.S. and the UK as well as increasing unemployment of low-skilled workers in continental Europe. Investigating the employment effects of HPWSs in Germany, Bauer and Bender (2002b), for example, confirm the hypothesis that organizational change towards HPWSs is skill-biaed. A survey of this literature is given by Bauer and Bender (2002a).

Finally, the contradictory results may be traced back to different estimation strategies. Several methodological problems make it difficult to identify the causal effects of HPWSs on establishment performance. Because of these problems, existing studies may be biased for at least one of the following three reasons: unobserved heterogeneity resulting in omitted variable bias, the potential endogeneity of HPWO measures, and heterogeneity in the returns to use or adopt HPWSs.

Studies using cross-sectional data are likely to suffer from unobserved establishment heterogeneity resulting in omitted variable bias. Such a bias may, for example, occur if the management quality of a firm is positively related to both establishment performance as well as the probability to adopt innovative workplace systems. A few studies approached this problem by using panel data (see, for example, Black and Lynch 2001, Capelli and Neumark 2001, Huselid and Becker 1996 and Ichniowski, Shaw, and Prennushi 1997).

Studies based on longitudinal data, however, may suffer from what is known in the literature as the "late-adopter" problem (Capelli and Neumark 2001). It could be expected that there exists considerable heterogeneity in the costs and returns of using or adopting HPWSs across firms. Those establishments that adopt HPWSs from an early stage on are likely to have relatively high returns from using these practices, whereas those that adopt these practices at a later stage are likely to consist mainly of firms with below-average returns. The latter adopt flexible workplace systems only after a sufficient decrease of the costs of implementing these systems or because they are forced to introduce these practices after some exogenous external shock. If the incidence of HPWSs in a longitudinal data set is already very high in the first wave, estimates of the performance effects that are based on fixed-effects estimators or first-differences are likely to be dominated by the effects of "late-adopters". Hence, to the extent that this problem exists, the estimated returns to HPWSs in longitudinal studies are likely to be biased downward.

In addition, empirical studies of the effects of HPWSs on establishment performance are likely to suffer from potential endogeneity bias. Treating the decision to adopt flexible workplace systems as an investment decision, it is obvious that only those firms that expect high returns to the adoption of HPWSs and/or low costs of doing so will implement these practices (Ichniowski and Shaw 1995). If these costs and benefits are correlated with the performance of an establishment, the decision to introduce innovative workplace systems is endogenous, leading to biased esti-

mates. Several empirical studies have shown that the decision to adopt HPWSs is significantly affected by negative external transitory shocks, indicating that ignoring the potential endogeneity of HPWS-measures leads to downward biased estimates of these practices on establishment performance (see, for example, Ichniowski and Shaw 1995 and Nickell, Nicolitsas, and Patterson 2001).

Using a German employer-employee-linked panel data set, this paper aims at investigating the extent to which estimated effects of the implementation of innovative workplace systems on establishment performance are affected by the methodological problems mentioned above. In order to investigate these potential sources of biased estimates, I proceed in four steps. To provide a benchmark, I first estimate a simple cross-sectional model of the effects of adopting flexible workplace practices on labor productivity (defined as sales per employee) and labor efficiency (defined as the inverse of unit labor costs). In a second step, I investigate to what extent these baseline estimates are biased due to unobserved heterogeneity by taking first differences. After removing potential omitted variable bias due to establishment fixed effects, I apply an instrumental variable (IV) estimator in order to address the potential endogeneity of HPWO measures. Finally, I use a correlated random coefficient model to investigate potential selection problems arising through heterogeneity in the costs and benefits from adopting innovative workplace systems.

In the next section, I provide a more detailed discussion of the empirical strategy. Section three gives a short description of the sample and the variables used to analyze the effects of adopting flexible workplace systems on labor productivity and labor efficiency in Germany. Section four presents estimations of the determinants of implementing these systems. The estimation results of the impact of innovative workplace systems on labor productivity and labor efficiency are discussed in Section five. The paper closes with a short summary.

2. Methodological Problems in Estimating the Returns to Flexible Workplace Systems

Estimates of the impact of innovative workplace systems on establishment performance based on cross-section data are likely to be inconsistent due to potential biases arising through unobserved establishment heterogeneity, the potential endogeneity of HPWO measures in productivity equations, and heterogeneity in the returns to

HPWSs. In this section, I will discuss the econometric strategy used in this study to to remove these potential biases in order to obtain consistent estimates of the average productivity effects of flexible workplace systems. This strategy allows me to evaluate the extent to which cross-sectional estimates are biased and which potential sources of this bias play an important role.

2.1. Unobserved Heterogeneity

Consider the following model:

$$Y_{it} = X'_{it}\beta + \gamma Z_{it} + \epsilon_{it}, \quad \text{where } \epsilon_{it} = \alpha_i + \zeta_{it} \tag{1}$$

$$Z_{it} = X'_{it}\lambda + \eta_{it}, \quad \text{where } \eta_{it} = \theta_i + \omega_{it}, \tag{2}$$

where Y_{it} is a measure of the performance of establishment i in year t, X_{it} is a vector of observed characteristics, Z_{it} is a variable measuring the use of flexible workplace practices, and ϵ_{it} and η_{it} are unobservable determinants of establishment performance and the use of flexible workplace practices, respectively. It is assumed that the unobservable determinants of Y_{it} and Z_{it} consist of time-invariant establishment fixed effects (α_i and θ_i) and time-variant unobserved shocks (ζ_{it} and ω_{it}). The latter are assumed to be normally distributed with mean zero and variance ${\sigma_\zeta}^2$ and ${\sigma_\omega}^2$, respectively.

The coefficient γ is the *true* effect of innovative workplace systems on establishment performance. The use of equations (1) and (2) makes it possible to highlight the most important problems in estimating γ. In order to obtain consistent estimates, the least squares estimator of γ requires that $E[\epsilon_{it}\eta_{it}] = 0$. In an ideal setting, where different bundles of innovative workplace systems are randomly assigned to different establishments, estimates of equation (1) using cross-section data would provide consistent estimates of γ. In non-experimental studies, such a random assignment is usually not fulfilled. If there are unobserved establishment fixed effects – captured by α_i and θ_i in equations (1) and (2) – that covary with both Y_{it} and Z_{it}, cross-sectional estimates of γ suffer from omitted variable bias.

The direction of this bias is *a priori* unclear. It is possible, for example, that establishments with a high-quality management and skilled and motivated workers are more likely to achieve above-average labor productivity and have a higher probability to introduce innovative workplace systems. In this case, cross-sectional

estimates of γ are biased upward. It might be the case, however, that successful firms may not want to depart from existing, apparently optimal workplace organizations (Ichniowski, Kochan, Levine, Olson, and Strauss 2000), whereas less successful firms may be tempted to experiment with innovative workplace systems in order to solve long-term structural problems. In such a situation, cross-sectional estimates of γ will be biased downward.

The problem of omitted variable bias resulting from unobserved establishment fixed effects could be addressed by using several strategies. Some studies attempt to solve this problem by studying single firms, a single, narrowly defined industry, or different workplaces within one establishment. Another solution is the use of longitudinal data. Having repeated observations over time, first-differencing the data removes the establishment fixed effects α_i and θ_i. Denoting first differences by Δ, i.e., $\Delta W_{it} = W_{it} - W_{it-1}$, for $W = Y, X, Z, \epsilon, \eta$, the model described by equations (1) and (2) could be written as:

$$\Delta Y_{it} = \Delta X'_{it}\beta + \gamma \Delta Z_{it} + \Delta \epsilon_{it}, \tag{3}$$

$$\Delta Z_{it} = \Delta X'_{it}\lambda + \Delta \eta_{it}. \tag{4}$$

Assuming that there are no unobserved shocks to establishment performance that also affect the use or the adoption of HPWSs, i.e., assuming that $E[\Delta\epsilon_{it}\Delta\eta_{it}] = 0$, estimating equation (3) provides consistent estimates of γ.

