The Wage Effects of High Performance Work Organization In Manufacturing

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Abstract

In this paper I utilize establishment-level data to examine the relationship of work organization and wages in manufacturing. This 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 utilizes a nationally representative data set that can examine the impact of new work systems not only upon employees directly involved but also the consequences of work systems for other workers in the firm. These data permit controls for skill, technology, and a range of other relevant factors. The paper also studies the distributional effects within occupational groups of new work systems and in addition relates the wage impact to the institutional details of the establishment's wage system.

The key finding in this paper is that for core blue-collar employees in manufacturing, higher wages are associated with High Performance Work Organization (HPWO) systems. This finding is strong and robust to various tests and specifications. In addition, the data utilized here permit a parceling out of reasons that 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, these considerations are not the dominant channel through which work organization influences wages. Rather, the key mechanism appears to be productivity gains, independent of skill and technology, which are shared via various across-the-board wage payment systems.

I also find that HPWO systems are also associated with higher wages for managers but via a different channel than for employees directly involved. In addition, I show that the wage gains of HPWO systems do not lead 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 which shows that, even after controlling for a substantial set of standard variables, firm-specific wage effects remain important. For example, Dickens and Katz (1987) show that if a firm pays an efficiency wage premium for one occupation, it will pay the same premium for all others, a finding which makes sense only in the context of a firm-specific wage policy. Goshen (1991) finds that a firm (establishment) effect accounts for between 31 percent and 51 percent of the variation across firms in wages. Davis and Haltiwanger (1991) find strong plant-level effects in their wage-determination models.

In this paper I utilize establishment-level data to examine the relationship of work organization and wages in manufacturing. This 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 utilizes a nationally representative data set that can examine the impact of new work systems not only upon employees directly involved but also the consequences of work systems for other workers in the firm. The data permit controls for skill, technology, and a range of other relevant factors. The paper also studies the distributional impacts within occupational groups of new work systems and in addition relates the wage effect to the institutional details of the establishment's wage system.

The key finding in this paper is that for core blue-collar employees in manufacturing, higher wages are associated with High Performance Work Organization (HPWO) systems. This finding is strong and robust to various tests and specifications. In addition, the data utilized here permit a parceling out of reasons that 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, these considerations are not the dominant channel through which work organization affects wages. Rather, the key mechanism appears to be productivity gains, independent of skill and technology, which are shared via various across-the-board wage payment systems.

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Work Organization and Wages

High Performance Work Organization is a summary term which stands for the introduction of a range of practices which include self-managed teams, quality programs, and job rotation. (For a discussion of the various meanings of this term and a history of its introduction into U.S. firms, see Applebaum and Batt, 1994. Later in this paper I discuss how I empirically capture the practices.) 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 upon 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); the attitudes of employees towards 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 has been addressed by a number of prior studies, but it seems fair to say that this literature is thinner than 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, Applebaum, 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 holding 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 impacted wages, as did her measures of product market strategy. By contrast, Hunter and Lafkas (2003) studied customer service representatives in banking and 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 on manufacturing, 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 upon wages only when they interacted the work organization variable with union status. Handel and Gittleman (2004), utilizing data collected in 1995, did not find any impact of HPWO systems upon wages. 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 these data and measures that different researchers use. For example, in measuring HPWO systems, some researchers (e.g., Handel and Gittleman) use indicators of the presence or absence of the practice, while others (e.g., Black, Lynch, and Krivelyova as well as Osterman) use a measure of penetration. There is similar variation in the outcome measures. Some (Applebaum et al., Batt, Hunter and Lafkas, Osterman) focus on the effect of HPWO systems on workers directly involved with the HPWO systems, while others (e.g., Cappelli and Neumark; Handel and Gittleman , Black, Lynch, and Krivelyova) examine the wages of all workers in the establishment.

