THE WAGE EFFECTS OF HIGH PERFORMANCE WORK ORGANIZATION IN MANUFACTURING

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An unresolved question about now-widespread innovative work systems such as teams and quality programs is whether they influence wage determination. This study examines that possible association in manufacturing. The author uses data from the 1997 National Establishment Survey that allow examination of how new work systems affected not only employees who were directly involved in them but other workers as well. The key finding is that for core blue-collar manufacturing employees, higher wages were associated with High Performance Work Organization (HPWO) systems. While higher skill levels and computer-based technologies were associated with higher wages, the key mechanism appears to have been productivity gains, *independent of skill and technology*, that were shared via various across-the-board wage payment systems. HPWO systems appear to have increased managers' wages as well, although through different channels. The author finds no evidence that HPWO-related wage gains led to greater wage inequality among the directly involved employees.

The determination of wages is a central concern in labor economics, and a long-standing tradition emphasizes the wage policy of the firm. A focus on the firm was perhaps the central preoccupation of the generation of labor economists who emerged after World War II. Their work developed such firm-specific concepts as wage contours and the key wage, pattern bargaining and orbits of coercive comparison, and the wage-setting mechanisms found in internal labor markets. However, the advent of human capital theory led scholars to pay much less attention to wage setting in the firm and instead to emphasize market-wide considerations.

Nonetheless, in recent years the firm has made something of a comeback. This has been driven by research showing that, even in analyses that control for a substantial set of standard variables, firm-specific wage effects remain important. For example, Dickens and Katz (1987) showed that if a firm pays an efficiency wage premium for one occupation, it will pay the same premium for all others, a finding that makes sense only in the context of a firm-specific wage policy. Goshen (1991) found that a firm (establishment) effect accounts for

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between 31% and 51% of the variation across firms in wages. Davis and Haltiwanger (1991) found strong plant-level effects in their wage-determination models.

In this paper I use establishment-level data to examine the relationship between work organization and wages in manufacturing. This investigation is motivated by the substantial spread of new work systems (teams, quality programs, and the like) and the important question of whether these innovative work systems have influenced wage determination. The paper uses a nationally representative data set that can illuminate the impact of new work systems not only on employees directly involved but also on other workers in the firm. The data permit controls for skill, technology, and a range of other relevant factors. The study also examines the distributional effects within occupational groups of new work systems and, in addition, relates the wage effect to the institutional details of the establishment's wage system.

Work Organization and Wages

High Performance Work Organization (HPWO) is a summary term that stands for the introduction of a range of practices, including self-managed teams, quality programs, and job rotation.[1] The diffusion of HPWO has been substantial and has captured the attention of a wide range of researchers. Among the topics investigated have been the determinants of adoption (Osterman 1994; Gittleman, Horrigan, and Joyce 1998); the impact of work systems on productivity and performance (MacDuffie 1995; Huselid 1995; Ichniowski, Kochan, Levine, Olson, and Strauss 1996; Black and Lynch 2001; Hamilton, Nickerson, and Owen 2003; Bartel 2004); employees' attitudes toward these systems (Freeman and Rogers 1999; Hunter, MacDuffie, and Dorcet 2002); and the interaction of HPWO with technology, skill, and training (Osterman 1995; Lynch and Black 1998; Bresnahan, Brynjolfsson, and Hitt 2002).

The consequences of HPWO systems for wages have been addressed by a number of prior studies, but it seems fair to say that this literature is thinner than that on other questions, for the understandable reason that wage data are hard to acquire. (For a useful review of this literature, see Handel and Levine 2004.)

In their study of three industries, Appelbaum, Bailey, Berg, and Kalleberg (2000) found that teams and their overall HPWO index (but not quality circles) were associated with higher wages in two industries (steel and apparel) but not in a third (medical instruments). Batt (2001) found that after she held constant her full set of controls, two HPWO practices (quality circles and teams) were not associated with higher wages, whereas a measure of discretion in work positively affected wages, as did her measures of product market strategy. By contrast, Hunter and Lafkas (2003), in a study of customer service representatives in banking, found that quality circles were associated with higher wages but that their measure of discretion was not. Cappelli and Neumark (2001), working with a nationally representative dataset from manufacturing firms, found a generally positive relationship between HPWO systems and establishment labor costs per worker. Black, Lynch, and Krivelyova (2004), working with the same data, found an effect of HPWO systems on wages only when they interacted the work organization variable with union status. Handel and Gittleman (2004), using data collected in 1995, found no wage impact of HPWO systems. Osterman (2000) found that wages did not increase in a nationally representative sample of establishments that introduced HPWO systems.

This lack of consistency reflects, in part, variation in the nature of the data and measures that different researchers have used. For example, in measuring HPWO systems, some researchers (such as Handel

[1]For a discussion of the various meanings of this term and a history of HPWO systems' introduction into U.S. firms, see Appelbaum and Batt (1994). Later in this paper I discuss how I empirically capture the practices.

and Gittleman) have used indicators of the presence or absence of the practice, while others (Black, Lynch, and Krivelyova, for example, and Osterman) have used a measure of penetration. There has been similar variation in the outcome measures. Some (Appelbaum et al.; Batt; Hunter and Lafkas; Osterman) have focused on the effect of HPWO systems on workers directly involved with the HPWO systems, while others (for example, Cappelli and Neumark; Handel and Gittleman; Black, Lynch, and Krivelyova) have examined the wages of all workers in the establishment.

Questions and Expectations

It is theoretically useful and empirically important to distinguish among three types of impact: effects on the level of wages for employees directly involved in the new systems, on the level of wages for other employees, and on the earnings distribution. This paper examines all three questions and also asks about the channels through which work systems affect wages.

