Restructuring the Workplace and Changing Skill Demands

by

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1. Introduction

Rising wage inequality in recent decades has been a source of concern for economists and policy-makers. Of particular concern is the decline in wages of low-skilled workers, both in relative and absolute terms. Much of this decline has been attributed to declining demand for skilled workers, particularly as a result of skill-biased technological change (see Berman, Bound and Griliches (1994), Acemoglu (1998) and Chennells and Van Reenen (1999)).

While there has been considerable documentation and analysis of firms' investments in new technologies over the past twenty years, especially information and communication technology, many American companies have also been adopting more flexible organizational practices in order to improve company performance over this same period. These so called "high-performance workplace practices" (HPW) include employee involvement programs aimed at giving non-managerial employees more input into the decision making process of the business, self-managed teams, job rotation, company provided training, and incentive-based compensation plans. Very little research, however, has focused on this organizational restructuring as an additional source of changing skill demands.

Most of the work on the impact of work re-organization on firm outcomes has examined the relationship between workplace organization and productivity. In particular, there have been several studies that have found a significant impact of HPW practices on the productivity of U.S. businesses. This research includes case studies (e.g. Krafcik (1998), Womack, Jones and Roos (1991), Ichinowski (1992) and Batt (1995)), intra-industry studies (e.g. Ichinowski, Shaw and Prennushi (1997), Arthur (1994), Kelley (1996), Bailey (1993) and Dunlop and Weil (1996)), and studies based on more nationally representative samples of businesses (e.g. Ichinowski

(1990), Huselid (1995), Black and Lynch (1996), Black and Lynch (2000) and Black and Lynch (2001)).

HPW practices also seem likely to benefit the workforce because workers are unlikely to contribute in the manner these practices require unless they are assured a share of the gains (Osterman (2000)). Black and Lynch (2000) find that wages of workers increase when employers extend their usage of HPW practices. It is also argued that these organizational changes require a higher level of human capital from individual workers since they need to deal effectively with increased uncertainty and responsibility (see Osterman (1994) and Lynch and Black (1998).) However, in spite of the evidence that organizational change affects productivity and wages, there have been very few studies that have examined its impact on the demand for labor by skill type. This paper seeks to address this gap in the literature by first examining the factors that are associated with the adoption of these high-performance workplaces and then focusing on their impact on skill demands within a business.

We examine this issue using a unique nationally representative sample of businesses over the period of 1993-1996, the Educational Quality of the Workforce National Employers Survey (EQW-NES) and the Bureau of the Census's Longitudinal Research Database (LRD). The EQW-NES is composed of two waves of interviews of representative samples of U.S. manufacturing and non-manufacturing establishments in 1993 and 1996, including a panel of approximately 700 establishments. The survey has a higher response rate than most previous studies, and it contains very detailed information on specific employer workplace practices including innovations in the organization of work and investments in new technology. More specifically, the EQW-NES provides information on workplace practices such as reengineering activities over time, the extent of employee participation in decision-making, the use of profit

sharing and the diffusion of computer usage among non-managerial workers. The EQW-NES also provides information on other relevant characteristics of the establishment such as book value of the capital stock, sales, materials, and whether or not the establishment is unionized. Finally, it can be matched with the Bureau of the Census' Longitudinal Research Database (LRD) so that we can obtain a longer history of economic performance of the establishments and address potential endogeneity problems.

This paper takes advantage of the panel nature of the dataset to explore what factors are associated with an employer's decision to adopt a more flexible workplace environment. We find that those establishments with more educated workers and more non-managers using computers are also more likely to adopt these practices. Employers also appear to adopt high performance practices when past profits are higher; unionized establishments are less likely to have these practices.

After examining factors related to the adoption and diffusion of high performance workplace practices, we turn our attention to the effects of these workplace practices on employee skill demand. A primary concern with this type of estimation is the endogeneity of workplace practices; firms with high-skilled workers may be more likely to adopt high-performance organizational structures. Because we are able to match our dataset to the LRD dataset, we can instrument for workplace practices and thereby deal with this issue. We find that high-performance organizational change does appear to be skill-biased, suggesting that these changes have had an impact on the wage structure.

