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"Flexible" Work Practices and Occupational Safety and Health: Exploring the Relationship Between Cumulative Trauma Disorders and Workplace Transformation

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Abstract: This paper matches establishment-level data on workplace transformation (e.g., quality circles, work teams, and just-in-time production) with measures of cumulative trauma disorders at these same establishments to explore the relationship between "flexible" workplace practices and workplace health and safety. The results reveal a positive, statistically significant, and quantitatively sizeable relationship between cumulative trauma disorders and the use of quality circles and just-in-time production.

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I. Introduction

Over the course of the last two decades, the U.S. workplace has undergone substantial transformation, spurred on, in part, from pressures to restore international competitiveness, the need to adopt new technologies, and the new emphasis placed on product quality and market responsiveness. These changes in work systems have sparked a vigorous debate in the academic, business and policy-making communities as to what practices, technologies and strategies are required for U.S. businesses to succeed in the present environment, a debate nowhere more intense than around the development and adoption of new human resource practices.[1] Indeed, new, "flexible" human resource practices such as quality circles, total quality management, and self-directed work teams have often been hailed as key to increasing productivity and product quality, particularly when combined with other workplace re-organizations such as just-in-time inventory systems, design-for-manufacture, or statistical process controls.

These methods of human resource coordination originate in Japanese management practices, where they were designed to utilize worker input for productivity and product quality improvements. Quality circles are labor-management committees that meet regularly on company time to raise problems encountered in production and to work jointly to find solutions. Self-directed work teams bring participation directly to the shopfloor, where the 10-15 employees generally comprising a team are made responsible for such things as troubleshooting, job assignment and quality control. When combined with other systems such as just-in-time inventory control – a "demand-pull" approach whereby a minimal amount of inventory is maintained during production – these human resource practices have created a production process where bottlenecks and troublespots appear quickly, and where re-adjustment can take place more efficiently through continual "rebalancing" of both staff and equipment. Such a production system also allows for more effective market response, as re-adjustment can come by way of a simple re-specification of output design or target level, rather than the more complicated coordination and monitoring of various department or division production schedules typical of a mass production system.

In light of these strengths, it is not surprising that such re-organization has become an important phenomenon in the American workplace. A 1992 study of establishments with fifty or more employees found that nearly eighty percent of such establishments had some experience with these innovative work practices (Osterman, 1994, p. 177), and a 1993 survey of establishments of all sizes reports that over forty percent have some experience with workplace transformation (Gittleman, Horrigan and Joyce, 1998, p. 99).[2] These practices, however, are not without their critics, who are skeptical of the glowing endorsements of workplace reorganization found throughout the literature. The critics charge that such innovations have reduced worker autonomy and control on the shopfloor, that productivity gains are exacted almost solely through speed-up and intensification of work, and that workplace transformation comes at a high human cost in terms of worsened worker health and safety (Parker and Slaughter 1994; Delbridge, Turnbull, and Wilkinson 1992).

Indeed, this last point has gained much attention in recent years, as an increasing number of authors have begun to draw parallels between the introduction and rising prevalence of workplace transformation beginning in the 1980s and the disturbing rise in occupational illnesses, and cumulative trauma disorders in particular, that have taken place over roughly the same period.[3] Cumulative trauma disorders – conditions such as carpal tunnel syndrome which

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[1] See Appelbaum and Batt (1994) or Levine (1995) for recent reviews of these issues and the surrounding literature.

[2] This survey also found that nearly 70 percent of establishments with 50 or more employees had some experience with workplace transformation.