Turning first to the effect of HPWO on the wages of employees who are directly involved, the most obvious channel is altered demand: HPWO systems raise the demand for skill and hence lead to higher wages as employers seek to recruit or train more able employees. There is widespread agreement that HPWO requires increased skill. For example, in a study of establishments in Britain and France, Caroli, and Van Reenen (2001) found that the introduction of organizational practices that were similar in many respects to HPWO systems led to a fall in demand for unskilled labor. Indirect evidence along these lines is that firms that adopt HPWO systems are also more likely to increase their investments in training (Osterman 1995; Lynch and Black 1998). This increase in skill can take several forms. Higher-level skills may be required as, for example, employees take on tasks such as statistical analysis of quality issues. In addition, soft skills such as problem-solving or interaction skills may become increasingly important in HPWO settings.

One important source of any increase in skill due to HPWO is the link between HPWO and technology. Indeed, technology is of such importance that it deserves to be treated as a distinct factor rather than simply subsumed in the general discussion of skill. There is good evidence that firms that adopt new work systems also appear to be more likely to invest in technology, and this in turn is associated with higher levels of education (Bresnahan, Brynjolfsson, and Hitt 2002; Autor, Levy, Murnane 2002). A study that directly examined the relationship in manufacturing between new technology and wages (but that had no data on HPWO systems) reached a skeptical conclusion for special-purpose technology such as CAD/CAM and automated feeder lines but did find a positive relationship for general-purpose technologies such as personal computers (Doms, Dunne, and Troske 1992).

A third channel through which HPWO systems might affect wages is via their implications for the performance of the firm. A substantial body of research shows that firms that adopt HPWO systems achieve higher levels of productivity (see the earlier citations on this point). It is reasonable to hypothesize that as more productive work systems are introduced, wages will rise, either because the higher levels of productivity shift out the firm's demand curve or because they generate a larger surplus, which can be distributed to employees via "ability to pay" or rent-sharing considerations.

Finally, it is important to recognize that all of these channels between HPWO and wages are mediated by two "softer" considerations: managerial strategy and the distribution of power within the firm. This paper cannot test managerial strategy, but it does take up the issue of power.[2] Con-

[2]Different firms may choose different managerial strategies with respect to the utilization of labor, and these choices have consequences for wages. For example, Batt (2001) showed how telecommunications firms' strategic decisions with regard to market segmentation lead to different wage effects of the

sider, for example, the gains that accrue due to the increased productivity of HPWO systems. These gains increase the firm's "ability to pay," but just how wages are affected will depend on relative power. One obvious source of power is unionization, and thus it is reasonable to expect that in firms that are unionized, employees will enjoy a great share of any surplus that is generated. However, it is also plausible that HPWO systems themselves increase employee power. This is because these systems require more extensive employee contributions, in the forms of ideas, attention to quality, willingness to learn a broader range of skills, and so on. As the firm becomes more deeply committed to the HPWO systems, employees gain the capacity to, in a sense, hold the firm hostage. The traditional organizational sociology literature has long highlighted this implicit power of employees (Gouldner 1954; Burawoy 1979), and the point here is that HPWO systems may by their nature enhance this power. The consequence is that HPWO systems might be associated with higher wages not due to skills, productivity, or technology, but rather because employees simply are more powerful within the organization by virtue of these new work systems.

Turning to other employees, it is important to recognize—as the literature only occasionally does—that HPWO systems could increase the wages of workers directly involved (through one or more of the channels discussed below) but have different consequences, or no consequences, for others. For example, the standard view of teams is that they may substitute for the work of lower-level managers. This could happen to the extent that teams engage in scheduling and logistics and to the extent that they take over disciplinary functions. Accounts of teams suggest that these consequences are not uncommon (see, for example, Batt 2004). How this substitution will affect observed managerial wages is, however, unclear. On the one hand, this process can drive down managers' wages in the labor market as the demand for their services declines. However, if the firm reduces its managerial cadre by eliminating the jobs most affected by the advent of HPWO systems, then the managers who remain will be higher in the hierarchy and the average observed managerial wage will increase. An alternative view is that if HPWO systems improve the performance of the establishment or are operated in such a way that managers are complements in production, then managerial wages might rise.

HPWO systems can also have an impact on the distribution of wages within the establishment. Such an outcome is obviously likely if wage levels are differentially affected across occupational groups, as the above discussion of worker and managerial wages suggests might happen. However, even within one group of employees, the HPWO systems might have a distributional effect. For example, Lindbeck and Snower (2000) argued that because HPWO systems involve new skills (for example, the ability to work in teams) that as yet are not widely available, the wage distribution among employees who work in these systems will become more unequal as firms seek to identify and reward those (relatively few) employees who fit in well with the new systems.

Another way to understand these dynamics is to consider how HPWO systems might interact with internal labor markets. In an internal labor market, social pressures and wage-setting practices act to limit the impact of market forces and to compress the internal wage distribution (Doeringer and Piore 1972). However, as HPWO systems increase the productivity premium of skills

same technology and work system. Autor, Levy, and Murnane (2002), in their study of banking, demonstrated how computerization led to different wages and work organization in different parts of the same bank, depending on the bank's assessment of the need for quality and customer interaction.

A different version of the managerial strategy argument comes from efficiency wage theory. HPWO systems require employees to contribute ideas and effort to a greater extent than traditional systems, and the question facing the firm is how to induce this contribution. Paying higher wages that are associated with HPWO is in effect an efficiency wage strategy that may make sense.

(particularly newly valued abilities such as the capacity to solve problems or to work in teams), firms may find that the payoff to attracting, motivating, and retaining skilled labor has increased, and hence they may be willing to permit greater pay dispersion. The spread of various forms of pay-for-performance compensation systems may both reflect and exacerbate this development.