The paper is structured as follows. We first describe the unique nature of our dataset that enables us to better address issues of adoption and skill-biased change than the previous literature. We then examine the characteristics of those businesses who adopt or use more

extensively these high-performance workplace practices. We next turn our attention to the impact of these work environments on skill demand in order to determine whether these flexible organizational structures are complements to skilled workers. The final section concludes.

2. Data

In order to understand the nature and importance of our contribution, it is useful to start with a description of the data set on which we will work. The first round of the EQW-NES was administered by the U.S. Bureau of the Census as a telephone survey in August and September 1994 to a nationally representative sample of more than 3,000 private establishments with more than 20 employees. The survey represents a unique source of information on how employers organize the workplace, invest in physical capital and utilize education and training investments. The survey over-sampled establishments in the manufacturing sector and establishments with more than 100 employees. The target respondent in the manufacturing sector was the plant manager. However, the survey was designed to allow for multiple respondents so that information could be obtained from establishments that kept information such as the book value of capital or the cost of goods and materials used in production at a separate finance office. The sample frame for the survey was the Bureau of the Census SSEL file, one the most comprehensive and up-to-date listings of establishments in the United States.

The response rate in the first round EQW-NES for manufacturing establishment establishments was 75 percent. This is substantially higher that most other voluntary establishment surveys. Of the 1,831 manufacturing establishments who participated in the survey, not all respondents completed all parts of the survey by the interview cutoff date of October 1, 1994. Therefore, the final number of manufacturing establishments in the sample for

which all parts of the survey were completed was 1,621. This represents a 66 percent "completed' survey response rate. A second survey was administered by the Census Bureau in August 1997.[1] There was over-sampling of establishments in California, Kentucky, Michigan, Maryland and Pennsylvania and a sub-sample of establishments that had been contacted in the first round. The final sample of completed interviews for the second round included 2,479 manufacturing establishments, representing a 63 percent response rate. A panel of 766 establishments (approximately 2/3rd manufacturing and 1/3rd non-manufacturing) can be constructed using two rounds of the EQW-NES. We include only manufacturing establishments in our sample since we match the EQW-NES to the Longitudinal Research Database (LRD).

The LRD, housed at the Center for Economic Studies at the Bureau of the Census, was created by longitudinally linking the establishment level data from the Bureau of the Census's Annual Survey of Manufacturers (ASM). The LRD data include information on shipments, value added, materials, inventories, employment, wages, expenditures on equipment and structures, energy use and ownership status of the establishment (for more information on the LRD see Davis and Haltiwanger (1991)). Although we could use data from the LRD from as far back as 1972, we restrict our analysis to the period 1987 through 1996. The LRD is basically a universe of all manufacturing establishments with more than 250 employees but is only a sub-sample of establishments with less than 250 employees. Therefore, by restricting our sample to establishments in the EQW-NES that were in the LRD from 1987 onwards we are likely to omit smaller establishments and establishments that were "born" after 1987.

As mentioned above, the primary purpose of matching the EQW-NES to the LRD is to obtain a longer economic history of the establishment. This allows us to use measures of past

[1] For more detailed information on response rates for the EQW-NES II see the following address:

performance, skill mixture, investment and ownership status as instruments for changes in information technology and organizational capital. We use the LRD data for information on book value of capital and total value of shipments. However, because the data were missing for some establishments, we use the EQW-NES to replace the missing values.[2]

While the LRD has information on total value of shipments, it does not have a measure of capital stock every year. Therefore we use the standard perpetual inventory method to construct an estimate if the value of the capital stock in each year starting from the book value in a base year and using the information together with an estimate of the portion of the capital stock that depreciates every year. We chose 1987 as the base year. In addition, value added, total value of shipments and capital numbers have been adjusted using deflators from the NBER Productivity Database assembled by Bartelsman and Gray (2000). (See the Data Appendix for more information on the deflators used.)