[3] Kenney and Florida (1993) and Wokutch (1992), among others, make these links in the case study literature.

have their origins in repeated pressure, vibration or motion – have witnessed a dramatic rise since the early 1980s, as seen in Figure 1. The reported rate of cumulative trauma disorders (CTDs) per 10,000 workers rose from 3.6 to 27.3 between 1982 and 1999, an annual average growth rate of 12.7 percent.[4] Over the same period, CTDs rose from 21.4 to 66.3 percent of all new cases of illness. By the early 1990s illnesses associated CTDs caused the longest absences from work among leading health and safety related events and exposures (U.S. Department of Labor 1992, p. 3, 5).[5]

Despite the importance of this trend in CTDs, and the link posited with workplace transformation, surprisingly little research has been undertaken to explore this relationship. Moreover, the work that has been done is predominantly in the form of case studies, particularly in the automotive industry. While these case studies offer some insights into the mechanisms through which a transformed workplace can affect CTDs, there is little guarantee that such conditions are reproduced in other industries, or that any link between workplace transformation and CTDs is systematic. There have been only two establishment level, cross-industry studies of this relationship (Fairris 1997; Fairris and Brenner 2001), both of which were forced to use industry-level measures of CTDs as proxies for the establishment-level measures, thereby making their conclusions far from definitive.

In this paper, we utilize data from two surveys carried out by the Bureau of Labor Statistics to analyze the relationship between CTDs and workplace transformation. The analysis treats establishments of all sizes, across all industries, making its results more generalizable than previous case study work. More importantly, it links establishment-level CTD rates to

[4] The decline in CTDs beginning in 1994 may be due to a variety of factors. Those related to workplace transformation include the slower pace of growth in workplace reorganization and the greater attention given to CTD-related problems in those workplaces that have already undergone transformation.

establishments' experience with workplace transformation, thereby resolving the principal data problem plaguing previous cross-industry research. The results suggest that workplace transformation, and quality circles and just-in-time production in particular, have a positive, statistically significant, and sizeable effect on CTDs. While not the end of the story, we feel this research goes a long way in furthering our understanding of the systematic relationship between workplace transformation and CTDs. In the next section we briefly present prior research linking CTDs and workplace transformation. In section III we discuss the data and estimation methodology, and in section IV we present the findings. We conclude in section V.

II. Prior Research

The case study literature depicts the causal link between workplace transformation and CTDs as following from the increased repetition, speed, and force required to complete work tasks in transformed workplaces. These factors, individually or in combination, are believed to lead to increased rates of CTDs. Several analysts locate their origins in the way workplace transformation attempts to "rationalize" production beyond that achieved under mass-production and Taylorist methods (e.g., Kenney and Florida 1993). This rationalization implies the breaking down of job tasks into their smallest feasible components – thereby making them more repetitive – as well as more carefully studying each task so as to optimize its execution during production. This latter aspect can lead to speed-ups which, especially when combined with increased repetitiveness, increase the risk of CTDs.

Some analysts argue that this increased risk of CTDs is made worse by other features of transformed workplaces. For example, just-in-time inventory controls may be instituted in order to identify bottlenecks or troublespots in production and to produce cost savings by reducing

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[5] It must be noted that while CTDs are rapidly becoming a major occupational and safety concern for the U.S. workplace, they affect a much smaller percentage of the workforce than do injuries. For example, in 1997 the rate

inventories, but they may also heighten the risk of CTDs. Just-in-time systems prevent workers from "building stock" or "working up the line" so as to secure periods of rest during production. Moreover, parts used in just-in-time inventory control systems are frequently attained through subcontractors, with the attendant defect problems, which cause workers to exert greater force – and strain on muscles, joints, tendons and nerves – when installing parts. Taken together, these problems of increased repetition, shorter recovery time (either breaks per shift or idle seconds per cycle), and excessive force have been confirmed by ergonomists as contributing causally to increased CTDs (Armstrong 1986; Putz-Anderson 1988).