Questions and Expectations

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

Turning first to the effect of HPWO on the wages of employees who are directly involved, the most obvious channel is that 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 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 which 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 treatment as a distinct factor, not simply subsumed in the general discussion of skill. There is good evidence that firms which 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 which 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 its 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 a reasonable hypothesis to expect 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[1]. Consider, for example, the gains that accrue due to the increased productivity of HPWO systems. These gains affect the firm's "ability to pay," but just how this is worked out will depend upon power considerations. 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 due not 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 is only occasionally done in the literature) 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). The consequences of this substitution upon observed managerial wages is, however, ambiguous. On the one hand, this process can drive down managerial 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 a way in which 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. One obvious way this can happen is if the level of wages of different occupational groups are differentially affected, 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) argue that because HPWO systems involve new skills (for example, the ability to work in teams) which as of yet are not widely available, the wage distribution among employees who work on 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 of thinking about this is to note that 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, it is possible that as HPWO systems increase the productivity premium of skills (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 more 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 which cuts the other way. To the extent that HPWO systems involve increased use of teams, then 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 in this direction.

In short, the questions this paper seeks to answer are: (1) What is the relationship of HPWO systems and the level of wages of those employees directly involved in the execution of those systems? (2) What is the relationship of HPWO systems and the level of wages of other employees, particularly managers, in the establishment? (3) What is the relationship of HPWO systems and the distribution of wages of employees involved in the new work systems? In answering these questions, the paper tries to pay attention to the various channels of impact discussed above and to distinguish among them.

THE DATA

The data in this paper are from the 1997 National Establishment Survey. The 1997 survey and its 1992 precursor are both telephone surveys of a representative sample of American establishments which are in the private for-profit sector and which have at least fifty employees (see Osterman, 1994 and Osterman, 2000). Other than these restrictions, the surveys (appropriately weighted) are representative of the entire economy.[2] [3]

The surveys were directed to establishments, i.e., specific business addresses, rather than to headquarter locations. Hence the questions were about practices at the given establishment as opposed to questions directed to headquarters about practices elsewhere in the country. This very likely leads to more accurate responses and is the practice which tends to be followed in most research of this kind. The sampling frame was the Dunn and Bradstreet listing of establishments, a frame which is considered one of the best, if not the best, available for a survey of this kind (Kalleberg et al., 1990). In the 1992 survey the response rate was 65.0 percent and in the 1997 survey the response rate was 57.7 percent. 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 consisted of a follow-up to the establishments who responded in 1992 (there were 806 establishments interviewed in 1992 and of these the 1997 survey reinterviewed 462) plus an additional

sample of 221 new establishments. There is no bias in which establishments in the original sample were successfully reinterviewed in 1997.[5]

One complication that permeates the literature is that there is no unambiguous way of defining a high performance work organization and knowing whether or not the establishment is following this path. There is variation in the literature, and the establishment survey utilized 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) utilizing British data employs variables for flexible assignments, teams, quality circles, and information sharing; Handel and Gittleman (2004) use rotation, job redesign, teams, TQM, employee involvement, Just-in-time production, profit sharing, and pay for skill; Black, Lynch, and Krivelyova (2004) use rotation, teams, and profit sharing; Cappelli and Neumark (2004) use teams, information sharing, and quality circles; Pil and Macduffie (1996) use teams, rotation, problem solving groups, and quality circles; Hunter and Lafkas (2002) use discretion and quality circles; and Cappelli and Neumark (2001) use 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 paragraph immediately above suggest 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 do so in a later section and in the context of understanding variation across establishments in the impact of HPWO systems upon wages. In my view it is cleaner to distinguish between work organization variables on the one hand and pay practices on the other.

The "core" workers are defined as the non-managerial employees most directly involved in the production of the goods or services sold by the enterprise. They could either have been blue- or white-collar workers (in this paper 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 that they would be asked.

In utilizing a survey of this kind, a reasonable question concerns the quality of these data. Osterman (2000) discusses the measurement of HPWO practices and how these data in this survey compare to patterns in other surveys. The key conclusion is that the NES survey appears consistent with others 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 the respondents were sent a fax with these questions 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.
>
> 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 below provides the relevant comparisons. The March 1998 CPS is used because the earnings data refer to the prior year (1997). The NES results utilize 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 twenty-five and larger. 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 establishments of one hundred 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, and this should substantially strengthen our confidence in the quality of these data.

Table 1 here

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.

Table 2 Here

HIGH PERFORMANCE WORK ORGANIZATION AND WAGES FOR CORE EMPLOYEES

In this section I begin 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 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] 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).

Table 3 here

The results of these first regressions are shown in Table 3[10]. Both HPWO variables are significantly positive.[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 upon 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, which leads to this can be interpreted as representing a channel via which wages and HPWO systems are linked.