3. Adoption

Table 1 contains weighted descriptive statistics on the usage of various types of workplace practices by US manufacturing establishments with more than 20 employees in 1993 and 1996. The data show that many employers have undergone workplace restructuring over the 1990s. For example, the proportion of manufacturing establishments offering profit sharing has increased from 17 to 45 percent over the period 1993-1996. Over this same time period many more non-managerial workers in manufacturing were meeting on a regular basis to discuss workplace issues and the proportion of workers involved in job rotation increased from 18 to 25

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http://www.irhe.upenn.edu/cgi-bin/cat.pl#nes1997.

percent. Perhaps one of the more radical forms of workplace reorganization is re-engineering. This is when businesses start over from scratch and re-design the entire production process from the input of raw materials to the output of final product. Much of this redesign effort incorporates innovations from information technology and tries to break down functional silos. Over a quarter of all manufacturing establishments with more than 20 employees reported that they underwent a major re-engineering effort between 1993 and 1996. Many establishments also reported that the skills required to perform production jobs over the previous three years had increased. Only 3 percent of establishments indicated that skill requirements of production workers had decreased. The only workplace practice whose usage did not appear to change much over the 1990s is self-managed teams. The proportion of workers in self-managed teams was 12 percent in 1993 and 16 percent in 1996. Osterman (2000), using the National Survey of Establishments, finds similar results to the EQW survey. In his survey, which has a slightly different time and sampling frame, the utilization of job rotation and other high performance practices such as quality circles and TQM grew considerably over the 1990s, while self-managed teams remained at the same level. He suggests that self-managed teams may be one of the most difficult innovations to implement because it is most likely to be disrupted by turnover and restructuring.

In order to understand how organizational change affects firms and workers, it is important to understand what motivates firms to adopt these high-performance workplace practices. In earlier work, Lynch and Black (1998), using cross-sectional data, found a significant relationship between formal training programs and employer characteristics such as

[2] We find that for our 93-96 panel, the correlation between book value of capital stock reported in EQW-NES and capital stock measure that we derive from the LRD is around 0.73. The correlations between EQW-NES total value of shipments and total value of shipments reported in the LRD is approximately 0.91.

establishment size, the presence of high-performance work systems, capital-intensive production, and workers' education. Their findings suggested that employer-provided training complements rather than substitutes for investments in physical capital and education.

Osterman (1994) focused more specifically on adoption of workplace practices among core employees using cross-sectional data. He found that those establishments whose product was subject to international competition, used a high skill technology, had worker-oriented values, and were part of a multi-establishment firm were also more likely to have flexible work practices. The presence of unions appeared to have no association with adoption of workplace practices. Gittleman, Horrigan and Joyce (1998) find similar results on the characteristics of establishments that adopt various work organization practices but also find that the recent adoption of new technology was associated with greater workplace innovation.

In a study of British businesses Nickell, Nicolitsas and Patterson (1997) examined the impact of slack demand and financial pressure on the decision to reorganize a firm's operations. Building on the theoretical work of Caballero and Hammour (1994), they argued that firms may be more likely to reorganize when demand is slack because reorganization costs would be lower since the value of foregone output is lower. This is the so-called "pit stop" theory of innovation. Bad times increase pressure on managers to innovate and employees to accept innovations in order to keep a business afloat. However, when times are bad and if capital markets are imperfect, this may also make it more difficult for employers to cover the costs of innovation and in turn lower the probability of innovating. They find that lower profits are associated with increased levels of management innovation but those firms with higher debt burdens are less likely to introduce innovations.

Caroli and Van Reenen (2001) also examine the determinants of organizational change for two panels of British and French firms. They find for British firms that those businesses that faced large rises or fall in demand in the previous year were significantly more likely to have organizational changes than those with stable demand. Unionized firms were more likely to innovate in the British panel while unionized firms in France were less likely to innovate. Finally, for both British and French employers, greater wage inequality appeared to be associated with a lower probability of organizational change while being large or high tech was associated with a higher probability of innovating.

Because our dataset provides information about firms in both 1993 and 1996, we are able to exploit this time series variation and look at not only the cross-section relationship between workplace practices and establishment characteristics but also what types of establishments choose to change their organizational structure. To do so, we focus on three measures of high-performance workplace adoption. The first is a simple count of the number of workplace practices an establishment has adopted; it is based on the following indicators of workplace practices: the existence of stock options or profit sharing as a component of compensation, >20% of the workforce working in self-managed teams, >20% of the workforce involved in job rotation, >50% of the workforce meeting regularly in groups to discuss workplaces issues, >50% of production workers trained, whether the establishment has been reengineered over the period 1993-1996. The indicator therefore can range from zero for businesses that have adopted none of these practices to six for those that have adopted them all.