Evidence for the specific causal links between workplace transformation and CTDs exist in a variety of case studies – many of which focus on Japanese auto transplants in the U.S. For example, there is evidence to suggest that transformed workplaces demand greater intensity from workers. Fuchini and Fuchini (1990, p. 37) report that the cycle-time goal of Japanese transplants is to run production with as close to 60 seconds of work every minute as possible. Treece (1989, p. 80) demonstrates that in the case of New United Motors Manufacturing Inc. (NUMMI) – a Toyota-General Motors joint venture operating in the former GM-Freemont plant – the actual record is not far from the goal. Treece found that NUMMI workers worked an average of 55 seconds each minute, as compared to the average of 45 seconds of work per minute performed by workers at the GM-Linden plant, a comparable but untransformed facility.

There is also evidence to suggest that transformed workplaces possess worsened health and safety for workers. For example, Wokutch's case study of a Japanese auto transplant in the U.S. found that in 1988 the injury and illness frequency in the plant was 91 percent higher than the rate for the industry as a whole, and 66 percent higher than similar plants employing 1000 or more people (Wokutch 1992, p. 192). Moreover, CTDs accounted for nearly 50 percent of those

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of CTDs was still less than one-tenth of the rate for other workplace injuries.

reported injuries and illnesses in that year (ibid, p. 195). In fact, Wokutch reports that the CTD rate considered separately was nearly five times as high as the rate for comparably-sized auto plants, despite the plant's workforce being younger, and presumably healthier, than the industry average (ibid, p. 193).

Several case studies offer a glimpse into the specific relationship between increased intensification and rationalization of production and worsened workplace health and safety. In their case study of CAMI – the Canadian joint venture between GM and Suzuki – Rinehart, Huxley, and Robertson (1997) make a case for such a link. They argue that increased hours and overburdened jobs led the number of CTD-related illnesses between 1992-1994 to more than double, rising from 12 percent of all reported illnesses and injuries to roughly 33 percent by the end of the period (Rinehart, Huxley, and Robertson 1997, p. 80). They also report that this increased stress was prevalent in the workplace, as approximately 40 percent of workers felt that their job exposed them to repetitive strains "often or all of the time" (ibid, p. 70).

Finally, consider the results of the 1993 model change at NUMMI described by Levine (1995) and Adler, Goldoftas, and Levine (1997). During implementation, absences due to health and safety problems increased 12 percent, with particularly acute problems reported in the assembly department (Levine 1995, p. 32). Within the first month of production hand and arm ailments in that department more than doubled, back and neck cases increased seven times, and one assembly group had 11 out of 16 workers reporting work-related injuries or illnesses (Adler, Goldoftas, and Levine 1997, p. 424). These problems were only exacerbated by the company's suspension of job rotation until output reached 25% of slated volume per shift (ibid, p. 424). Failure to respond to these ergonomic hazards resulted in the union's request for Cal-OSHA intervention, which in turn produced two citations, noting that "serious employee injuries due to repetitive stress, as well as employee symptoms of impending stress injury [had] increased alarmingly," and that "in many cases, the nature of particular tasks – repetitiveness, high necessary force from postures with high static loading – predict ergonomic problems from first principles" (quoted in Levine 1995, p.33 and p. 30).

In light of this case study evidence, there have been only two studies to date which attempt to systematically explore the relationship between CTDs and workplace transformation across a broad range of manufacturing industries (Fairris 1997; Fairris and Brenner 2001). However, both studies suffered an important limitation in data: because CTD data at the establishment level were unavailable, 3-digit industry-level CTD data were used as proxies for establishment-level CTDs, and were matched to establishment level workplace transformation variables for purposes of analysis. The research presented in this article is intended to correct the major deficiency in these two studies by linking CTD and workplace transformation data, both at the establishment level. It is to a more detailed discussion of these data that we now turn.