There is, however, an argument that cuts the other way. To the extent that HPWO systems involve increased use of teams, the need to maintain group cohesion within the team may lead firms to compress wages. The spread of job rotation, which should serve to equalize the skill distribution, is also a force acting in this direction.

The issues I explore in this study can be summarized in three questions. (1) What is the relationship between HPWO systems and the level of wages of employees directly involved in the operation of those systems? (2) What is the relationship between HPWO systems and the level of wages of other employees, particularly managers, in the establishment? (3) What is the relationship between HPWO systems and the distribution of wages of employees involved in the new work systems? In addressing these questions, I try to pay attention to the various channels of impact discussed above and to distinguish among them.

Data

The data in this paper are from the 1997 National Establishment Survey. The 1997 survey and its 1992 precursor were both telephone surveys of a representative sample of American establishments that were in the private for-profit sector and that had at least fifty employees (see Osterman 1994 and Osterman 2000). Other than these restrictions, the surveys (appropriately weighted) were representative of the entire economy.[3]

The surveys were directed to establishments, that is, specific business addresses, rather than to headquarter locations. Hence the questions pertained to practices at the given establishment, not to practices elsewhere in the country. This survey design, which very likely elicits more accurate responses than surveys asking headquarters-based respondents about practices at far-flung installations, tends to be the one used in most research of this kind. The study employs the Dunn and Bradstreet listing of establishments, which is considered one of the best sampling frames—if not the best one—available for a survey of this kind (Kalleberg et al. 1990). The response rates were 65.0% for the 1992 survey and 57.7% for the 1997 survey. These response rates are high for surveys of this kind, and no important biases exist in the pattern of non-response.[4] The 1997 survey was a follow-up to the earlier survey (of the 806 establishments interviewed in 1992, the 1997 survey re-interviewed 462), supplemented by an additional sample of 221 new establishments. There is no evidence of selection bias in the composition of the establishments in the original sample that were successfully reinterviewed in 1997.[5]

One complication that permeates the literature is the absence of any unambiguous way to define a high performance work

[3]In 2001, 72% of private sector employees worked in firms with fifty or more employees (Small Business Administration, http://www.sba.gov/advo/research/). Firms can have multiple establishments, and in 1988, 51% of employees worked in establishments of fifty or more (Osterman 1994).

The 1992 survey did not include wage data on core or managerial employees, nor did it collect data on the wage distribution within each group. Because I therefore cannot construct a panel analysis of wages, this paper is cross-sectional, using only the 1997 survey.

[4]Osterman (1994) described the examination of bias in the 1992 survey. For 1997, using the Dun and Bradstreet data, which are available for all establishments in the sample regardless of whether they responded, I estimated a logit model with the dependent variable being whether or not the establishment responded and the independent variables being employment size of the establishment, whether or not the establishment was a part of a larger organization, and whether or not the establishment was in manufacturing. None of these variables were statistically significant, indicating that no important biases exist in the response patterns.

[5]Using the 1992 data, I estimated a logit model in which the dependent variable was whether or not the

organization and to know whether or not the establishment is following this path. There is variation in the literature, and the establishment survey used here offers several options. However, despite variation around the edges, virtually all authors work with a common set of variables that measure aspects of work organization, and a smaller number of authors also add variables measuring innovative pay systems. Whitfield (2000), using British data, employed variables for flexible assignments, teams, quality circles, and information sharing; Handel and Gittleman (2004) used rotation, job redesign, teams, TQM, employee involvement, just-in-time production, profit-sharing, and pay for skill; Black, Lynch, and Krivelyova (2004) used rotation, teams, and profit sharing; Cappelli and Neumark (2004) used teams, information sharing, and quality circles; Pil and MacDuffie (1996) used teams, rotation, problem-solving groups, and quality circles; Hunter and Lafkas (2002) used discretion and quality circles; and Cappelli and Neumark (2001) used rotation, teams, TQM, cross-training, profit-sharing, and pay-for-skill.

The approach I follow is to ask about "core" employee involvement in self-managed work teams, job rotation, quality circles or off-line problem-solving groups, and Total Quality Management. As the foregoing paragraph suggests, and as other reviewers of the literature have noted (Cappelli and Neumark 2001), these are the practices that are widely accepted as central to the idea of HPWO.

In this paper I also examine pay systems, but I do so in a later section and in the context of understanding variation across establishments in the wage impact of HPWO systems. In my view, distinguishing between work organization variables on the one hand and pay practices on the other avoids some problems that arise when the analysis combines the two categories into one.

establishment was reinterviewed in 1997, and the independent variables were size, whether the establishment was part of a larger organization, and whether or not it was in manufacturing. None of these variables were statistically significant.

"Core" workers are defined as the nonmanagerial employees most directly involved in the production of the goods or services sold by the enterprise. They can be either blue- or white-collar workers, but in this study they are all blue-collar.[6] This approach has been generally accepted by other scholars.

The respondent was the most senior manager who was in a position to provide data regarding human resource and employment practices in the establishment.[7] The respondents, once identified, were sent a fax alerting them to some of the more data-intensive questions they would be asked.

In using a survey of this kind, a reasonable question concerns the quality of the data. Osterman (2000) discussed the measurement of HPWO practices and how the pattern of data in this survey compares to patterns in other surveys. The key conclusion is that the NES survey results appear consistent with results of other surveys in the field.

In addition to the HPWO variables, the other crucial set of data concerns wages. The wage data in the 1997 NES survey were collected by asking the respondent to answer the following questions, first with respect to core workers, then with respect to managers, and finally with respect to all other employees (recall that these questions were faxed to the respondents in advance of the telephone interview):

We are asking about the paycheck before deductions, so please include these sources of compensation: wages and salaries, bonuses, and profit sharing. Please omit employer contributions to benefits such as pensions and health, the value of deferred compensation such as stock options, and overtime pay.