Our second indicator of the flexibility of workplace organization is an index of the organizational practices created using a principle components factor analysis. We include the

same measures of workplace organization but are now able to incorporate the information contained in the continuous variables without making them 0,1 indicators.[3]

Table 2 presents a description of the variables used in the adoption estimation. The reported means are unweighted values for the 1996 cross section observation used in the analysis presented in Table 3. Note that the establishments used in the analysis are disproportionately larger than the weighted establishments reflecting the oversampling of larger establishments in the EQW survey.

Column 1 of Table 3 presents results from estimating an ordered probit where the dependent variable is the number of practices adopted. Column 2 of Table 3 presents the regression results when the index of HRM practices is used as the dependent variable. The results are similar in both regressions. Consistent with earlier research, establishments that are part of a multi-establishment firm are more likely to have more high performance workplace practices, as are establishments with a strong emphasis on communication skills when hiring. High performance workplace practices are also more likely to be found in establishments with higher-educated employees. Unlike Osterman (1995), we find that unionized establishments are associated with fewer HPW practices. Importantly, establishments with higher average operating profits in the 5 years prior to the 1996 survey year are more likely to have adopted more workplace innovations. This finding is consistent with the view that employers innovate when they can afford it. In addition, we find that there is greater use of workplace innovation in those businesses that have invested in information technology as reflected by the percentage of non-

[3] As a result, we include the proportion of workers meeting regularly to discuss work-related issues, the proportion of non-managerial workers in self-managed teams, the proportion of non-managerial workers involved in job rotation and the proportion of production workers trained as continuous variables.

managerial workers using computers. We find no evidence that the degree of wage inequality in an establishment is associated with organizational change.

In Table 4 we exploit the panel nature of our dataset and look at how changes in workplace organization between 1993 and 1996 are associated with the characteristics of the establishment in 1993. The dependent variables include the change in the count of practices over this time period, the change in the index, and an indicator if the establishment has re-engineered its work environment over the period 1993-1996. Note that change in the count of practices and the change in the index are undoubtedly plagued by measurement error since we are looking at changes over a relatively short period of time; nonetheless, we think the results are informative.

The results using the panel data are consistent with the cross-section results. (Note that we are now looking at the 1993 characteristics instead of 1996 characteristics and our sample size is significantly reduced because we are restricted to the matched sample.) As before, the establishments more likely to adopt high performance workplace practices or extend their usage of these practices are those that had invested in information technology in the past (as proxied by the percentage of nonmanagerial workers using computers in 1993) and those with more educated workforces. Employers that placed a priority on excellent communication skills when hiring in 1993 were also more likely to adopt HPW practices in 1996. However, past performance in terms of operating profits no longer appears to be associated with high performance workplace practices adoption or diffusion. Finally, we now find some evidence that those establishments with greater wage inequality are less likely to have organizational

change. This result is consistent with Caroli and Van Reneen's work on British and French businesses.[4]

In summary, we find establishments with more educated workers or with a higher proportion of workers using computers are also more likely to have or extend their usage of high performance workplace practices. Businesses are more likely to have these practices when past profits are higher, while unionized establishments and those with more wage inequality are less likely to have these practices. The analysis up to now, however, has been largely descriptive in nature. However, we can now use these findings to help inform our choice of instruments when we next examine the impact of organizational restructuring on the demand for skills.

4. Organizational Change and Skill Demand

Organizational innovations and their effect on skill composition have been a subject of several theoretical studies by authors such as Kandel and Lazear (1992), Kremer and Maskin (1995) and Acemouglu (1998). One example of the growing theoretical literature is Aghion, Caroli, and Garcia-Penalosa (1999) who argue that organizational change contributes to the up-skilling of within-firm occupational structure and rising wage inequality. More generally, this body of theoretical research predicts that there are complementarities between technical change, organizational innovation and skills.