III. Data and estimation approach

To investigate the link between workplace transformation and CTDs, we created a unique data set by matching establishment micro data from two surveys conducted by the Bureau of Labor Statistics (BLS) – the 1993 Survey of Occupational Injuries and Illnesses (OSH survey) and the 1993 Survey of Employer Provided Training (SEPT). The OSH survey is an annual, nationally representative mail survey of about 250,000 private industry establishments. Surveyed establishments report annual counts of various types of injuries and illnesses, as well as the total annual hours worked by all employees, the annual average number of employees, and the establishment's industry. The injury and illness data are drawn from logs that establishments maintain under the Occupational Safety and Health Act. One of the data elements that establishments are required to report is the number of newly identified cases of disorders associated with repeated trauma. This count, along with the estimate of total hours worked, was used to calculate a rate of repeated trauma (CTD) cases per 100 full-time workers. It is important to stress that this estimate yields the rate of newly identified CTD cases occurring in the reference year. Cases that were first recognized in a previous year, but that continue into the reference year, are not counted again.

The 1993 Survey of Employer Provided Training was designed to collect information on the existence of formal training programs offered or financed by private industry establishments. Surveys were mailed to approximately 12,000 establishments and 7,895 returned useable data to the BLS. The survey sample was stratified by industry and establishment size, and, with the application of weights, provides nationally representative estimates (Gittleman, Horrigan, and Joyce 1998). In addition to asking a large number of questions about training programs, including formal safety and health training, the survey obtained answers to a variety of other background questions, including the existence of various workplace practices and the composition of the establishment's work force. Specifically, establishments were asked if they had any of the following practices in 1993: just-in-time inventories, worker teams, total quality management, quality circles, and job rotation. A glossary of terms included in the questionnaire helped respondents understand each of these terms, (and can be found in ibid, p.114). The survey also asked how many employees were on the payroll, how many of these had worked for less than a year, how many worked part-time, and how many were covered by a collective bargaining agreement, which allowed us to calculate the percentage of inexperienced workers, the percentage of part-time workers, and the percentage of workers who were unionized in the establishment.

Matching the OSH survey to the SEPT survey yielded a sample of 1848 establishments with valid data from both surveys. Establishment weights were calculated for the matched data based on the initial SEPT weights.[6] Table 1 reports CTD rates by industry and establishment size from the matched data. The sample statistics were calculated using employment weights (i.e. the product of the establishment weight and the number of employees in the establishment). Thus, these estimates address the question: what is the CTD rate faced by the average worker? The table shows that overall, CTD cases are relatively rare. On average only about 1 in every 400 workers is afflicted by such a condition in any given year. However, repeated trauma cases are more frequent both in manufacturing and in larger establishments. Overall, manufacturing establishments in this sample reported an employment-weighted CTD rate of 1.2 cases per 100 workers in contrast to the rate of only 0.07 for all establishments in non-manufacturing. Further, manufacturing establishments with 1000 or more workers reported an even higher rate, 2.66 per 100 workers.

Table 2 reports sample statistics for key independent variables in the study. As with Table 1, these statistics were calculated using employment weights. A dummy variable was created for each of the workplace transformation variables, taking the value 1 if the workplace practice existed in the establishment and zero otherwise. The means of the variables, when multiplied by 100, give the percentages of workers employed in an establishment with each of the workplace practices. Among the workplace transformation characteristics listed in the table, total quality management was most prevalent, followed by the use of teams. All of the workplace transformation characteristics were more common in manufacturing establishments than non-manufacturing establishments, and they were more prevalent in larger manufacturing

[6] Specifically, the observations in the matched data were grouped by cells defined by eight major industry groups and five size classes. The SEPT establishment weights in each cell in the matched data were then adjusted to sum to

establishments than in all manufacturing establishments. The table also shows the employment-weighted means of the variables related to workforce composition. As expected, larger manufacturing establishments are most frequently unionized and have the smallest percentage of part-time and inexperienced workers.

The estimate of establishment size deserves special discussion. It is important to note that this estimate does not show the average employment in an establishment, which would have been obtained by using establishment weights to calculate the means. When using employment weights, these means show the number of employees in the establishment of the average worker. Since larger establishments have more workers, this estimate tends to be substantially larger than the average number of workers per establishment. In contrast to the estimates in Table 2, employment in the average establishment is only 29, while it is 63 in manufacturing establishments and 233 in manufacturing establishments with more than 50 workers.