Yet only a few empirical studies on the effects of HPWSs on establishment outcomes have been able to employ panel data and hence were able to control for potential omitted variable bias in the estimates of γ (Black and Lynch 2001; Capelli and Neumark 2001; Caroli and Reenen 2001; Huselid and Becker 1996; Ichniowski, Shaw, and Prennushi 1997). A problem arising in studies using longitudinal data is connected to the duration of treatment. [2] Many studies using panel data refer only to a short period of time after the introduction of innovative workplace practices. If these practices need some time to elapse before showing significant effects on establishment performance, inference based on a short treatment period might lead to misleading conclusions.[3] In the empirical analysis below, I will investigate this

[2] Another problem that has been discussed in this context is the problem of measurement error. While panel data is able to mitigate problems arising through unobserved time-invariant heterogeneity, panel-data estimates are more sensitive towards errors in the measurement of HPWSs (Huselid and Becker 1996). In this paper, however, this issue will not be investigated further. A detailed discussion on the importance of measurement error in the data set used also in this study is provided by **?**).

[3] See also the theoretical discussion in Pil and MacDuffie (1996)

problem by comparing short-run and long-run productivity effects of implementing high performance workplace systems.

2.2. Endogeneity of HPWO measures

An additional problem arises because the use or the implementation of HPWSs is likely to be endogenous. Transitory shocks – captured in equations (1) and (2) by ζ_{it} and ω_{it} – that are correlated with both Y_{it} and Z_{it} could lead to inconsistent estimates of γ. Even though this problem has been recognized by the literature, it has been largely ignored in empirical analyses (Athey and Stern 1998). Only a few studies try to address this problem by using lagged values of their HPWO-measures (see, for example, Caroli and Reenen 2001 and Osterman 2000).

Imagine that there is an instrumental variable (V_{it}) available that causes changes in the use of flexible workplace systems without having a direct effect on establishment performance. The system of equations (3) and (4) could then be written as follows

$$\Delta Y_{it} = \Delta X'_{it}\beta + \gamma \Delta Z_{it} + \Delta \epsilon_{it}, \tag{5}$$

and

$$\Delta Z_{it} = \Delta X'_{it}\lambda + V_{it}\delta + \Delta \eta_{it}, \tag{6}$$

respectively. Two-stage-least-squares (2SLS) or general method of moments (GMM) estimates of equations (5) and (6) provide consistent estimates of the effect of flexible workplace systems on establishment performance if the instrument V_{it} satisfies two conditions. First, V_{it} has to be partially correlated with ΔZ_{it} in equation (6), i.e., $\delta \neq 0$. Second, V_{it} must be uncorrelated with unobserved transitory shocks to establishment performance, i.e. $E[V_{it}\Delta\epsilon_{it}] = 0$. In the following empirical analysis, equations (5) and (6) are estimated using GMM. A detailed discussion of the construction and the validity of the instruments used in this study will be given in the next section.

Similar to the case of omitted variable bias discussed above, the direction of a potential endogeneity bias in γ could not be determined *a priori*. In particular, it is unclear whether establishments that face a negative or establishments that experience a positive shock are more likely to implement innovative workplace systems. Establishments that face a negative demand shock, for example, might be forced

to introduce innovative workplace practices in order to increase the productivity of their workers. On the other hand, firms with a positive shock may have more resources available to experiment with this type of organizational innovations.

Empirical evidence indicates that establishments adopt innovative work systems when they face a negative shock. Using data for the UK, for example, Nickell, Nicolitsas, and Patterson (2001) find that firms with economic problems have a significantly higher probability to change their organizational structure. Theoretically, this finding is explained with lower opportunity costs of reorganization in terms of foregone output when demand is slack. In a similar vein, Ichniowski and Shaw (1995) show that the threat of a shutdown has a significant positive effect on the adoption of HPWSs suggesting also that only extraordinary circumstances, such as a high probability of job loss, can overcome the resistance of employees against the introduction of new organizational structures. A similar pattern could also be observed with regard to the adoption of new technologies. Using data for the U.S., Dunne, Haltiwanger, and Troske (1997), for example, find that the adoption of new technologies and reorganization of the workforce are concentrated in recessions. This evidence suggests that ignoring the potential endogeneity of HPWO measures leads to downward biased estimates of γ.

2.3. A Correlated Random-Coefficients Model

The decision to adopt innovative workplace systems and the degree to which these practices are used by an establishment is the result of an optimal decision process. An establishment will only introduce flexible workplace practices if the expected returns to these practices are higher or equal to the costs of implementation. Because of this optimal decision process, the sample of establishments that make a particular choice on the use of flexible workplace practices is not random. Hence, establishments for whom a particular degree of flexibility in the organization of work is optimal are compared to establishments for whom this degree is not optimal.

The marginal returns to flexible workplace practices, γ, estimated based on the models described above, only coincide with the *average* returns for all establishments, if the benefits and costs of implementing these practices are identical across firms. If the performance effects of implementing innovative workplace systems are heterogeneous, the estimated marginal returns are likely to be different from the

average returns.

In this subsection, I describe a correlated random coefficient model, which allows the estimation of the average return to the use of flexible workplace practices.[4] The model further allows to investigate the extent to which the models described in the previous sub-sections suffer from omitted variable bias and from self-selection bias arising through the heterogeneity of the expected benefits and costs of implementing flexible workplace practices.

The random coefficient model differs from equations (3) and (5) by a random slope coefficient γ_i:

$$\begin{aligned} \Delta Y_{it} &= \Delta X_{it}'\beta + \gamma_i \Delta Z_{it} + \Delta\epsilon_{it} \\ &= \Delta X_{it}'\beta + \bar{\alpha} + \bar{\gamma}\Delta Z_{it} + (\alpha_i - \bar{\alpha}) + (\gamma_i - \bar{\gamma})\Delta Z_{it} + \Delta\zeta_{it}, \end{aligned} \tag{7}$$

and

$$\Delta Z_{it} = \Delta X_{it}'\lambda + V_{it}\delta + \Delta\eta_{it}, \tag{8}$$

where $\bar{\alpha}$ and $\bar{\gamma}$ denote the means of α_i and γ_i, respectively, and where $E[\Delta Z_{it}\Delta\zeta_{it}] = 0$. Assume that the instruments V_{it} satisfy the conditions

$$E[\alpha_i - \bar{\alpha}|V_{it}] = 0 \tag{A1}$$
$$E[\gamma_i - \bar{\gamma}|V_{it}] = 0. \tag{A1'}$$

and that[5]

$$E[\Delta\zeta_{it}|\Delta Z_{it}, V_{it}] = 0, \quad E[\nu_{it}|V_{it}] = 0, \tag{A2}$$
$$E[\alpha_i - \bar{\alpha}|\Delta Z_{it}, V_{it}] = \psi_{0Z}\Delta Z_{it} + \psi_{0V}V_{it}, \tag{A3}$$
$$E[\gamma_i - \bar{\gamma}|\Delta Z_{it}, V_{it}] = \psi_{1Z}\Delta Z_{it} + \psi_{1V}V_{it}. \tag{A4}$$

Assumption (A2) strengthens the usual IV orthogonality condition. Assumptions (A3) and (A4) require the conditional expectations of α and γ to be linear in ΔZ_{it} and V_{it}.

[4] This model has originally been developed by Garen (1984) to correct for selectivity bias in estimates of the returns to schooling. A theoretical model of schooling choice justifying the use of a correlated random coefficient model has been derived by Garen (1984) and Card (1995). A discussion of the assumption assuring identification in this type of models are given by Wooldridge (1997) and Heckman and Vytlacil (2000). A structural analysis of the correlated random coefficient model is provided by Belzil and Hansen (2002). See also the survey by Card (1999). The correlated coefficient model has also been applied to other settings. Chay and Greenstone (1998), for example, evaluate the willingness to pay for clean air based on this type of model.

[5] See Wooldridge (1997) and Heckman and Vytlacil (2000) for alternative assumptions on the stochastic relationship between γ and V_{it}.