[6]In the survey for manufacturing establishments, 81% of core workers were classified as blue-collar, 10% as technical, and 8% as professional. When the regressions in Tables 3 and 4 were reestimated using all core workers, the results did not change.

[7]In 1997, 18% of the respondents were line managers and the rest were senior human resource managers. I created a dummy variable indicating whether or not the respondent was a line manager and entered it into the full wage equations reported below. Its coefficient was not statistically significant.

Table 1. Earnings of Blue-Collar Manufacturing Employees: Comparison of the March 1998 CPS with the 1997 National Establishment Survey.

	CPS, Employers of Size 25 or More; NES, Establishments of 50 or More (mean)	*CPS, Employers of 100 or More; NES, Establishments of 100 or More (mean)*
CPS	$23,000 ($25,707)	$25,000 ($27,801)
NES	$22,987	$23,307

Notes: The first CPS figures are for median (50th percentile) earnings. Figures in parentheses are means. CPS data are limited to private-sector employees between ages 17 and 64.

What is the typical compensation per year from these sources?

By typical we mean about half the group will be paid more and half will be paid less.

Now, using the same basis as before, what would you say is the typical compensation per year for the twenty-percent best-paid in the group?

Using the same basis as before, what would you say is the typical compensation per year for the twenty-percent lowest-paid in the group?

In order to gauge the accuracy of the responses, we need a source of data with which to make comparisons. An ideal comparison dataset would control for occupation and establishment size in a nationally representative survey, but unfortunately such a dataset is not available. The best choice appears to be the March Current Population Survey, which has a variable for employer size. Employer size is not the same as establishment size and, to make matters slightly worse, the coding in the CPS does not include a break at 50 employees. Nonetheless, by comparing the wage distributions in the two surveys, we can see how closely they match, and if the match is reasonably close, this should substantially increase our confidence in the National Establishment Survey.

Table 1 provides the relevant comparisons. The March 1998 CPS is used because the earnings data refer to the prior year (1997). The NES results use establishment weights, but when employee weights are used, the results are substantively identical. The NES earnings figures refer to core blue-collar workers, while the CPS refers to all blue-collar workers. In the table, the first column uses the entire NES dataset and limits the CPS data to firms with 25 or more employees. This is the best match possible if the entire NES file is used. The second column creates a better match by limiting the NES and the CPS to firms or establishments of 100 or more.

As is apparent, given the various differences in definitions and sampling frame, earnings in the NES are remarkably similar to those in the CPS. This should substantially strengthen our confidence in the quality of these data.

The variables (and their means) used in this paper are defined in Table 2. As already noted, core employees were defined as the group of non-managerial employees most directly involved in the production of the good or service. Questions about work organization referred only to core employees. As Table 2 makes clear, some additional questions in the survey were also limited to core employees, some questions were directed to other occupational groups such as managers, and some questions referred to the entire establishment.

High Performance Work Organization and Wages for Core Employees

In this section I initiate the analysis by examining for blue-collar core employees in manufacturing the relationship between wage levels and the penetration of HPWO systems.

I begin with a simple regression examining the impact of HPWO on wages with only two controls, the union status of the establishment and its size. These two controls are standard in the literature.[8] In addition, it is

[8]Note that union status refers to whether or not some core workers are covered by collective bargain-

Table 2. Variable Definitions and Means.

Variable	*Definition*	*Mean*
Dependent Variables		
Log Core Wages		10.11
Log Managerial Wages		10.94
90/10 Ratio Core		1.71
90/10 Ratio Managers		1.83
Independent Variables		
HPWO Sum	Sum of the fraction of core employees who are engaged in each of the four HPWO practices	1.10
HPWO Component	First principal component of percentage of core workers engaged in the four HPWO practices	.322
PERTEAM	Percentage of core workers involved in self-managed work teams	.18
PERQC	Percentage of core workers involved in quality circles or problem-solving groups	.29
PERTQM	Percentage of core workers involved in TQM programs	.26
PERROTATION	Percentage of core workers involved in job rotation	.37
SIZE	Number of regular (not contingent) employees in the establishment	253.59
UNION	1 if employees at the establishment are covered by collective bargaining, 0 otherwise	.29
PART-TIME (core and managers)	Percentage of (core, manager) workers who work less than 35 hours per week	Core: .02 Manager: .007
FEMALE (core and managers)	Percent of (core, manager) workers who are female	Core: .31 Manager: .14
HIGH SCHOOL (core and managers)	1 if the typical education level of (core, managerial) employees is high school degree, 0 otherwise	Core: .92 Manager: .05
COLLEGE (core and managers)	1 if the typical education level of (core, managerial) employees is college degree, 0 otherwise	Core: .03 Manager: .65
CONTINGENT, core	Percentage of the core labor force that is either agency or in-house contingent	.03
PC (core and managers)	Fraction of (core, managers) who use a general-purpose computer or workstation or dumb terminal times the percentage of the day those (core, managers) who do use a general-purpose computer/workstation/dumb terminal spend working with it	Core: .04 Manager: .29
COMPUTER (core and managers)	Percentage of (blue-collar, white-collar) workers who use a computer other than a general-purpose computer, e.g., robotics or CAD	Core: .21 Manager: .27
ACROSS-BOARD	Percentage of annual pay increase (core, managers) due to across-the-board factors (as opposed to individual performance or merit)	Core: .62 Manager: .33

worth keeping in mind that the model implicitly controls for occupation and industry, since the sample is limited to blue-collar core employees in manufacturing.

In these regressions I show the results from two specifications: the first component derived from a principal components analysis[9]

ing. In these data 29% of establishments responded positively. This does not mean that 29% of workers were covered. Note also that the size variable, number of employees, is the variable classically used in studies of wages. (See Hollister [2004] for a review.)