In order to determine how workplace transformations affect repeated trauma rates, we estimate regressions with the CTD rate as the dependent variable. For independent variables we include dummies for the workplace transformation features listed in Table 2, a dummy for whether safety and health training was offered, employment, employment squared, the three workforce composition variables, and 2-digit SIC dummies to control for variations across industries in workplace environments that cause repeated trauma.

Two aspects of the empirical analysis deserve mention. First, as with most complex survey designs, weights must be applied to our matched data to obtain unbiased estimates with consistent standard errors.[7] The statistical package STATA provides a regression command that we utilized to obtain approximately correct standard errors. This calculation is based on a first-

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the same value as the sum of weights for the observations in that cell in the original SEPT micro data.

order Taylor-series linearization method, commonly known as the White variance, or "sandwich" estimator (StataCorp 1997).[8] Second, we must re-emphasize that the means in Tables 1 and 2, and the regressions discussed below are estimated using employment weights. Thus, the question that is being answered by using such weights is: how is the repeated trauma rate facing the average worker affected by workplace transformation?[9]

IV. Results

Column (1) of Table 3 contains the estimated coefficients of the CTD regression on the full sample, which includes both manufacturing and nonmanufacturing industries. While all of the workplace transformation variables are positively associated with the rate of cumulative trauma disorders, only just-in-time production possesses an estimated coefficient that is statistically significantly different from zero. The effect of just-in-time production on CTDs is significant in a quantitative sense as well, accounting for roughly twenty percent of the mean CTD rate.

Recall from Table 1 that the mean CTD rate in manufacturing is 1.20, while its counterpart in nonmanufacturing is only 0.07. Moreover, Table 2 reveals that workplace transformation is much more significant in the manufacturing sector (also see Gittleman et al. 1998): 43 percent of manufacturing workers work in establishments with just-in-time production, as against 11 percent for nonmanufacturing. Quality circles have a mean of 20 percent in the manufacturing sample, but only 9 percent in the nonmanufacturing sample.

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[7] The statistical literature has shown that standard errors of regression parameters are not correctly estimated when the analyst ignores the sample design (see, for example, Skinner et al. 1989 or Ullah and Breunig 1998).

[8] The "sandwich" estimator requires that there be more than one observation in each stratum. The original SEPT sample had 98 strata defined by establishment size and groups of 2-digit SIC industries. Because some of the strata only had one observation in the matched OSH-SEPT analysis file, we were forced to collapse the number of strata to 40. We chose to use only 40 strata largely out of convenience. In theory, failing to account for all strata should tend to raise standard error estimates. In our sample, standard errors obtained using the sandwich estimator calculated without any strata were essentially the same as they were with the 40 strata. So it is unlikely that there would be any additional benefit to defining strata closer to that used in the original SEPT sampling.

[9] The use of employment weights also addresses heteroskedasticity in the CTD estimates. As Ruser (1985) showed, the variances of injury and illness rates are inversely related to establishment size. Using employment weights places greater emphasis on those observations with lower variance for the dependent variable.

When we analyze the determinants of CTDs in manufacturing and nonmanufacturing separately, it is clear that inclusion of the nonmanufacturing sector accounts for very little of the observed relationship between CTDs and workplace transformation variables in the column (1) results. Statistically significant relationships between workplace transformation and CTDs exist in the manufacturing sector only. Thus, in what follows we concentrate our attention on the manufacturing sector, the initial results for which are reported in column (2). Here we find that both quality circles and just-in-time production are positively associated with CTD rates and statistically significantly different from zero. These two workplace transformation variables collectively account for roughly fifty percent of the mean CTD rate in manufacturing.