From assumptions (A1) through (A4) it could be derived that $E[\alpha_i - \bar{\alpha}|\Delta Z_{it}, V_{it}] = \psi_{0Z}\eta_{it}$ and $E[\gamma_i - \bar{\gamma}|\Delta Z_{it}, V_{it}] = \psi_{1Z}\eta_{it}$. Using these relationships, the conditional expectation of ΔY_{it} could be written as

$$E[\Delta Y_{it}|\Delta Z_{it}, V_{it}, X_{it}] = \Delta X'_{it}\beta + \bar{\alpha} + \bar{\gamma}\Delta Z_{it} + \psi_{0Z}\eta_{it} + \psi_{1Z}\eta_{it}\Delta Z_{it}. \quad (9)$$

Following Garen (1984), consistent estimates of the average return to the adoption of flexible workplace systems ($\bar{\gamma}$) could be obtained by the *control function*-estimator

$$\Delta Y_{it} = \Delta X'_{it}\beta + \bar{\alpha} + \bar{\gamma}\Delta Z_{it} + \psi_{0Z}\hat{\eta}_{it} + \psi_{1Z}\hat{\eta}_{it}\Delta Z_{it} + \Delta\upsilon_{it}, \quad (10)$$

where $\hat{\eta}_{it}$ are the estimated residuals from the first-stage equation (8). Note that equation (10) differs from a 2SLS estimator by the term $\psi_{1Z}\hat{\eta}_{it}\Delta Z_{it}$, which controls for heterogeneity in the returns to the adoption of flexible workplace practices as a potential source of bias. If these returns are constant across establishment (i.e. $\gamma_i = \bar{\gamma}$), equation (10) reduces to the standard 2SLS estimator described in equations (5) and (6).

Note further that the coefficients ψ_{0Z} and ψ_{1Z} in equation (10) allows to analyze the importance of omitted variable bias and the importance of self-selection bias arising in conventional estimates (see, for example, Garen 1984, Card 1999, and Chay and Greenstone 1998): the coefficient $\psi_{0Z} = Cov(\alpha_i, \eta_{it})/Var(\eta_{it})$ provides a measure of the importance of omitted variable bias; and$\psi_{1Z} = Cov(\gamma_i, \eta_{it})/Var(\eta_{it})$ measures the importance of heterogeneity in the average returns to flexible workplace practices.

As already discussed above, the direction of the bias in conventional estimates of γ arising through omitted variable bias, i.e., the sign of ψ_{0Z}, is unclear *a priori*. In addition, it is hard to derive unequivocal expectations on the direction of the bias arising through heterogeneous returns to the adoption of flexible workplace practices (i.e., the sign of ψ_{1Z}). Usually one would expect that those firms with the highest returns of using these practices are also more likely to implement them. Based on this argument $Cov(\gamma_i, \eta_{it}) > 0$, implying that the estimated returns to flexible workplace practices in conventional regressions are biased upward (i.e., that $\psi_{1Z} > 0$).

However, panel studies on the productivity effects of adopting HPWSs are likely to suffer from the "late-adopter" problem (Capelli and Neumark 2001). Establishments with above-average returns to the use of flexible workplace systems are likely to adopt them at a relatively early stage. Firms that adopt these practices at a

later stage are likely to consist mainly of firms with relatively low net returns to the use of HPWSs. They adopt flexible workplace systems only after a sufficient decrease of the implementation costs, or because they are forced to introduce these practices after some exogenous external shock. Following this argument, it is likely that studies using longitudinal data are dominated by the marginal returns to the adoption of HPWSs for establishments with below-average returns, implying that $\psi_{1Z} < 0$. Hence, depending on which of the discussed effects dominate, heterogeneity in the returns to the adoption of HPWSs could lead to a positive or negative bias in conventional estimates of γ.

3. Data Description

The following analysis of the effects of technological and organizational change on establishment performance is based on a German employer-employee linked data set that was constructed through the combination of the *IAB Establishment Panel* and the *Employment Statistics Register*. The *IAB Establishment Panel* is an annual representative survey of establishments employing at least one employee who pays social security contributions.[6] Starting in 1993, the survey was administered through personal interviews. The second data source, the *Employment Statistics Register*, is an administrative panel data set of individuals based on the integrated notifying procedure for the German health insurance, statutory pension scheme, and unemployment insurance that has been introduced in 1973.[7]

Both data sets contain a unique firm identification number, which allows me to merge the information on employees provided by the *Employment Statistics Register* with the information in the *IAB Establishment Panel*. The empirical analysis disregards establishments in the agricultural and mining sector, non-profit firms as well as all firms with missing values for the variables used. In addition, I do not consider banks and insurance companies, since they report either their balance or

[6] See Bellmann, Kohaut, and Kühl (1994), Bellmann (1997), and Kölling (2000) for a detailed description of the *IAB-Establishment Panel*.

[7] Since 1973, employers are obliged to provide information to the social security agencies for those employees registered by the social security system. Employers have to notify the social security agencies about the beginning and ending of any employment relationship. In addition, they have to provide an annual report for each employee covered by social insurance who is employed on the 31st December of each year. This report includes information on the sex, year of birth, nationality, marital status, number of children, occupation, and qualification of the employee. See Bender, Hilzendegen, Rohwer, and Rudolf (1996) and Bender, Haas, and Klose (2000) for a detailed description of the data set and the notifying procedure. Note further that during the period under study about 84% of all employed persons in Germany are covered by the social security system.

their volume of insurance contributions rather than turnover. I further consider only establishments that either participated in 1993 and 1995 or in 1993 and 1997, respectively. These exclusions leave 1,319 observations for 1995 and 921 observations for 1997. To this sample of establishments, I merged information on all employees in a particular establishment who pay social security contributions obtained from the *IAB Establishment Panel*. The individual information has been extracted for every 30th of June, the day of reference for the *IAB-establishment panel*.

As dependent variables (Y_{it}), I study the log of sales per worker, where the number of workers consists of all employees covered by the social security system. In addition, I consider the log of the ratio of sales to total labor costs as dependent variable. This ratio, which corresponds to the log of the inverse of unit labor costs, allows me to analyze the effects of adopting flexible workplace systems on labor efficiency. Unfortunately, many establishments do not report their total labor costs. Therefore, the usable sample is reduced to 1,128 observations for the year 1995 and 772 observations for the year 1997 when analyzing the impact of flexible workplace systems on labor efficiency.

In 1995, establishments participating in the *IAB-establishment panel* were asked the following questions: *"Have there been any of the following organizational changes in your establishment over the last 2 years?"* From the answers to this question I created dummy variables indicating whether an establishment *(i)* reduced the number of hierarchy levels, *(ii)* transferred responsibilities to subordinates, and *(iii)* introduced team-work or self-responsible working groups. Note that that these changes cover three out of four practices that were identified by Betcherman (1997) and OECD (1999) as main characteristics of flexible workplace systems.[8]

The work of Milgrom and Roberts (1990, 1995) indicates that only the introduction of a cluster of new practices allows firms to reach a new optimal organization. If practices are introduced in clusters, the above-described indicators of organizational change should be highly correlated with each other, making it difficult to identify the separate effects of these indicators. I therefore applied a principal component analysis to the three dummy variables described above to derive an index of decentralization. The first principal component accounted for 60.9% of the variance and had an eigenvalue of 1.827. The second and third principal component had eigenvalues below 1, supporting the aggregation of the information on organizational

[8]The fourth characteristic is a job design that involves multi-tasking.

change to one common factor. The scoring coefficients used for the calculation of the decentralization index are 0.429 for the reduction of hierarchy levels, 0.438 for the delegation of responsibilities, and 0.415 for the introduction of teamwork. Table 1 shows the incidence of HPWO adoption in the final sample. Between 1993 and 1995, about 21% of all establishments reduced the number of hierarchy levels, 35% transferred responsibilities to lower hierarchy levels, and about 25% introduced self-managed teams.