While there is little evidence on the relationship between organizational structure and skill demand, there is a significant body of work on technology-skill complementarity. In spite of the volume of this research, there is still much disagreement over the extent of the effects of

[4] We re-estimated all equations in Tables 3 and 4 including the proportion of workers in each of 5 occupational categories. None of the results reported change except that the coefficient of the average education variable drops but it remains positive and significant. Excluding wage inequality does not alter any results.

technological change on the decline in wages and employment prospects of the less skilled workers. Earlier work on the U.S. was done by Berman, Bound and Griliches (1994), who investigated changes in the demand for skilled labor in manufacturing in the 1980s and found evidence of skill-biased technological change. Other examples using U.S. data include Krueger (1993), Bartel and Lichtenberg (1987), Autor, Katz and Krueger (1998), Doms, Dunne and Troske (2000). Machin and Van Reenen (1998) find evidence of skill-biased technological change at the industry level in seven OECD countries. However, along with Dunne, Haltiwanger and Troske (1996) who use U.S. plant level data, they speculate that rapid unobserved (in standard data sets) organizational changes may be responsible for a large fraction of changes in skill structure.

Among the few studies that do examine the effects of organizational change on skill demand, most are plagued by problems such as the endogeneity of organizational change and unobserved establishment heterogeneity due to data limitations. For example, Breshnahan, Brynjolfsson, and Hitt (1999) find evidence of complementarities between technology, organizational innovations and skills; however, their data on workplace practices are cross-sectional so they are unable to address potential problems of endogeneity and unobserved heterogeneity bias. Caroli and Van Reneen (2001) use data on British and French establishments and also find support for the hypothesis of skill biased organizational change. They have panel data on firms covering three periods of time so they are able to control for unobserved heterogeneity across firms. They address the problem of endogeneity of organizational innovations by using past values of organizational capital but unfortunately the survey data they use for Britain do not include measures of capital stock and output and their measures of organizational change are somewhat limited.

Methodology. To test for skill biased organizational change we follow Brown and Christensen (1981) in deriving the share equation of a quasi-fixed cost function. We assume that the cost function has a translog form, returns to scale are constant, and firms choose variable factors to minimize costs subject to an output constraint. In addition, we assume that the only variable factors of production are skilled and unskilled labor, and there are three quasi-fixed factors (physical capital denoted by K, information technology capital denoted by IT, and organizational capital denoted by OC). Using Shepard's Lemma generates an equation for unskilled labor's share of total labor costs of the form:

$$(1)\ Suit = constant + \alpha \ln(Wuit/Wsit) + \beta\, lnKit + \gamma\, lnYit + \phi\, lnITit + \delta\, lnOCit + \varepsilon_{it}$$

Suit is the share of unskilled labor costs in total labor costs in establishment (i) at time (t), Wu/Ws is the ratio of unskilled to skilled worker wages, K is the book value of the capital stock, Y is value added. Because many empirical studies substitute total value of shipments for value added, we also present results using total value of shipments for ease of comparison. Finally, IT is the measure of information technology capital (which we proxy with the proportion of non-managerial workers using computers in their job), and OC is an index of workplace practices associated with organizational capital.

There are several econometric problems associated with estimating Equation (1). First, failure to address unobserved across-firm heterogeneity will bias our empirical results. Unobserved heterogeneity will arise if, for example, an establishment has a management team that is more likely to hire skilled workers and introduce organizational innovations. To remove time invariant fixed effects, we first difference the cost share equation. A second concern is the

possible endogeneity of information technology and organizational capital. To mitigate this problem we instrument for both information technology and organizational capital measures. A final concern is the inclusion of the relative wage as an independent variable; given the definitional relationship between our dependent variable (wage bill share of unskilled workers) and the wage measures, estimates will suffer from division bias. In an effort to address this, we also estimate equation 1 using the employment share of unskilled workers as our dependent variable.

As we did earlier in the paper, we use an index of workplace practices as our measure of organizational structure. One reason to do so is to attempt to capture the synergistic effects of bundling organizational practices together as suggested by the theoretical work by Kandel and Lazear (1992) and Milgrom and Roberts (1995), and empirical studies by Black and Lynch (2000), Huselid (1995) and Ichniowski et. al. (1995). A second reason for constructing the index is entirely pragmatic. Since we are relying on instrumental variables estimation, we do not have a sufficient number of valid instruments to examine each of the individual practices. As before, this index was constructed using both continuous and discrete measures. The dummy variables include indicators whether or not the establishment offers profit sharing or stock options, and whether or not the establishment undertook any reengineering efforts over the period 1993-1996. The continuous variables are proportion of workers meeting regularly to discuss work related issues, proportion of non-managerial workers in self-managed teams, proportion of non-managerial workers involved in job rotation and proportion of production workers trained. Since our primary focus is the change in workplace organization, we have first differenced our measures of organizational capital (with the exception of reengineering, which is already a change) and estimated the principal components using changes rather than levels.