In the remaining columns of Table 3, results are presented for the manufacturing sample with restrictions on the size of establishments. The results in Table 1 reveal that small establishments tend to have much smaller rates of cumulative trauma disorders. This is perhaps due to the fact that the division of labor and specialization which is associated with repetitive job tasks typically also gives rise to economies of scale and thereby large plant sizes. The results in Table 2 show that smaller plants also tend to be less transformed, perhaps because they are less needful of small-group mechanisms for worker input, such as quality circles and teams, which are attempts to overcome the ways in which large, bureaucratic organizations stifle worker input. The results in the remaining columns of Table 3 reveal that both the quantitative and statistical significance of the quality circles and just-in-time variables increase as the sample is restricted to larger size establishments.

We have said nothing thus far about the job rotation variable, whose estimated coefficient is positive and statistically significant in all of the results of Table 3. While job rotation is a common feature in transformed workplaces, where a premium is placed on flexible and multi-skilled workers, it has a much longer history in U.S. manufacturing, where it has served other purposes beyond flexibility and productivity. One of those purposes is to reduce fatigue and stress related to repetitive motion. Indeed, the contemporary case study literature is clear that job rotation is generally a palliative to rising problems of cumulative trauma disorders (e.g., Rinehart et al. 1997). The positive relationship between rotation and CTDs is, thus, at first blush rather surprising. But, of course, if job rotation serves in part to reduce problems associated with repetitive job tasks, then it is also more likely to exist where CTD rates are high.

That is, the positive relationship between job rotation and CTD rates may be due to endogeneity bias. The data do not allow us to employ instrumental variables techniques to test this proposition more formally. However, the cross-industry analysis cited earlier – utilizing a different data set – did provide such an opportunity, and the results from that work offer considerable support for the claim that the estimated coefficient on the job rotation variable suffers from endogeneity bias (Fairris and Brenner 2001). In this prior work the estimated coefficient on the instrumented job rotation variable became negative, albeit statistically insignificant. None of the other results, however, were substantively altered by the correction for endogeneity bias.

Some of the relationships between various control variables and CTD rates in the results of Table 3 are also worthy of mention. The positive relationship between CTDs and the percentage of the workforce that is inexperienced, and the negative relationship between CTDs and the percent part-time, seem sensible. Repetitive strains are less likely to occur, ceteris paribus, when muscles, nerves and tendons are experienced and better-prepared and when workers are thoroughly familiar with job tasks and their potential ergonomic hazards, and more likely to occur the longer is the amount of time spent doing a repetitive task. This is consistent with case study findings. Repetitive strains tend to spike during the early stages of a model change in auto manufacturing, for example, when workers' are acclimating to newly-designed repetitive tasks (e.g., Adler, Goldoftas, and Levine 1997). Repetitive strains also seem to increase when the length of the workday increases (Rinehart et al. 1997, p. 71).

The positive relationship between CTDs and percentage union is puzzling, but similar results were found in an earlier analysis of repetitive motion disorders (Fairris and Brenner 2001), and it is a common finding in the literature on workplace health and safety more generally (Fairris 1992). Various hypotheses exist to explain this relationship, but few of them have been subjected to careful empirical research. Although repetitive motion disorders must have existed to some extent throughout the history of highly-repetitive job tasks, they have only recently come to be viewed by employers and health officials as serious job-related health concerns. Unions may put pressure on employers to acknowledge CTDs as a serious health concern and to more accurately record and report their existence in production. In this case, the positive relationship between CTDs and percent union may be due to reporting bias. Alternatively, it may be the case that repetitive job tasks generally are less appealing to workers, and that the workplace discontent to which they give rise also fosters union organizing activity. The positive association between CTDs and percent union thus might reflect the fact that unions are more likely to exist in establishments where job tasks are repetitive, which is precisely where repetitive motion disorders themselves are more likely to occur. In this case, the positive association is due to endogeneity bias.