The vector of control variables (X_{it}) includes the log of total employment, the log of total investments per worker as a proxy for the capital stock, the log of material costs per worker,[9] the share of exports on total sales, a dummy variable indicating whether the firm invested in IT technology in the last year, a discrete variable indicating the state-of-the-art of the production technology used in the establishment, a dummy variable indicating whether the firm is covered by wage agreements, three dummy variables indicating the age of an establishment, a dummy variable indicating whether an establishment is a single firm rather than part of a multi-establishment firm, and 12 industry dummies. From the *Employment Statistics Register* I merged information on the employment share of professionals and engineers, the employment share of female employees, the employment share of foreign workers, and the mean age of the employees. Precise variable definitions and descriptive statistics of all variables are provided in in the appendix.

The estimation of the 2SLS model described in equations (5) and (6) and the correlated random coefficient model described in equations (10) and (8) requires the use of an instrumental variable V_{it}. This instrumental variable has to satisfy the conditions that it is correlated with ΔZ_{it} but uncorrelated with $\Delta\epsilon_{it}$. For the correlated random coefficients model, the instrument has to satisfy the somewhat stronger conditions described in equations (A1) through (A4). In the following empirical analysis, I will make use of the incidence of flexible workplace systems in the U.S. to instrument the adoption of these systems in Germany. This instrument has been constructed as follows.

I used the *National Employer Survey (NES)* from 1994 – a data set that has

[9]Many firms refused to provide information on total investments and material costs. In order to avoid to avoid the loss of an unacceptable number of observations, I imputed these two variables for those firms with missing values using the following procedure. I regressed total investments per worker and material costs per worker on all other covariates for all observations with valid information. Based on this regression I predicted total investments per worker and material costs per worker for those establishments with missing information on these two variables. A discussion of different methods of imputation is provided by Little and Rubin (1987).

been widely used in the U.S. to analyze the determinants and performance effects of HPWSs – to construct an index of decentralization for U.S. establishments. A description of the NES is given in the appendix to this paper.[10] From the *National Employer Survey (NES)* I used the responses to the following questions to derive an index of decentralization using principal component analysis:

- Has your establishment adopted a formal Total Quality Management program?
- Does your establishment allow "job-sharing" between employees?
- What percentage of non-managerial and non-supervisory employees are currently involved in job-rotation?
- What percentage of non-managerial and non-supervisory employees are currently involved in self-managed teams?
- Over the last three years, have the number of hierarchy levels in your organization increased, decreased or stayed the same?

In a second step, I calculated the mean of the resulting decentralization index for 120 cells, which have been defined on industry-level, firm size and ownership structure. Finally, these cells have been merged to the corresponding cells in the German data.

According to Ichniowski and Shaw (1995), one of the most important determinants of the implementation of innovative workplace systems is the availability of information on how to implement these practices, information on which practices are complementary to each other and therefore should be implemented together in order to be productivity-enhancing, as well as information on the costs and the potential returns of implementing these practices. If there is incomplete information and if search for this type of information is costly, firms will implement these practices with a lower probability. As information on innovative practices improves over time, more firms should begin to implement these practices. It is difficult to make international comparisons on the dissemination of flexible workplace practices. The figures reported by the OECD (1999) suggest, however, that the diffusion of HPWSs started somewhat earlier in the U.S. than in Germany. Assuming that information on the experience with these practices in the U.S. spreads over to Germany, the use

[10] A more detailed description of the data set is given by Black and Lynch (2001) and Capelli and Neumark (2001).

of these practices in the U.S. should be positively correlated with the probability of implementing innovative work systems in Germany.

It may be argued that the use of innovative workplace practices in the U.S. also affects the performance of German firms, if U.S. and German firms compete on international markets. If U.S. firms adopt productivity-enhancing workplace practices earlier than their German competitors, they may gain a cost advantage which in turn may have a negative impact on the revenues of the German firms. In this case, the instrument used in the following analysis is invalid since the requirement that $Cov(V_{it}, \Delta\epsilon_{it} = 0)$ might be violated. However, given that U.S. foreign trade occurs mainly within the NAFTA and German firms mainly export to and import from other EU member countries, this problem seems to be at most of second order.

4. Determinants of Implementing Innovative Work Systems

The direction of a possible bias in the estimated productivity effects of flexible workplace practices due to unobserved time-invariant plant heterogeneity, the potential endogeneity of the index of decentralization, and heterogeneity in the returns to adopting these practices is unclear *a priori*. In order to obtain some idea of the likely direction of the bias in conventional cross-sectional estimates, Table 2 reports OLS-estimation results on the determinants of implementing flexible workplace practices between 1993 and 1995 using the index of decentralization derived above as dependent variable. As independent variables I consider several factors which have been identified in the literature as having an impact on the potential costs and returns of implementing flexible workplace systems (see, for example, Osterman (1994), OECD (1999), Ichniowski and Shaw (1995), and Kölling and Möller (2001)). All independent variables are measured for the year 1993.

A common finding in the literature is that larger firms have a higher probability to adopt flexible workplace systems because the fixed costs of adopting these systems as well as the costs of gathering information on the potential costs and returns of these practices are a smaller percentage of their revenues. In addition, large firms may have economics of scale in the implementation and operation of these systems and are more likely to have relatively more financial resources available to collect information on innovative workplace system and to experiment with them (Ichniowski and Shaw 1995). To control for firm-size effects, the following estimations include

the log of total establishment employment and a dummy variable indicating whether the establishment is a single firm.

The use of modern information and production technology is often considered to be complementary to innovative workplace systems (see, among others, Athey and Stern (1998), Milgrom and Roberts (1990), Milgrom and Roberts (1995), and Caroli and Reenen (2001)) and hence increase the potential returns of adopting HPWSs. To capture these effects, the regressions include the log of total investments per employee, a dummy variable indicating whether an establishment invested in information technology in the past year and a variable indicating whether an establishment uses state-of-the-art production technology as independent variables.

When planning to change the organization of work, a firm may have to overcome the opposition of workers who have made investments in firm-specific capital that are valuable only under the current workplace system (Ichniowski and Shaw 1995). To proxy these costs of implementing new workplace systems, I included the mean age of the employees as a control variable. To the extent that this variable is correlated with average firm tenure, it should show a negative impact on the probability to adopt HPWSs. In addition, I consider a dummy variable indicating whether an establishment was founded less than five years ago. It could be expected that the resistance against changes in workplace organization is less strong in young firms.

The current and the expected performance of an establishment is an additional factor that might influence the decision to adopt innovative workplace systems. As discussed above, however, it is unclear whether successful firms or firms that face a transitory demand shock or structural productivity problems have a higher inclination to change their organization. Successful firms may have the financial resources available to gather costly information on the potential costs and returns of implementing new workplace systems as well as to experiment with these systems. Firms that face slack demand or structural productivity problems, on the other hand, have lower opportunity costs of reorganization in terms of foregone output and hence may have a higher probability to implement new workplace systems. These firms may also have less problems to overcome potential opposition to a reorganization from their current workers due to threat effects. If the workers could be persuaded that they will lose their job if the firm refrains from necessary changes, their resistance against these changes may be weakened. The following variables are included to measure potential effects of the economic situation of an establishment

on the decision to adopt flexible workplace practices: the share of exports on total revenues, a dummy variable indicating whether an establishment expects increasing revenues in the following years, and three dummy variables indicating the profit situation of the establishment in 1993, where a bad-profit situation acts as the reference group.

Finally, the existing literature suggests that trade unions are important for the decision to adopt HPWSs. Therefore, the following estimations further include a dummy variable which takes the value one if the establishment is covered by collective trade union agreements. Note that the expected direction of this union effect is, however, unclear from a theoretical point of view.[11] In addition, it could be expected that firms with relatively high labor costs have bigger incentives to introduce HPWSs. The regressions therefore include the logarithm of the average wage per worker as independent variable.

Column (1) of Table 2 reports the results when only the control variables discussed above are included in the specification. In column (2), the specification is augmented by twelve industry dummies to control for potential industry effects. Finally, the decentralization index merged from the U.S. data is added to the specification in column (3). For this variable to be a valid instrument, a statistically significant correlation with the implementation of flexible workplace systems in Germany is required.