[9]Principal components analysis is like factor analysis but the results are not rotated. The first principal

Table 3. Basic Regressions on ln(Core Wages). (Standard Errors in Parentheses)

	Specification[a]	
Independent Variable	*(1)*	*(2)*
SIZE	.00002 (.00003)	.00002 (.00003)
UNION	.2041** (.0395)	.2041** (.0395)
HPWO Sum	.0451** (.0190)	—
HPWO Component	—	.0270** (.0114)
CONSTANT	9.9955** (.0313)	10.0366** (.0229)
R^2	.123	.123
F	10.53** (3,225)	10.53** (3,225)

[a]Specification (1) is a simple summation of the fraction of penetration of each practice; specification (2) is the first component derived from a principal components analysis of the degree of penetration of the four practices.

*Statistically significant at the .10 level; **at the .05 level.

of the degree of penetration of the four practices, and a simple summation of the fraction of penetration of each practice (this variable obviously can range from zero to four).

The results of these first regressions are shown in Table 3.[10] Both HPWO variables are positive and statistically significant.[11] Not surprisingly, the union variable is also positive and significant, whereas size seems not to have an effect on wages in this sample. As is apparent, the qualitative results are reassuringly the same regardless of which HPWO variable is used. Given that the results do not depend on the measure (and this is true for all of the regressions that follow), I choose to use the sum of penetration rates. This is more straightforward than the principal component. No conclusions would change were the other variable used.

The next set of regressions adds variables that are aimed at examining some of the channels through which HPWO systems might affect wages. The question is whether, when these additional controls are added, the HPWO variable declines in either magnitude or statistical significance. If it does, then the particular variable, or set of variables, that leads to this can be interpreted as representing a channel by which wages and HPWO systems are linked.

With this in mind, the first column of Table 4 adds measures of the characteristics of the work force, and in column (2), technology variables are added.

Looking across the columns, the main point is that even after substantial additional controls, the impact of HPWO on wages remains strong and statistically significant. What these results imply is that a one unit increase in the penetration of HPWO practices is associated with a wage

component, which accounts for the largest amount of variance among the four variables, is used. The program used is the STATA factor command.

[10]The sample size shown in the tables reflects reductions both due to missing variables (which cut the sample to 492) and due to the limitation to manufacturing.

[11]I also ran the regressions including dummy variables for two-digit SIC manufacturing industries. The results did not change. For example, in the equation using the simple summation HPWO variable the coefficient was .0578 (.0196).

Table 4. Wage Regressions, Core Workers.
(Dependent Variable: ln(Median Core Wage)

	Specification[a]	
Independent Variable	*(1)*	*(2)*
HPWO Sum	.0415**	.0596**
	(.0172)	(.0171)
SIZE	.00004	.00004
	(.00003)	(.00002)
UNION	.1103**	.0497
	(.0420)	(.0427)
PART-TIME-Core	.5584**	.2372
	(.1407)	(.2728)
FEMALE-Core	−.3955**	−.5227**
	(.0724)	(.0765)
HIGH-SCHOOL-Core	−.2023**	−.1377**
	(.0719)	(.0685)
COLLEGE-Core	.2635**	.0726
	(.0847)	(.0825)
CONTINGENT-Core	−.5525**	−.5718**
	(.2578)	(.2502)
PC-Core	—	.7914**
		(.2022)
COMPUTER-Core	—	.2471**
		(.0584)
CONSTANT	10.341**	10.253**
	(.0842)	(.0823)
R^2	.344	.434
F	15.20 (8,208)	13.57 (10,177)

[a]Specification (1) adds measures of the characteristics of the work force, and specification (2) adds technology variables.
*Statistically significant at the .10 level; **at the .05 level.

gain of just under 4%. This magnitude seems both reasonable and economically significant.

As noted, there are controls for work force characteristics, skill level, and technology utilization within the establishment. Because the effect of HPWO is not diminished by these controls, it is hard to tell a story in which HPWO leads firms to seek higher-skilled workers, and then the need to acquire (or train or retain) the skill pushes up wage levels. These results are consistent with those of Cappelli and Neumark, who also found that labor costs per worker were increased by HPWO systems even after the analysis controlled for labor quality (Cappelli and Neumark 2001). Evidently, there is a direct association between work organization and wages that is independent of the skill level of the work force. This is a point I will reinforce and return to below.

The remaining variables in column (1) generally behave as expected. Wages are lower when the predominant education level of core employees is high school and higher when the predominant level is college. A higher fraction of women in the core labor force is associated with lower wages. (Black, Lynch, and Krivelyova [2004] reported a similar finding.) It also appears that as the fraction of employees who are contingent increases, wages fall. It is important to note that this variable represents the fraction of blue-collar workers who are contingent and hence is specific to the

occupation of the core employees. The only anomaly in the equations is the behavior of the part-time variable.[12] An increase in the fraction of the core work force that is part-time is associated with higher core wages. The normal expectation is that part-time workers are paid less than full-time workers. However, in the more complete model (in the next column), the coefficient falls sharply and becomes statistically insignificant.[13]

Column (2) introduces controls for technology. These variables measure the use of computers by workers as opposed to the investment by the firm in computer technology. It makes sense to focus on use when considering the role of computers in increasing the demand for skill. The variables I use here are comparable to those used in other studies of the effect of computerization on wages and on work organization (see, for example, Bresnahan, Brynjolfsson, and Hitt 2002; Black, Lynch, and Krivelyova 2004; and Cappelli and Neumark 2001). As the variable definitions show, these IT measures are specific to core workers. The results here are clear: the greater the usage of IT by core workers, the higher the core wages. This reinforces the widespread finding in the literature that increased use of technology is associated with both higher skill levels and higher wages. It is also interesting to note that when the technology variables are introduced, the wage gains associated with college education fall. The implication is that, to at least some extent, the relationship between increased education and wages is a proxy for more intensive contact with technology.