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

Table 4 here

Looking across the columns, the main point is that even after substantial additional controls, the impact of HPWO upon wages remains strong and significant. What these results imply is that a one unit increase in the penetration of HPWO practices is associated with a wage gain of just under four percent. This magnitude seems both reasonable and economically significant.

As noted, these are controls for workforce 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 controlling 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 workforce. 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 wages are 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) report 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 workforce that is part-time is associated with higher core wages. The normal expectation is that part-time workers are paid less than

full-time. However, in the more complete model (in the next column), the coefficient falls sharply and becomes insignificant.[13]

Column 2 introduces controls for technology. These variables measure the utilization 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 utilized 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 variables 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 utilization 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.

Endogeneity

One possible concern about the foregoing results is that causality runs 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 workforce to justify the wages.

To test for this, 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 in Osterman (1994) to affect HPWO adoption. These are 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 (although 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 exogenaity (the probability on the Chi-square test of the null hypothesis of no edogenaity was .47, hence the null was not rejected). Of course, this test is only as good as the instruments but nonetheless is reassuring. As an additional check I did nonetheless estimate an instrumental variables model using these instruments and the results are presented in Table 5.[14]

Table 5 here

As is apparent, the HPWO variable remains positive and statistically significant and, in fact, increases substantially in magnitude. My findings regarding endogenaity are consistent with that 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 impacted by these systems. To address this, Table 6 reruns the models, this time looking at the determinants of managerial wages. The HPWO variables refer to the core blue-collar workforce, but the other variables in the model are specific to managerial employees in the establishment.

Table 6 here

In the most stripped- down model in column 1, the HPWO variable is positive and significant (and this is true regardless of which of the two HPWO variables are utilized). 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 effect appears to be 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 rise, wages fall. Unionized establishments have lower managerial wages, a finding consistent with a broad literature on the compression effect of unions (Freeman and Medoff, 1984). The only surprise in these models is that, unlike the case of blue-collar workers, the technology variables are not associated with increased managerial wages.

The Relationship of HPWO and the Distribution of Wages

Recall the hypothesis that HPWO systems place a premium on both new and 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 examines this argument for core employees. The dependent variable is the ratio of the median wages among the top twenty percent of core earners and the median among the bottom twenty percent (i.e., 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 is 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 Applebaum, Bailey, Berg, and Kalleberg (2000), who found that HPWO systems did not impact the distribution of wages within the industries they studied, and with other research (Davis

and Haltiwanger, 1991) which found 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—but not 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 the remainder of non-managerial employees in the establishment.[15]

Table 7 here

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 upon 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 and that the establishments tend to place their most able employees into the HPWO systems and hence that the impact of HPWO systems upon wages is via skill, regardless of the fact that I control for education. This is not an argument that is ever possible to totally refute; 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 as well as the arguments in the literature that HPWO practices should not be viewed in isolation but rather as part of a bundle of practices which 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 to wages. Only job rotation performs differently. This is an anomaly that is hard to explain although others (Cappelli and Carter (n.d.) also find that job rotation—in contrast to the other practices they examine—has a negative effect on wages.[16]

Table 8 here

The Wage Channel

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

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 increase wages. Rather, firms which 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 workforce.

These data 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 which, 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 there were something about the firm per se (e.g., it was 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).

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 percent of wage increases, while individual performance or merit accounted for 38 percent (it is interesting to note that for managers the relative importance is reversed: across-the-board increases accounted for 33 percent and individual factors 67 percent).[17]

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 significance (recall that it has been robustly significant through all prior specifications) while its interaction with across-the-board pay is positive and significant. What this implies is that in establishments that place a strong emphasis on distributing the benefits of organizational performance to their workforce via broad-based pay increases, then HPWO systems lead to higher wages, whereas when individual merit- based pay is more important, then HPWO systems do not have a positive wage effect.[18] This is certainly supportive of the productivity hypothesis for explaining 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).

Table 9 here

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 to various tests and specifications. In addition, the data utilized here permit a parceling out of reasons that HPWO systems might impact 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, these considerations are not the dominant channel through which work organization impacts wages. Rather, there is a mechanism, independent of skill and technology, which leads to higher wages. I present suggestive evidence that this mechanism is productivity, although this particular conclusion is only inferential.

These data also enables 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 do also apply to managers, but via a different channel than 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 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 vs. individual merit wage setting—are also important.