The estimation results reported in Table 2 generally confirm the existing evidence on the determinants of HPWO-adoption for other countries.[12] The extent of HPWO-adoption between 1993 and 1995 is higher for firms employing more employees in 1993 and lower for single firms. Total investments per employee and the indicator variable for the use of modern production technology in 1993 do not show a statistically significant impact on changes in the organization of work. Investments in IT in 1992 have a highly significant positive effect on the reorganization of the workplace towards flexible systems, confirming the hypothesis that new information technologies and innovative workplace systems are complements to HPWSs.

Coverage by collective wage agreements affects the decision to reorganize the workplace positively. The estimated coefficients are, however, not statistically sig-

[11] See Lindbeck and Snower (2001) and Hübler and Jirjahn (2002) for theoretical models on the impact of trade unions on the adoption of HPWSs.

[12] See, for example, Osterman (1994) and Ichniowski and Shaw (1995) for the U.S., Caroli and Reenen (2001) for France and the UK, Nickell, Nicolitsas, and Patterson (2001) for the UK and Kölling and Möller (2001) for Germany. International evidence is provided by the OECD (1999).

nificant. Similarly, the average wage per worker does not have significant effects on the decision to adopt flexible workplace systems. There is some indication that firms with an older workforce face higher costs of adopting new workplace systems. The notion that resistance by workers against changes in the organization of work plays an important role is confirmed also by the result that younger firms have a significant higher inclination to change their organization than firms that exist longer than five years.

An expected increase in revenues does not affect the decision to adopt flexible workplace systems significantly. The profit situation in 1993, however, appears to be important in explaining the decision to reorganize the workplace between 1993 and 1995. The estimation results reported in Table 2 indicate that the incidence of workplace reorganization is the lower the better the profit situation of a firm. Hence, similar to the UK and the U.S. (Ichniowski and Shaw 1995; Nickell, Nicolitsas, and Patterson 2001) it appears that firms that face a negative demand shock or establishments with structural problems have a higher probability to reorganize the workplace. For the empirical analysis of the effects of innovative workplace systems on establishment performance, this result has several implications. First, assuming that these problems are time-invariant at least for the period from 1993 to 1995, one could expect that omitted variable bias leads to downward biased estimates of the returns to adopt HPWSs in cross-sectional models. One could further expect that cross-sectional estimates of the returns to innovative workplace practices are biased downwards due to potential endogeneity of the HPWO measure. Therefore, applying two-stage-least squared estimation as described in equations (5) and (6) should result in a higher estimated return to innovative workplace practices. In the correlated random coefficient model, one would expect that both ψ_{0Z} and ψ_{1Z} are negative.

5. Performance Effects of Innovative Work Systems

5.1. Labor Productivity

The estimation results relating the adoption of innovative workplace systems between 1993 and 1995 to labor productivity are presented in Tables 3 and 4.[13] Col-

[13]The full estimation results are available upon request.

umn (1) of these tables present the results from a specification that include only establishment characteristics as control variables. The results when adding twelve industry dummies to this basic specification are reported in column (2), and column (3) present the results when controlling in addition for the characteristics of the workforce in an establishment. Finally, in column (4) of Tables 3 and 4 the sample has been restricted to plants with at least 100 employees.

Panel A of Table 3 shows the results from simple cross-sectional estimates of changes in the organizational structure of an establishment between 1993 and 1995 on labor productivity in 1995. These results act as a benchmark that is used to analyze the existence and importance of potential biases due to unobserved heterogeneity, potential endogeneity of the decentralization index, and heterogeneity in the costs and returns to adopt innovative workplace practices. The estimates in Panel A of Table 3 suggest that reorganizing the workplace towards more flexible systems between 1993 and 1995 has negative but statistically insignificant effects on labor productivity in 1995.

The discussion in section two together with the estimation results on the determinants of adopting innovative workplace practices in the previous section suggest that the estimates of γ reported in Panel A of Table 3 are biased downward. This notion is confirmed by the results reported in Panel B of Table 3, which shows the estimated coefficient for the decentralization index when time-invariant establishment fixed effects are removed by first-differencing all variables using the respective observations for 1993. Accounting for unobserved establishment fixed effects, the estimated coefficients for the index of decentralization become positive and statistically significant, suggesting that establishments with time-invariant unobserved characteristics that decrease their productivity implement innovative workplace practices in order to solve structural productivity problems. These results confirm those presented in section three as well as the existing empirical evidence on the determinants of HPWO-adoption.

Table 3 further shows that the estimated coefficient for the index of decentralization drops from 0.038 to 0.023 when adding industry dummies to the baseline estimation in column (1). Considering also variables that characterize the structure of the workforce in the establishments further reduces the point estimate for the decentralization index to 0.020 (see Column (3)), indicating that a one standard deviation increase in the decentralization index increases labor productivity by about

2%. This coefficient, however, is only statistically significant on a 10% level. Column (4) shows that restricting the sample to firms with at least 100 employees does not have a significant impact on the estimation results if compared to column (3).

The results on the determinants of flexible workplace practices discussed in the last section suggest that the coefficients reported in Panel B of Table 3 may still be biased downward due to the potential endogeneity of the index of decentralization. The GMM estimates of equations (5) and (6) using the constructed decentralization index for U.S. establishments in 1994 as an instrument for the change in workplace organization in Germany between 1993 and 1995 reported in Panel C support this notion. Referring to the specification in column (3), the estimated coefficient for the index of decentralization rises from 0.020 to 0.083 when taking potential endogeneity bias into account. Hence, even after considering unobserved time-invariant heterogeneity, the estimated returns to the adoption of flexible workplace practices are biased downward, because firms that face a temporary productivity shock have a higher probability of implementing these practices.

Panel C of Table 3 further reports the F statistic for the test of the statistical significance of the excluded instrument and the partial R^2 of the excluded instrument from the first-stage regression of each specification. Both tests strongly confirm the validity of the used instrument. The test statistics further indicate that the reported IV estimates do not suffer from inconsistencies due to weak instruments (Bound, Jaeger, and Baker 1995).

As discussed above, it is likely that panel studies on the productivity effects of adopting HPWSs suffer from the "late-adopter" problem. Because of this problem, the marginal effects obtained through the IV model reported in Panel C represent the returns to implementing innovative workplace systems for a nonrandom subpopulation and hence may not represent estimates of the average returns of adopting these systems. To examine this problem, I estimate the random coefficient model specified in equation (10) using the same instrument as in Panel C. The results from estimating this model are presented in Panel D of Table 3. Referring again to the estimated coefficient in column (3), a one standard deviation increase in the decentralization index increases labor productivity by about 10%. This increase is economically important and is comparable to the results of studies for the U.S.[14]

[14] See, for example, Boning, Ichniowski, and Shaw (2001), Bresnahan, Brynjolfsson, and Hitt (2002) and Black and Lynch (2001) as well as the discussion in Becker and Huselid (1998).

The selection bias control function has a negative coefficient estimate ($\hat{\psi}_{1Z} < 0$) indicating that the "late-adopter" problem plays indeed a role. Note however, that after adding industry dummies and controls for the structure of an establishments' workforce this coefficient is only significant on a 10% level. It appears further that the estimated average returns to the adoption of flexible workplace practices are only slightly higher than the IV estimates reported in Panel C. Thus, the bias in the 2SLS estimates due to the "late-adopter"-problem seems to be negligible. Furthermore, $\hat{\psi}_{0Z}$ is negative, indicating again that conventional estimates of γ are biased downward due to unobserved establishment characteristics that are positively correlated with the probability to implement flexible work systems but negatively correlated with productivity. After controlling for industry heterogeneity and the structure of an establishments' workforce, however, $\hat{\psi}_{0Z}$ becomes statistically insignificant, indicating that first-differencing the data controls most of the bias arising through omitted variables.

A final problem with the estimates of the productivity effects of innovative workplace systems depicted in Table 3 could be seen in the timing of measurement. It is reasonable to assume that some time needs to elapse for new workplace systems to show their entire effect on labor productivity. The employees need to acquire the necessary skills to be able to work in the new organizational environment. Furthermore, they may have to get used to the new work methods, changing communication ways and different decision-making responsibilities before innovative workplace systems display their full productivity effects. Thus, estimates of the effects of changes in the workplace organization between 1993 and 1995 on labor productivity in 1995 might provide an incomplete picture of the long-run productivity effects of these practices.