Results. We first begin by presenting the OLS regressions when we estimate equation (1) using the production worker share of the wage bill as our dependent variable. Table 5 column 1 presents these results. While computer use and workplace practices do appear to have a negative effect on the share of wages paid to production workers, neither effect is statistically significant. We see this same pattern when we substitute the total value of shipments for value added (see Column 2 of Table 5). However, as mentioned above, a primary concern with these results is the endogeneity of workplace practices and computer use; it may be the case that firms with increasing skill demand are also increasing their use of high-performance workplace practices and the intensity of their computer use. As a result, we use instrumental variables techniques to correct for this.

We use six predetermined variables to instrument for the index of organizational practices and the technology variable. The variables include: total employment growth between 1987 and 1992, non-production/production employment growth between 1987 and 1992, average operating profits over the 1987-1992 period, growth in value added per worker over the 1987-1992 period, growth in new machinery per worker, and the change in status indicator. The last variable is observed over the 1991-1992 period, and equals unity if the establishment changed status from single to multiple establishment (or vice versa), or the establishment became a part of a different multiple establishment structure.

The only variable that is a significant predictor for both organizational practices index and computer diffusion is total employment growth. The growth in the ratio of non-production to production workers and average operating profits are significant in the first-stage equations for the index of organizational practices while the growth of new machinery per worker, value added

per worker, and the change in status indicator are all significant predictors for the technology variable.

When we instrument for the index of organizational practices and computer diffusion we now see strong evidence of skill biased organizational change. As shown in columns 3 and 4 of Table 5, the index of organizational practices comes in negative and statistically significant, regardless of the output measure used.[5] However, the evidence of skill biased technological change is somewhat weaker, with the coefficient smaller in magnitude and statistically significant at only the 10 percent level.

Throughout, we would expect the coefficient associated with relative wages to be negative. However, as discussed above, the potential endogeneity of wages and division bias could be driving the positive and significant coefficient we observe across all specifications. In an attempt to mitigate the problem, we estimate employment shares of production workers; these results are presented in Table 6. The coefficient associated with relative wages becomes negative and significant in all specifications and we observe no qualitative changes with respect to the effects of organizational and technological innovations. This suggests that we are observing employment responses to organizational and technological change and our results do not just reflect changes in factor prices.

Finally, we examine more qualitative information from the survey on whether the skill demand of production workers in the establishment has increased over the past three years. To do so, we substitute this variable for the production worker share of the wage bill. In this case, a positive coefficient on computer use or organizational change would be interpreted as evidence

[5] The Hausman tests of the efficiency of the IV estimator are as follows: Table 5 col. 3 chi squared = 16.13 p-value = 0.0003; Table 5 col. 4 chi squared = 16.14 p-value = 0.0003; Table 6 col. 3 chi squared = 17.19 p-value = 0.0002; and for Table 6 col. 4 chi squared = 17.29 p-value = 0.0002.

of skill-biased change. Table 7 presents the results of a linear probability model with an indicator of increased skill demand as the dependent variable. Consistent with our earlier findings, we find little evidence of skill-biased organizational change with simple OLS estimates and some evidence of skill-biased technological change (Columns 1 and 2). However, when we instrument for changes in workplace organization and changes in computer use (Columns 3 and 4), we find strong evidence of skill-biased organizational change. The evidence of skill-biased technological change becomes much weaker, however. Nevertheless, these results look consistent with the wage share and employment share results presented in Tables 5 and 6.

5. Conclusions

In this paper, we have examined characteristics of establishments that have adopted high performance workplace practices and the impact of this restructuring on the demand for less skilled workers. We find strong evidence of a decrease in the demand for less skilled workers due to organizational innovations along with evidence of skill biased technological change. The results also indicate that decreases in the wage bill shares of production workers seem to be driven by changes in relative employment shares rather than changes in relative factor prices. While much of the debate on the worsening position of unskilled workers has concentrated on the role of changing technological factors, we provide evidence in this paper that changing organizational structure may also be playing a significant role in the 1990s.