[12]Part-time workers are not considered contingent because they may have job security. Taken together, part-time and contingent work is often termed "nonstandard," in contrast to "standard," secure, full-time work (Kalleberg, Reskin, and Hudson 2000).

[13]In thinking about this, it is important to note that the measure of part-time status—less than 35 hours per week—is fairly loose. A reasonable interpretation of the results is that causality is running in the other direction: when core wages are high, firms use fewer hours per worker.

Endogeneity

One concern about the foregoing results is that causality could run the other way: high-wage firms choose to adopt HPWO systems. This might happen as firms that find themselves paying high wages (because of some set of organizational constraints) search for ways to increase the productivity of their work force to justify the wages.

To test for this possibility, I first need instruments that belong in an equation for adoption of HPWO systems but not in a wage equation. Such instruments are hard to find, but here I use organizational characteristics that were found by Osterman (1994) to affect HPWO adoption: whether the establishment has a human resources department; whether the establishment is part of a branch firm; the age of the organization; and whether the organization competes in a competitive product market. None of these variables should affect wages in a standard neoclassical wage determination model. (Of course, it is true that one can tell institutional stories that connect these variables to wage setting. In this sense it is probably impossible to find perfect instruments.)

As a first step, I performed a Hausman-Wu test on whether the HPWO variable is endogenous. The test failed by a large margin to reject exogeneity (the probability on the Chi-square test of the null hypothesis of no endogeneity was .47, hence the null was not rejected). Of course, this test is only as good as the instruments, but nonetheless the result is reassuring. As an additional check, I did nonetheless estimate an instrumental variables model using these instruments. The results are presented in Table 5.[14]

As is apparent, the HPWO variable remains positive and statistically significant and, in fact, increases substantially in magnitude. My findings regarding endogeneity

[14]In the first stage equation, the coefficient on branch status is .3613 (.1676); on HR Department, −.4428 (.1485); on age, −.0043 (.0034); and on market competitiveness, .4351 (.1330).

Table 5. IV Wage Regressions, Core Workers. (Dependent Variable: ln(Median Core Wage)

Variable	*Coefficient (Standard Error)*
HPWO Sum, instrumented	.1608**
	(.0511)
SIZE	.00005
	(.00003)
UNION	.1305**
	(.0452)
PART-TIME-Core	.6787**
	(.1550)
FEMALE-Core	–.5039**
	(.0793)
HIGH-SCHOOL-Core	–.0292
	(.0855)
COLLEGE-Core	.0644
	(.1016)
CONTINGENT-Core	–.5731**
	(.2740)
PC-Core	.1657**
	(.0699)
COMPUTER-Core	.2717**
	(.0696)
CONSTANT	9.9907**
	(.1288)
R^2	.315
F	13.66 (10,200)

*Statistically significant at the .10 level; **at the .05 level.

are consistent with those of Cappelli and Carter (n.d.), who tested for endogeneity in a similar model via Hausman tests (but using different data and different instruments) and did not find it to be a problem for their results.

Managerial (and Other Employee) Wages

I now turn to the determination of managerial wages. Recall that the issue is whether managers, who are not directly involved in the HPWO systems, nonetheless see their wages affected by these systems. To address this, I rerun the models, this time looking at the determinants of managerial wages (Table 6). The HPWO variables refer to the core blue-collar work force, but the other variables in the model are specific to managerial employees in the establishment.

In the most stripped-down model in column (1), the HPWO variable is positive and statistically significant (and this is true regardless of which of the two HPWO variables is used). However, once controls are introduced, there is no longer any relationship between the extent of HPWO and managerial wages. Put differently, as the penetration of HPWO systems deepens, the wages of managers rise, but this appears to be an effect due to intervening variables such as skill and education rather than the direct effect that we observed for blue-collar employees.

The implication of the above is that HPWO systems do affect managerial wages but that they do so through the kind of intervening variables that we can measure. A story consistent with this is that managing HPWO systems requires more skill than does traditional work organization. This greater level of skill is being picked up in the education and other variables in the model.

The remaining variables in the managerial model perform well. The size of the establishment increases managerial wages, a finding that is consistent with much of the executive compensation literature. The impact of managers' education tracks core workers: higher education levels are associated with higher wages. Similarly, as the fraction of managerial employees who are women rises, wages fall. Unionized establishments have lower managerial wages than nonunion establishments, a finding consistent with a broad literature on unions' wage-compression effect (Freeman and Medoff 1984). The only surprise in these models is that, unlike for blue-collar workers, for managers the technology variables are not associated with increased wages.

The Relationship of HPWO and the Distribution of Wages

Recall the hypothesis that HPWO systems place a premium on both new and

Table 6. Wage Regressions, Managers.
(Dependent Variable: ln(Median Managerial Wage)

	Specification[a]		
Independent Variable	*(1)*	*(2)*	*(3)*
HPWO Sum	.0411**	−.0048	−.0003
	(.0211)	(.0185)	(.0197)
SIZE	.00002	.00001	.00002
	(.00003)	(.00003)	(.00003)
UNION	−.0006	−.0824**	−.0832**
	(.0440)	(.0375)	(.0385)
PART-TIME-Core	—	.0828	.0827
		(.1301)	(.1325)
FEMALE-Core	—	−.6494**	−.6610**
		(.1132)	(.1191)
HIGH-SCHOOL-Core	—	−.4443**	−.4492**
		(.0805)	(.0859)
COLLEGE-Core	—	.1737**	.1639**
		(.0390)	(.0410)
PC-Manager	—	—	.0153
			(.1002)
COMPUTER-Manager	—	—	−.0038
			(.0527)
CONSTANT	10.885**	10.961**	10.962
	(.0349)	(.0422)	(.0569)
R^2	.018	.338	.339
F	1.40 (3,225)	15.99 (7,219)	11.96 (9,209)