To examine this issue more formally, I estimated the effects of organizational changes between 1993 and 1995 on labor productivity in 1997. The results of these estimations are reported in Table 4. Overall, the estimated returns to the implementation of innovative workplace systems are higher than those presented in Table 3, indicating that these systems require some time to display productivity effects. The estimated coefficient in column (3) of Panel D indicate, that the long-run average productivity effect of a one standard deviation increase in the decentralization index is slightly more than 22%. With regard to the potential biases of simple cross-sectional estimates, Table 4 shows a similar pattern as in Table 3. The cross-

sectional estimates are biased downward because of time-invariant establishment fixed effects and the endogeneity of the decentralization index. As in Table 3, the latter plays a more important role.

The only remarkable differences to the results reported in Table 3 occur in the correlated random coefficient model. First, even though the estimated coefficient of the selection bias control function ($\hat{\psi}_{1Z} < 0$) is negative, it is statistically insignificant, indicating that heterogeneity in the returns to the implementation of flexible workplace practices disappear in the long-run. One explanation for this result is that the long-run productivity increase resulting from adopting innovative practices for "late-adopters" converge to those that adopted these systems earlier. Second, when using long-differenced data, omitted variable bias plays again a significant role. These results suggest that there are some other, more long-run unobserved influences that are not captured by the control variables. These long-run influences could be effectively controlled in short panels but play an important role when using long differences.

5.2. Labor Efficiency

The estimation results reported in Tables 3 and 4 suggest that employers gain from adopting flexible workplace systems through higher labor productivity. This result, however, does not imply that the establishments also benefit from these systems through lower unit labor costs (Capelli and Neumark 2001). The empirical study of Bauer and Bender (2002a), which employs the same data set used here, shows that innovative workplace practices are also associated with higher wages. Hence, whether these practices result in a reduction of unit labor costs depend on whether the increased labor productivity overcompensate an accompanied rise in labor costs per worker. To investigate this issue, I repeated the above analysis using the log of the ratio of total turnover to total labor costs as dependent variable. A positive coefficient on the decentralization index in this specification would imply that labor productivity rises more than total labor costs, lowering unit labor costs.

Table 5 shows the findings on the effects of implementing flexible workplace practices between 1993 and 1995 on the inverse of unit labor costs in 1995. The respective results for 1997 are reported in Table 6. The baseline cross-sectional results in Panel A, column (3) of Table 5 suggest that the implementation of innovative

work systems between 1993 and 1995 has a negative impact on labor efficiency in 1995. This effect, however, is only significant on a 10% level. When first-differencing the data to remove unobserved time-invariant establishment effects, the coefficient on the constructed index of decentralization becomes positive, indicating again that plants with unobserved characteristics that negatively affect labor efficiency have a higher probability to change their organization. When taking the potential endogeneity of the decentralization index into account by using an IV estimator or the correlated random coefficient model, the coefficient on the decentralization index becomes statistically insignificant.

These results tend to be confirmed by Table 6. Different to Table 5, however, the impact of changing the organization between 1993 and 1995 on labor efficiency in 1997 becomes statistically significant in the correlated coefficient model. According to the point estimate in Panel D, column (3) of Table 6, a one standard deviation increase in the decentralization index increases long-run labor efficiency by about 12%. Note that this effect is smaller than the corresponding effect reported in Table 4, indicating that part of the increase in labor productivity is offset by increased labor costs. A similar result has been obtained by Capelli and Neumark (2001) for the U.S.. This results also reflects the results of Bauer and Bender (2002a). Using the same data set as in this paper, they find that the adoption of high performance workplace systems are associated with wage gains for employees.

6. Summary

The existing empirical literature on HPWSs is predominantly concerned with the effects of these practices on establishment performance. Even though the majority of these studies suggest that the use or introduction of HPWSs has positive effects on establishment's performance, the findings of the literature as a group remain inconclusive. Among other reasons, this mixed evidence may be the result of different estimation strategies. The identification of the performance effects is subject to several methodological problems that have been addressed by the existing literature to an insufficient extent. In paricular, existing studies are potentially biased for at least one of the following three reasons: unobserved heterogeneity resulting in omitted variable bias, the potential endogeneity of HPWO measures, and heterogeneity in the returns to use or adopt HPWSs.

This paper investigates the extent to which estimated effects of the implementation of innovative workplace systems on establishment performance are affected by the above mentioned problems, proceeding in four steps. In order to provide some benchmark, I first estimated a simple cross-sectional model of the effects of adopting flexible workplace practices on labor productivity (defined as sales per employee) and labor efficiency (defined as the inverse of unit labor costs). In a second step, I investigated to what extent these baseline estimates are biased due to unobserved heterogeneity by taking first differences. After removing potential omitted variable bias due to establishment fixed effects, I applied an instrumental variable (IV) estimator in order to address the potential endogeneity of HPWO measures. Finally, even after removing omitted variable bias by using first differences and a potential endogeneity-bias by using an IV estimator, the estimated returns to adopt flexible workplace systems might be a downward biased estimate of the average returns to these practices, since panel studies are likely to measure only the returns for "late-adopters". This final issue has been addressed by estimating a correlated random coefficient model.

The estimation results indicate that cross-sectional estimates of the effects of implementing flexible workplace systems on labor productivity are biased downward due to unobserved time-invariant establishment heterogeneity and the potential endogeneity of the used measure for innovative workplace practices. The estimates further imply that the endogeneity bias is quantitatively more important than the bias resulting from omitted variables. The estimated average returns to the adoption of flexible workplace practices obtained by estimating the random coefficient model are only slightly higher than the corresponding IV estimates. Thus, the bias in the 2SLS-estimates due to the "late-adopter" problem seems to be negligible.

The estimated effects of flexible workplace systems on labor productivity are economically important and comparable to similar estimates obtained for the U.S. Investigating the long-run productivity effects of implementing HPWSs by using data for 1997 rather than 1995 further indicate that these returns are rising over time. However, the adoption of flexible workplace systems in German establishment does seem to have a corresponding positive impact on labor efficiency only in the long-run. The estimation results further imply that the positive wage effects connected with these practices(see Bauer and Bender (2002a)) increases labor costs to an extent which partly offset the increase in labor productivity.

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Table 1:

HPWSs and Index of Decentralization: Germany and U.S.

	All Establishments	Establishments with at least 100 Employees
Reduction of Hierarchy Levels	0.212	0.352
Transfer of Responsibilities	0.351	0.475
Introduction of Self-Managed Teams	0.245	0.387
Index of Decentralization	0.805 (1.020)	1.216 (1.111)
Index of Decentralization - U.S.	1.324 (0.430)	1.569 (0.417)

Source: LIAB, 1995; ESF, 1994; own calculations. *Notes:* Observations: 1,319.