While the wage policy of the firm is one institutional consideration that appears important, it is also the case that another version of the institutional argument does not appear relevant. When the HPWO variable is interacted with union status, it retains its significance as well as its magnitude. This finding (which contrasts with the pattern in 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. This represents a challenge for at least one version of the "power" explanation of the impact of HPWO systems upon wages.

One important limitation on the findings in this paper is that they are restricted to manufacturing. Indeed, a close reader of the literature might wonder how the patterns discussed in this paper relate to an earlier paper using the same data which showed that firms which implement 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, there are no pay gains 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 workforce 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 find weaker impacts 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.

Table 1

EARNINGS OF BLUE-COLLAR MANUFACTURING EMPLOYEES Comparison of 1998 March CPS with 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
Note: The first CPS figures are for median (50^{th} percentile) earnings. The figures in the parentheses are means. CPS data limited to private-sector employees between ages 17 and 64.		

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
PerRot	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 a 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 percent 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, CAD, etc.	Core: .21 Manager: .27
ACROSS-BOARD	Percent of annual pay increase (core, managers) due to across-the-board factors (as opposed to individual performance or merit)	Core: .62 Manager: .33

Table 3

Basic Regressions on ln(core wages)

(standard errors)

SIZE	.00002 (.00003)	.00002 (.00003)
UNION	.2041** (.0395)	.2041** (.0395)
HPWOSum	.0451** (.0190)	--
HPWOComponent	--	.0270** (.0114)
CONSTANT	9.9955** (.0313)	10.0366** (.0229)
R^2	.123	.123
F	10.53** (3,225)	10.53** (3,225)

** = significant at 5-percent level
* = significant at 10-percent level

Table 4
Wage Regressions, Core Workers
dependent variable = ln(median core wage)

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

** = significant at 5-percent level
* = significant at 10-percent level

Table 5
IV Wage Regressions, Core Workers
dependent variable = ln(median core wage)

HPWOSum, 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)

** = significant at 5-percent level
* = significant at 10-percent level

Table 6
Wage Regressions, Managers
dependent variable = ln(median managerial wage)

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

** = significant at 5-percent level
* = significant at 10-percent level

Table 7
Wage Regression, core worker distribution
dependent variable = 90/10 core wage ratio

HPWOSum	-.0007 (.0303)
SIZE	.00001 (.00004)
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)

** = significant at 5-percent level
* = significant at 10-percent level

Table 8
Coefficients for Individual Work Practices
dependent variable = ln(core wages)

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.

** = significant at 5-percent level
* = significant at 10-percent level

Table 9
Regression with Across-the-Board
dependent variable = ln(median core wage)

HPWOSum	.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 x HPWOsum	.1059** (.0264)
CONSTANT	10.252** (.0797)
R^2	.449
F	14.59 (11,172)

** = significant at 5-percent level
* = significant at 10-percent level

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[1] With respect to managerial strategy, different firms may choose different strategies with respect to the utilization of labor, and these have consequences for wages. For example, Batt (2001) shows how in telecommunications the decisions of firms about market segmentation strategies lead to different wage impacts of the same technology and work system. Autor, Levy, and Murnane (2002), in their study of banking, demonstrate how computerization led to different wage 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 which may make sense.

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

[3] 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. Hence I cannot construct a panel analysis of wages and therefore this paper is cross-sectional using the 1997 survey.

[4] Osterman (1994) describes 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, a logit model was estimated 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 significant, indicating that no important biases exist in the response patterns.

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

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

[7] In 1997 18 percent 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. It was insignificant.

[8] Note that union status refers to whether or not some core workers are covered by collective bargaining. In these data 29 percent of establishments responded positively. This does not mean that 29 percent of workers are 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 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 original sample size is reduced by missing variables (which reduces the sample to 492) and by the limitation to manufacturing, which reduces the sample to that reflected in the tables.

[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).

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

[13] In thinking about this, it is important to note that the measure of part-time status is fairly loose, less than 35 hours a week of work. 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.

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

[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 (i.e. with the HPWO variable, size, and union status) the HPWO variable was small in magnitude and insignificant.

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

[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 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 age of the establishment. The HPWO variable was not statistically significant.

[18] When the model is run with the across the board variable and the HPWO variable (and without the interaction term) both are positive and 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.