[a]Specification (1) is the stripped-down version of the model, without controls. Specification (2) adds measures of the characteristics of the work force, and specification (3) adds technology variables.
*Statistically significant at the .10 level; **at the .05 level.

unobserved skills and that the consequence will be a wider wage distribution as firms attempt to acquire or retain those employees with the skills newly in demand (Lindbeck and Snower 2000). Table 7 presents the empirical evidence relevant to this argument for core employees. The dependent variable is the ratio of the median wages among the top 20% of core earners to the median among the bottom 20% (that is, the 90/10 ratio). As is apparent, there is no evidence at all that HPWO systems are associated with a wider spread of wages within the core group. The conclusion, therefore, is that HPWO systems are associated with an increase in the wages of core employees as a whole but without any differential impact among groups of core workers. This is consistent with Appelbaum, Bailey, Berg, and Kalleberg (2000), who found that HPWO systems did not affect the distribution of wages within the industries they studied, and with the finding of other research (Davis and Haltiwanger 1991) that within-firm shifts do little to explain the overall patterns of inequality in the labor market. By contrast, Black, Lynch, and Krivelyova (2004) found in their fixed effect estimates—but not in cross-section estimates—that HPWO practices increased wage inequality. However, they examined inequality between production and non-production workers rather than inequality among employees who are themselves engaged in the innovative practices. In this sense my results are consistent with theirs, since I find a positive wage impact for core workers and no impact for

Table 7. Wage Regression, Core Worker Distribution. (Dependent Variable: 90/10 Core Wage Ratio)

Variable	*Coefficient (Standard Error)*
HPWO Sum	−.0007 (.0303)
SIZE	.00001 (.0'0004)
UNION	−.0005 (.0739)
PART-TIME-Core	2.5412** (.4835)
FEMALE-Core	.1104 (.1358)
HIGH-SCHOOL-Core	.2206* (.1218)
COLLEGE-Core	−.1636 (.1468)
PC-Core	.1419 (.3528)
COMPUTER-Core	−.0804 (.1037)
CONSTANT	1.4645** (.1452)
R^2	.182
F	4.38 (9,176)

*Statistically significant at the .10 level; **at the .05 level.

the remainder of non-managerial employees in the establishment.[15]

It is worth noting that the lack of a relationship between HPWO systems and the 90/10 ratio helps address concerns about the impact of selectivity on the results presented thus far. The analysis presented earlier shows that HPWO systems are associated with higher core wages even after controlling for education. However, a skeptic might still argue that there are unmeasured skills, that the establishments tend to place their most able employees in the HPWO systems, and hence that the impact of HPWO systems on wages is via skill, notwithstanding the fact that I control for education. This is not an argument that can ever be totally refuted; however, the fact that HPWO systems do not alter the earnings distribution among core employees does weaken the case for selectivity.

Individual Practices

The analysis thus far has used a summary measure of four HPWO practices. The justification for this is both simplicity and the arguments in the literature that HPWO practices should not be viewed in isolation but rather as part of a bundle of practices that reinforce each other (Ichniowski, Shaw, and Prennushi 1997; MacDuffie 1995).

These arguments notwithstanding, it is still of interest to examine individual practices, both to understand differences among them and as a robustness check on the summary measure. Table 8 repeats the analysis for each of the four practices individually. As is apparent, three of the four practices show a positive relationship with wages. Only job rotation performs differently. This is an anomaly that is hard to explain, although other researchers (Cappelli and Carter n.d.) also have found that job rotation—in contrast to the other practices they examine—has a negative effect on wages.[16]

The Wage Channel

We have seen that HPWO systems are associated with higher wages for core workers even after we hold skill (as well as technology and labor force characteristics) constant. Why is this? What explains the wage impact of HPWO systems?

[15]In a wage regression for all employees in the establishments comparable to the regressions in Table 3 and the first column of Table 6 (that is, with the HPWO variable, size, and union status), the coefficient on the HPWO variable was small in magnitude and statistically insignificant.

[16]When all four practices are entered at the same time, the coefficient on rotation is negative and statistically significant, the coefficients on quality circles and TQM are positive and significant, and the coefficient on teams is positive but insignificant.

There are two broad possibilities. The first is that the presence of HPWO systems is a proxy for a firm effect that also affects wages. Under this hypothesis there is nothing about HPWO systems per se that increases wages. Rather, firms that pay high wages for some other (unknown) reason also implement HPWO systems. In effect, the relationship between HPWO systems and wages is spurious. The second possibility is that HPWO systems improve productivity sufficiently to create the possibility of increasing wages. This could either happen because, as the standard story would suggest, the demand curve shifts out as productivity rises or because, as a rent-sharing model would suggest, a surplus is generated that is then shared with the work force.

I cannot definitively distinguish among these hypotheses, in part because I lack productivity data and in part because the firm effects argument is sufficiently elastic to survive virtually any test. Nonetheless, a variety of evidence can be assembled that, in my view, supports variants of the productivity argument.

There are several reasons to doubt that the firm effects story is the dominant explanation for the wage boost associated with HPWO systems. First, recall that there is little evidence that the adoption of HPWO practices is endogenous, and in any case the IV estimates, which controlled for a number of establishment characteristics, produced strong results for the HPWO variable. In addition, as we have seen, the higher wages for managers that are associated with HPWO systems are fully explained by the standard set of controls, and other employees (non-core and non-managerial) do not experience a comparable wage gain from the implementation of HPWO systems. Yet if something about the firm per se were responsible (for example, if it were more successful or followed a high-wage policy), then a reasonable expectation would be that wages would also increase for all employees. That is, in the firm effects story we would expect to see other occupational groups in HPWO-intensive firms also receiving higher wages (as was the case, for example, in the Dickens and Katz [1987] analysis of efficiency wages).