Data Appendix

The NBER Productivity deflators were constructed from 5-digit product deflators from BEA. These are largely created from the BLS industry-based producer prices which are extrapolated backwards using the old BLS product prices. The capital deflator was created by first generating a 3-digit industry real net capital stock value. The 3-digit data are converted to the 4-digit level by assuming that the industry asset type flows are the same for all 4-digit industries within a 3-digit industry. With this information, 4-digit deflators were created for equipment and structures separately.

Since the deflator data were unavailable for 1996, we regressed current price levels (using 2- or 3-digit level SIC data, depending upon availability) on price levels in the past two years and the current year's price index for stage of processing groupings from the BLS. We then generated imputed values for 1996 deflators using predicted value from this regression.

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Table 1: Usage of High Performance Workplace Practices – Weighted Averages for Manufacturing Establishments (Data Source: EQW Public Use file)

Variable Name	Description	Mean (1993)	Mean(1996)
profit sharing	Does your establishment contribute toward stock options or profit sharing, as a part of employee benefits? Yes=1	17%	45%
proportion self-managed teams	What percent of non-managerial and non-supervisory workers are currently involved in self-managed teams?	12%	16%
proportion involved in job rotation	What percent of non-managerial and non-supervisory workers are currently involved in job rotation?	18%	25%
proportion of workers meeting regularly	What percent of non-managerial and non-supervisory workers are involved in regularly scheduled meetings to discuss work-related issues?	41%	50%
reengineer	Has your establishment undergone re-engineering within the past three years? Yes=1	--	26%
proportion of workers trained	In the past year, what percent of employees received formal training?	41%	52%
change in Skill Requirements	In the last 3 years have the skills required to perform production or support jobs at an acceptable level increased, decreased, or remained the same in your establishment?	Up Same Down 51% 46% 3%	Up Same Down 46% 51% 3%

Table 2: Data Description (Unweighted)

Variable Name	Means (1996)	Description
profit sharing	60.2	Does your establishment contribute toward stock options or profit sharing, as a part of employee benefits?
proportion self-managed teams	20.3	What percent of non-managerial and non-supervisory workers are currently involved in self-managed teams?
proportion involved in job rotation	23.6	What percent of non-managerial and non-supervisory workers are currently involved in job rotation?
proportion of workers meeting regularly	61.0	What percent of non-managerial and non-supervisory workers are involved in regularly scheduled meetings to discuss work-related issues?
reengineer	50.9	Has your establishment undergone re-engineering within the past three years?
proportion production workers trained	66.4	In the past year, what percent of production employees received formal training?
average education of workers	12.55	What is the average number of years of completed schooling?
Unionized	48.6	Are any of your employees represented by a union or unions?
Count	2.983	Number of workplace practices
Employment growth	2.8%	Percent Change in employment (1990-1995)
Wage inequality	.48	Log(nonproduction workers pay / production workers pay)
Average operating profits	0.346	Average operating profits as a fraction of total sales 1990-1995

Table 3: Adoption of Workplace Practices (1996 Cross Section results)

Dependent Variable	Number of workplace practices	Organizational practices index
Independent Variables (1996 values)	1996	1996
Wage inequality	-.06 (.08)	-.12 (.10)
Communication Skills	.38*** (.09)	.45*** (.11)
Multi-establishment	.62** (.18)	.68** (.22)
Average Education	.12** (.06)	.12* (.065)
Unionized	-.20** (.09)	-.31** (.11)
Employment growth (1990-1995)	-.04 (.30)	.12 (.36)
Average Operating Profits (1990-1995)	.69** (.28)	.78** (.33)
% Minority	.001 (.002)	.0003 (.002)
% Women	.007** (.003)	.007** (.003)
Total Employment	.01 (.01)	-.003 (.06)
% non-managers using computers	.005** (.002)	.006** (.002)
Number of observations	601	601

Note: Standard errors in (). *** denotes significant at the 1% level ** denotes significant at the 5% level and * denotes significant at the 10% level. 2-digit industry controls are also included.