Table 2:

Determinants of HPWO-Adoption

	(1)	(2)	(3)
log(Total Employment)	0.177***	0.165***	0.149***
	(0.020)	(0.020)	(0.018)
Single Firm	-0.128*	-0.164**	-0.084
	(0.072)	(0.064)	(0.076)
log(Total Investments per Employee)	0.021	0.024	0.021
	(0.025)	(0.027)	(0.027)
Investments in IT	0.199***	0.194***	0.192***
	(0.054)	(0.054)	(0.053)
State-of-the-Art Technology	0.003	0.002	0.003
	(0.031)	(0.032)	(0.031)
Collective Wage Agreements	0.022	0.015	0.018
	(0.069)	(0.080)	(0.079)
Mean Age of Employees	-0.009**	-0.007**	-0.007*
	(0.003)	(0.003)	(0.003)
Age of Establishment < 5 Years	0.227**	0.212**	0.200*
	(0.101)	(0.102)	(0.101)
Expected Decrease in Revenues	-0.027	-0.053	-0.056
	(0.066)	(0.063)	(0.062)
Export Share	0.276**	0.157	0.133
	(0.118)	(0.123)	(0.121)
Profit Situation: Poor	-0.259***	-0.266***	-0.266***
	(0.081)	(0.087)	(0.085)
Profit Situation: Sufficient	-0.501***	-0.484***	-0.483***
	(0.072)	(0.069)	(0.068)
Profit Situation: Good	-0.450***	-0.431***	-0.426***
	(0.078)	(0.074)	(0.072)
log (Average Wage)	0.034	0.043	0.040
	(0.059)	(0.063)	(0.062)
Index of Decentralization in the U.S.	-	-	0.251**
			(0.104)
Constant	1.693***	1.607***	1.148***
	(0.239)	(0.230)	(0.293)
Industry Dummies	No	Yes	Yes
R^2	0.31	0.32	0.33

Source: LIAB, 1993; ESF, 1994; own calculations. *Notes:* Robust standard errors in parentheses. 1,319 observations. Specifications (2) and (3) also include 12 industry dummies. $***$: statistically significant at least at the 1% level. $**$: statistically significant at least at the 5% level. $*$: statistically significant at least at the 10% level.

Table 3:

Flexible Workplace Systems and Labor Productivity, 1995

	(1)	(2)	(3)	(4)
Panel A: Cross-Section 1995:				
Index of Decentralization	-0.020	-0.010	-0.010	-0.004
	(0.016)	(0.015)	(0.015)	(0.018)
R^2	0.54	0.56	0.57	0.60
Panel B: First-Differences 1993-1995				
Index of Decentralization	0.038***	0.023**	0.020*	0.020
	(0.011)	(0.012)	(0.012)	(0.013)
R^2	0.26	0.28	0.29	0.32
Panel C: First-Differences 1993-1995 - GMM IV				
Index of Decentralization	0.123***	0.088**	0.083**	0.098
	(0.026)	(0.037)	(0.037)	(0.071)
F(Excluded Instrument)	291.19	145.59	143.59	29.35
Partial R^2 (Excluded Instrument)	0.182	0.101	0.100	0.044
R^2	0.231	0.265	0.275	0.286
Panel D: First-Differences 1993-1995 - Correlated Random Coefficients				
Index of Decentralization	0.144***	0.105***	0.100**	0.101
	(0.027)	(0.039)	(0.039)	(0.072)
$\hat{\psi}_{0Z}$	-0.073**	-0.047	-0.044	-0.070
	(0.030)	(0.039)	(0.039)	(0.070)
$\hat{\psi}_{1Z}$	-0.031**	-0.026*	-0.026*	-0.009
	(0.013)	(0.014)	(0.014)	(0.013)
R^2	0.27	0.28	0.29	0.33
Establishment Characteristics	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes
Employee Characteristics	No	No	Yes	Yes
Only Establishments with at least 100 Employees	No	No	No	Yes
Observations	1,319	1,319	1,319	657

Notes: Robust standard errors in parentheses. $***$: statistically significant at least at the 1% level. $**$: statistically significant at least at the 5% level. $*$: statistically significant at least at the 10% level. All specifications control for the log of total employment, the log of total investments per worker as a proxy for the capital stock, the log of material costs per worker, the share of exports on total sales, a dummy variable indicating whether the firm invested in IT-technology in the last year, a discrete variable indicating the state-of-the art of the technology used in the establishment, a dummy variable indicating whether the firm is covered by wage agreements, three dummy variables indicating the age of an establishment, and a dummy variable indicating whether an establishment is a single firm or part of a multi-establishment firm. Specifications (2), (3), and (4) also include 12 industry dummies. Specifications (3) and (4) include the following variables describing the employment structure in an establishment: the share of professionals and engineers, the employment share of female employees, the employment share of foreign workers, and the mean age of the employees.

Table 4:

Flexible Workplace Systems and Labor Productivity, 1997

	(1)	(2)	(3)	(4)
Panel A: Cross-Section 1997:				
Index of Decentralization	0.010 (0.018)	0.015 (0.018)	0.014 (0.018)	0.032* (0.019)
R^2	0.65	0.66	0.67	0.67
Panel B: First-Differences 1993-1997				
Index of Decentralization	0.054*** (0.014)	0.043** (0.016)	0.044*** (0.017)	0.052*** (0.018)
R^2	0.29	0.32	0.33	0.29
Panel C: First-Differences 1993-1997 - GMM IV				
Index of Decentralization	0.141*** (0.032)	0.205*** (0.048)	0.211*** (0.048)	0.286** (0.107)
F(Excluded Instrument)	186.84	89.77	89.23	16.58
Partial R^2 (Excluded Instrument)	0.170	0.091	0.091	0.038
R^2	0.263	0.236	0.242	0.146
Panel D: First-Differences 1993-1997 - Correlated Random Coefficients				
Index of Decentralization	0.152*** (0.037)	0.216*** (0.047)	0.223*** (0.047)	0.288*** (0.093)
$\hat{\psi}_{0Z}$	-0.089** (0.039)	-0.161*** (0.052)	-0.164*** (0.051)	-0.228** (0.097)
$\hat{\psi}_{1Z}$	-0.016 (0.020)	-0.018 (0.021)	-0.020 (0.020)	-0.011 (0.018)
R^2	0.30	0.33	0.34	0.31
Establishment Characteristics	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes
Employee Characteristics	No	No	Yes	Yes
Only Establishments with at least 100 Employees	No	No	No	Yes
Observations	921	921	921	441

Notes: See notes to Table 3.

Table 5:

Flexible Workplace Systems and Labor Efficiency, 1995

	(1)	(2)	(3)	(4)
Panel A: Cross-Section 1995:				
Index of Decentralization	-0.050***	-0.034**	-0.028*	-0.019
	(0.017)	(0.016)	(0.016)	(0.019)
R^2	0.41	0.45	0.46	0.55
Panel B: First-Differences 1993-1995				
Index of Decentralization	0.045***	0.027**	0.026**	0.016
	(0.012)	(0.013)	(0.013)	(0.016)
R^2	0.08	0.10	0.11	0.15
Panel C: First-Differences 1993-1995 - GMM IV				
Index of Decentralization	0.067**	-0.003	-0.008	0.004
	(0.029)	(0.043)	(0.043)	(0.082)
F(Excluded Instrument)	236.39	122.97	122.60	27.30
Partial R^2 (Excluded Instrument)	0.174	0.100	0.100	0.048
R^2	0.080	0.099	0.103	0.145
Panel D: First-Differences 1993-1995 - Correlated Random Coefficients				
Index of Decentralization	0.083***	0.009	0.004	0.006
	(0.030)	(0.044)	(0.044)	(0.084)
$\hat{\psi}_{0Z}$	-0.004	0.054	0.058	0.021
	(0.037)	(0.049)	(0.050)	(0.087)
$\hat{\psi}_{1Z}$	-0.024	-0.020	-0.019	-0.006
	(0.015)	(0.016)	(0.017)	(0.017)
R^2	0.08	0.10	0.11	0.15
Establishment Characteristics	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes
Employee Characteristics	No	No	Yes	Yes
Only Establishments with at least 100 Employees	No	No	No	Yes
Observations	1,128	1,128	1,128	561

Notes: See notes to Table 3.