Table 8. Coefficients for Individual Work Practices. Dependent Variable: ln(Core Wages)

Description	*Coefficient (Standard Error)*
Percent in Teams	.1112** (.0520)
Percent in Quality Circles	.1333** (.0459)
Percent in TQM	.2416** (.0401)
Percent in Job Rotation	−.0815* (.0491)

Note: These coefficients are taken from equations that also include the full set of variables in column (2) of Table 4.

*Statistically significant at the .10 level; **at the .05 level.

By contrast, there is considerable face validity to the productivity story. As I have already discussed, there is a great deal of evidence that HPWO systems improve firm performance. In addition, in the present survey I can examine how wage-setting practices affect the relationship between HPWO systems and wage levels. The survey asked what percentage of an employee's wage increase was due to an across-the-board increase related to firm or group performance and what fraction was due to individual merit. For blue-collar core employees, the former accounted for 62% of wage increases, while individual performance or merit accounted for 38% (it is interesting to note that for managers the relative importance is reversed: across-the-board increases accounted for 33% and individual factors for 67%).[17]

[17]To see if there is a relationship between these wage setting practices and the use of HPWO systems, I estimated a model in which the fraction of pay due to across-the-board increases was the dependent variable and the independent variables included my measure of HPWO systems, union status, size, the presence of a human resources department, and establishment age. The HPWO variable was not statistically significant.

Table 9. Regression Interacting Across-the-Board Pay with HPWO. Dependent Variable: ln(Median Core Wage)

Variable	*Coefficient (Standard Error)*
HPWO Sum	.0065 (.0213)
SIZE	.00004 (.00002)
UNION	−.0053 (.0437)
PART-TIME-Core	.1887 (.2646)
FEMALE-Core	−.5019** (.0743)
HIGH-SCHOOL-Core	−.1409** (.0663)
COLLEGE-Core	.0151 (.0813)
CONTINGENT-Core	−.5777** (.2425)
PC-Core	.8884** (.1974)
COMPUTER-Core	.2382** (.0566)
ACROSS-BOARD × HPWO Sum	.1059** (.0264)
CONSTANT	10.252** (.0797)
R^2	.449
F	14.59 (11,172)

*Statistically significant at the .10 level; **at the .05 level.

In Table 9 I rerun the full model for core wages with an additional variable: the interaction of the importance of across-the-board pay with the HPWO variable. As is apparent, the HPWO variable itself loses statistical significance (recall that it has been robustly significant through all prior specifications) while its interaction with across-the-board pay is positive and statistically significant. What this implies is that when establishments place a strong emphasis on distributing the benefits of organizational performance to their work force via broad-based pay increases, HPWO systems lead to higher wages, whereas when individual merit-based pay is more important, HPWO systems do not have a positive wage effect.[18] This is certainly supportive of the productivity hypothesis as an explanation for the nature of the HPWO effect (and the importance of across-the-board pay setting is consistent with the lack of impact of HPWO systems on the 90/10 pay ratio for core employees).

Discussion

The key finding in this paper, that for core blue-collar employees in manufacturing higher wages are associated with HPWO systems, is strong and robust with respect to various tests and specifications. In addition, the data used here permit some informed speculation as to why HPWO systems might affect wages. The paper shows that while higher skill levels and computer-based technologies are, as much of the literature suggests, also associated with higher wages, they are not the dominant channel through which work organization affects wages. Rather, there is a mechanism, *independent of skill and technology*, that leads to higher wages. I present inferential evidence that this mechanism is productivity.

These data also enable me to examine two questions that have hitherto been only occasionally addressed in the literature on wages and HPWO systems. First, I find that the wage gains associated with HPWO systems extend to managerial workers, but via a channel different from that for core employees. Second, I show that the wage gains of HPWO systems do not lead to greater wage inequality among core employees. In addition, the finding regarding the importance of across-the-board pay systems is also new to the literature.

The findings in this paper suggest that some of the considerations emphasized by

[18]When the model is run with the across-the-board variable and the HPWO variable (and without the interaction term), the coefficients on both are positive and statistically significant. When the interaction variable is added to this equation, only the across-the-board variable is positive and significant, although both terms that include the HPWO variable are positive.

the older institutional ideas about firm-level wage setting remain relevant. Although skill and technology clearly play a role in wage determination, there is also evidence that the wage policies of the firm—as exemplified in across-the-board versus individual merit wage setting—are also important.

Traditional institutional considerations receive mixed support from the results of this study. On the one hand, I find evidence that the wage policy of the firm is indeed important. On the other hand, when the HPWO variable is interacted with union status, it retains its statistical significance as well as its magnitude. This finding (which contrasts with the pattern found by Black, Lynch, and Krivelyova 2004) suggests that the wage gains associated with new work systems do not depend on the union status of the establishment, and thus represents a challenge to at least one version of the "power" explanation of the impact of HPWO systems on wages.

One important limiting aspect of this study is its restriction to manufacturing. Indeed, a close reader of the literature might wonder how the patterns discussed in this paper relate to an earlier paper that, using the same data, showed that firms implementing HPWO systems do not pay higher wages (Osterman 2000). The answer is that the earlier paper included all industries and all core occupations. Indeed, when the models in this paper are rerun in non-manufacturing industries, no pay gains are associated with HPWO systems. Evidently, either HPWO systems are not associated with productivity gains in non-manufacturing settings or these gains are not shared with the core work force outside of manufacturing. It is also possible that the definitions of HPWO systems that are used in this paper (and in much of the existing research) are manufacturing-specific (Cappelli and Carter [n.d.] also found weaker effects outside of manufacturing). In other settings, practices that are not captured here may be functionally equivalent and may in fact yield better outcomes. This is an important question for additional research.

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