Table 4: Change in the Adoption of Workplace Practices (1993-1996)

Dependent Variable	Change in Number	Change in organizational practices index	Reengineer
Independent variables (1993 values)	1993-1996	1993-1996	
Wage inequality	-.16 (.17)	-0.32* (0.18)	-.23 (.22)
Communication Skills	.30* (.16)	.14 (.17)	.23 (.20)
Multi-establishment	-.26 (.18)	-.07 (.19)	.18 (.23)
Average Education	.18* (.10)	.20** (.10)	.34** (.14)
Unionized	-.01 (.16)	-.23 (.17)	-.10 (.21)
Employment growth (1987-1992)	.77 (.52)	.68 (.55)	.12 (.65)
Average Operating Profits (1987-1992)	0.21 (.40)	.10 (.42)	.36 (.52)
% Minority	-.003 (.003)	-.001 (.003)	-.005 (.004)
% Women	.003 (.004)	-.0003 (.004)	.003 (.005)
Total Employment	.03 (.05)	.03 (.06)	.31** (.13)
% non-managers using computers	.005** (.002)	.004* (.0025)	.003 (.003)
Number of observations	229	229	229

Note: Standard errors in (). *** denotes significant at the 1% level ** denotes significant at the 5% level and * denotes significant at the 10% level. Two digit industry controls are also included.

Table 5: Dependent Variable: Production Workers Share of Wage Bill (1993-1996)

Independent Variables	OLS	OLS	IV	IV
Organizational practices index	-0.0027 (0.0063)	-0.0036 (0.0063)	-0.117** (0.055)	-0.115** (0.053)
% non-managers using computers	-0.00026 (0.0002)	-0.00028 (0.00022)	-0.0029* (0.0016)	-0.0028* (0.0016)
ln capital	0.024 (0.02)	0.029 (0.0198)	0.074* (0.043)	0.072* (0.04)
ln value added	0.025** (0.011)	_	0.015 (0.021)	_
ln sales	-	0.0279** (0.014)	-	0.035 (0.025)
ln relative wages	0.085** (0.015)	0.084** (0.015)	0.072** (0.028)	0.074** (0.027)
average education of production workers	0.0019 (0.0088)	0.0013 (0.0088)	-0.0002 (0.0164)	-0.0012 (0.016)
N	190	190	190	190

Note: Standard errors in (). ** denotes significant at the 5% level and * denotes significant at the 10% level. Also included: union indicator.

Table 6: Production Workers Share of Total Employment

Independent Variables	OLS	OLS	IV	IV
Organizational practices index	-0.0014 (0.006)	-0.0022 (0.046)	-0.112** (0.054)	-0.109** (0.052)
% non-managers using computers	-0.00026 (0.00021)	-0.00028 (0.00021)	-0.00296* (0.00159)	-0.0029* (0.0015)
ln capital	0.033* (0.019)	0.038** (0.019)	0.082** (0.042)	0.081** (0.039)
ln value added	0.024** (0.011)	_	0.014 (0.02)	_
ln sales	_	0.027** (0.013)	_	0.035 (0.025)
ln relative wages	-0.072** (0.014)	-0.073** (0.014)	-0.085** (0.027)	-0.083** (0.026)
average education of production workers	0.0026 (0.008)	0.002 (0.008)	0.001 (0.016)	0.00008 (0.0158)
N	190	190	190	190

Note: Standard errors in (). ** denotes significant at the 5% level and * denotes significant at the 10% level. Also included: union indicator.

Table 7: Dependent Variable =1 if skill demand increased, 0 otherwise

Independent Variables	OLS	OLS	IV	IV
Organizational practices index	0.054 (0.054)	0.053 (0.054)	1.16** (0.487)	1.16** (0.39)
% non-managers using computers	0.0036** (0.0018)	0.0035* (0.0018)	0.021 (0.014)	0.02 (0.014)
ln capital	0.11 (0.17)	0.092 (0.168)	-0.333 (0.379)	-0.296 (0.36)
ln value added	0.021 (0.094)	_	0.13 (0.18)	_
ln sales	_	0.129 (0.119)	_	0.091 (0.229)
ln relative wages	-0.266** (0.125)	-0.256** (0.125)	-0.12 (0.24)	-0.131 (0.241)
average education of production workers	-0.075 (0.075)	-0.08 (0.075)	-0.035 (0.115)	-0.034 (0.145)
N	190	190	190	190

Note: Standard errors in (). ** denotes significant at the 5% level and * denotes significant at the 10% level. Also included: union indicator.