Table 6:

Flexible Workplace Systems and Labor Efficiency, 1997

	(1)	(2)	(3)	(4)
Panel A: Cross-Section 1997:				
Index of Decentralization	-0.042*	-0.031	-0.018	0.019
	(0.022)	(0.022)	(0.022)	(0.021)
R^2	0.50	0.53	0.54	0.68
Panel B: First-Differences 1993-1997				
Index of Decentralization	0.041**	0.025	0.024	0.048**
	(0.017)	(0.020)	(0.020)	(0.023)
R^2	0.10	0.12	0.13	0.19
Panel C: First-Differences 1993-1997 - GMM IV				
Index of Decentralization	0.087**	0.105	0.104	0.100
	(0.037)	(0.064)	(0.064)	(0.106)
F(Excluded Instrument)	157.61	75.38	75.58	15.65
Partial R^2 (Excluded Instrument)	0.171	0.091	0.092	0.044
R^2	0.088	0.103	0.107	0.174
Panel D: First-Differences 1993-1997 - Correlated Random Coefficients				
Index of Decentralization	0.109***	0.124**	0.122**	0.102
	(0.037)	(0.061)	(0.061)	(0.108)
$\hat{\psi}_{0Z}$	-0.023	-0.055	-0.058	-0.026
	(0.050)	(0.077)	(0.078)	(0.116)
$\hat{\psi}_{1Z}$	-0.032	-0.032	-0.030	-0.019
	(0.022)	(0.025)	(0.025)	(0.026)
R^2	0.08	0.10	0.11	0.15
Establishment Characteristics	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes
Employee Characteristics	No	No	Yes	Yes
Only Establishments with at least 100 Employees	No	No	No	Yes
Observations	772	772	772	367

Notes: See notes to Table 3.

7. Appendix

7.1. The National Employers Survey (NES)

The National Employers Survey (NES) is a nationally representative sample of more than 3,000 establishments administered by the U.S. Bureau of the Census as a telephone survey in August and September 1994. The survey excluded public-sector employers, non-profit institutions and corporate headquarters. Furthermore, plants with less than 20 employees have not been sampled. The survey over-sampled establishments in the manufacturing sector and establishments with more than 100 employees. The sampling frame for the survey was the Bureau of the Census Standard Statistical Establishment List (SSEL), a comprehensive and up-to-date listing of establishments in the U.S..

The target respondent of the survey was the plant manager in the manufacturing sector and the local business site manager in the non-manufacturing sector. The survey allowed for multiple respondents. Hence, it was possible to obtain information from establishments that kept information, such as for example the value of capital or the costs of goods and materials, at a separate office (typically at corporate headquarters for multi-establishment enterprises). The survey was administered by Computer-Assisted Telephone Interviewing (CAPI), which took approximately 28 minutes. The response rate in the National Employers Survey (NES) was 72%, which is substantially higher than the response rate in many other voluntary establishment surveys. A more detailed description of the reasons for non-participation and potential biases resulting from non-response is given by Black and Lynch (2001) and Capelli and Neumark (2001).

The National Employers Survey (NES) provides very detailed information on the use of HPWSs. It has therefore been used by several studies to investigate the effects of HPWSs on establishment performance (see, among others, Black and Lynch (2001) and Capelli and Neumark (2001)).

Appendix Table 1: Variable Definitions

Variable	Description
Sales/Worker	Total annual real sales in 1,000 DM over total number of employees paying social security contributions.
Sales/Labor Costs	Total annual real sales over total sum of annual real wages payed by the employer.
Employment	Total number of employees paying social security contributions.
Total Investments/Worker	Total annual investments in 1,000 DM over total number of employees paying social security contributions.
Material Costs/Worker	Total annual material costs in 1,000 DM over and 1995, 0 otherwise.
Decentralization Index	Index variable derived from several indicators for the existence of flexible workplace practices in German establishments using principal component analysis (see text for more details).
Decentralization Index U.S.	Index variable derived from several indicators for the existence of flexible workplace practices in U.S. establishments using principal component analysis (see text for more details).
Reduction of Hierarchy Levels	Dummy variable that equals 1 if establishment reduced number of hierarchy levels between 1993 and 1995, 0 otherwise.
Transfer of Responsibilities	Dummy variable that equals 1 if establishment transferred responsibilities to lower hierarchy levels between 1993 and 1995, 0 otherwise.
Self-Managed Teams	Dummy variable that equals 1 if establishment introduced self-managed teams between 1993 and 1995, 0 otherwise.
Investments in IT	Dummy variable that equals 1 if establishment invested in IT between 1993 and 1995, 0 otherwise.
State-of-the-Art Technology	Discrete variable ranging from 0 = production technology is totally out-of-date to 4 = production technology is state-of-the-art.
Share of Export	Share of exports on total sales.
Covered by Wage Agreements	Dummy variable that equals 1 if establishment is covered by centralized wage agreements.
Establishment Age < 5 Years	Dummy variable that equals 1 if establishment is less than 5 years old.
Single Firm	Dummy variable that equals 1 if establishment is single firm.
Share of Professionals and Technicians	Employment share of professionals and engineers.
Share of Females	Employment share of females.
Share of Foreigners	Employment share of foreigners.
Mean Age of Employees	Mean age of employees.
Profit Situation: Bad	Dummy variable that equals 1 if establishment reports that profit situation is bad, 0 otherwise
Profit Situation: Poor	Dummy variable that equals 1 if establishment reports that profit situation is poor, 0 otherwise
Profit Situation: Sufficient	Dummy variable that equals 1 if establishment reports that profit situation is sufficient, 0 otherwise
Profit Situation: Good or Very Good	Dummy variable that equals 1 if establishment reports that profit situation is good or very good, 0 otherwise

Appendix Table 2: Descriptive Statistics

	1993		1995		1997	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sales/Worker (in 1,000 DM)	434.699	1475.506	470.393	1539.759	541.985	1862.311
Sales/Labor Costs (in 1,000 DM)	8.307	33.892	7.797	24.963	8.577	32.222
Employment (in 1,000 DM)	0.536	1.330	0.499	1.218	0.504	1.429
Total Investments/Worker (in 1,000 DM)	27.993	65.295	14.487	36.017	2.050	1.189
Material Costs/Worker (in 1,000 DM)	205.924	1078.807	227.413	796.168	286.020	1047.302
Decentralization Index	0.266	0.337	0.266	0.337	0.272	0.342
Decentralization Index U.S.	0.362	0.118	0.362	0.118	0.360	0.118
Investments in IT	0.642	0.480	0.562	0.496	0.565	0.496
State-of-the-Art Technology	4.045	0.780	3.869	0.773	3.855	0.758
Export Share	12.686	21.079	13.465	21.863	13.066	21.327
Covered by Wage Agreements	0.895	0.307	0.867	0.339	0.887	0.317
Establishment Age < 5 Years	0.062	0.242	0.039	0.193	0.017	0.131
Establishment Age between 5 and 9 Years	0.063	0.243	0.061	0.240	0.061	0.239
Establishment Age between 10 and 19 Years	0.114	0.318	0.116	0.320	0.101	0.301
Single Firm	0.626	0.484	0.624	0.485	0.634	0.483
Share of Professionals and Technicians	5.101	13.555	5.580	14.312	5.463	14.312
Share of Females	31.293	28.481	29.911	27.634	28.835	26.945
Share of Foreigners	10.119	13.726	10.256	14.008	9.638	12.661
Mean Age of Employees	37.276	6.039	37.916	5.719	37.974	5.634
Profit Situation: Bad	0.193	0.395	0.118	0.322	0.144	0.352
Profit Situation: Poor	0.210	0.408	0.211	0.408	0.245	0.431
Profit Situation: Sufficient	0.334	0.472	0.353	0.478	0.364	0.481
Profit Situation: Good or Very Good	0.263	0.441	0.318	0.466	0.246	0.431
Chemical	0.091	0.288	0.091	0.288	0.087	0.282
Metal	0.080	0.271	0.080	0.271	0.087	0.282
Mechanical engineering	0.149	0.357	0.149	0.357	0.147	0.354
Transportation equipment	0.080	0.272	0.080	0.272	0.076	0.265
Paper/Wood	0.053	0.224	0.053	0.224	0.054	0.227
Textile	0.024	0.154	0.024	0.154	0.023	0.149
Food	0.048	0.213	0.048	0.213	0.043	0.204
Construction	0.096	0.295	0.096	0.295	0.104	0.306
Trade	0.168	0.374	0.168	0.374	0.170	0.376
Transport/Communication	0.044	0.205	0.044	0.205	0.051	0.220
Hotel/Restaurants	0.026	0.159	0.026	0.159	0.020	0.139
Printing	0.011	0.106	0.011	0.106	0.010	0.098
Services	0.129	0.335	0.129	0.335	0.128	0.334
Observations	1,319		1,319		921	

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