The concave relationship between CTDs and establishment size is a common finding in the literature on workplace health and safety. One plausible explanation for this relationship is that experience rating of workers' compensation premiums typically exists only for larger size establishments. According to this view, then, it is the monetary incentive provided by experience-rated premiums that accounts for the superior health and safety performance of the truly large establishments compared to that of medium size establishments (Ruser 1985).[10]

Finally, although we have not reported these results to conserve space, a number of the industry categorical variables are statistically significant in the manufacturing sector. This seems natural given the differing nature of production and industrial relations across industries. However, it raises a related question that is more interesting for the subject of this paper – namely, whether the impact of workplace transformation is different across manufacturing industries. This seems most plausible, for no matter how problematic a just-in-time inventory system may be for CTDs more generally, it is unlikely to have a significant impact on such disorders in industries where the production process does not require repetitive or awkward motions on the part of workers. In order to test for differences such as this, we interacted the 2-digit manufacturing industry categorical variables with the workplace transformation variables. The results (which are available from the authors upon request) show a weak pattern of substantive differences in the impact of workplace transformation on CTDs across industries. For example, the impact of quality circles on CTDs is positively and quantitatively larger in the transportation equipment industry than in any other industry. Teams have a positive and statistically significant impact on CTDs in the furniture and fixtures industry, but in no other industry.

We turn now to a number of specification concerns that might arise with regards to the results thus far presented. The first specification issue to which we devote some energy stems from the peculiar distribution of CTD rates across establishments in our data. Roughly 57

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[10] Alternatively, many other, largely untested, explanations for this concave relationship have been advanced, such as economies of scale in the production of safety, the substitution of capital for labor in particularly dangerous occupations, and the larger fraction of workers in the safer clerical and sales job categories in large establishments. For a recent discussion, see chapter three of U.S. Department of Labor (1994, pp. 105-107).

percent of manufacturing establishments (and 88 percent of all establishments) reported zero CTDs in our sample. If the estimation model is one in which we are attempting to relate aspects of transformed workplaces to the proclivity for CTDs, the zero observations are probably not all alike with regard to this proclivity. This implies there may be a problem of left-censoring in the data, and raises the issue of possible bias in the OLS results.

A common solution to this problem is to estimate the desired regression equation with a Tobit technique. Table 4 reproduces the manufacturing regression results using the Tobit estimation method. In general, these results confirm the positive, statistically and quantitatively significant impact of just-in-time production and quality circles on CTDs. While the quality circles variable is only marginally significant in the column (1) results, and just-in-time production is only marginally significant in the column (2) results, otherwise the results are supportive of our earlier findings. In fact, the estimated quantitative impacts are universally larger in the Tobit regressions than in the OLS regressions. The most striking difference in the results of Table 4 is that the teams variable now emerges with a positive and statistically significant relationship to CTDs.

We view the Tobit results as an important check on the robustness of the OLS findings. However, estimation of the CTD equation with the Tobit method carries several important drawbacks. One important limitation is the fact that in effect the Tobit method jointly estimates two separate equations, and imposes structural similarity on the estimated coefficients in each. The first equation models the existence of CTDs as a dichotomous (0/1) variable, and the second models the extent of CTDs only for those establishments reporting positive values of repetitive motion disorders. However, there is no reason to believe that the impact of a particular workplace transformation variable on the probability of reporting a positive CTD rate should be the same as its impact on the size of CTD rates among those establishments reporting positive CTDs.[11] Imposing structural similarity restrictions on coefficients in both the existence and extent equations may yield biased estimates of the overall impact of workplace transformation on CTD rates.

The above reference to separate equations representing the existence and extent of CTDs sounds strikingly similar to the well-known Heckman two-step selection correction model. Indeed, Heckman (1976) has shown that the Tobit is a special case of his more general model for selection correction with the same independent variables in both steps of the model. Because of the potentially important distinction between the effects of workplace transformation on the existence versus the extent of cumulative trauma disorders, and related bias in the Tobit results, we report in Table 5 the results of a Heckman two-step procedure applied to our manufacturing sample.

Several aspects of these results merit note. First, they strengthen our conclusion concerning the statistical significance and quantitative importance of the just-in-time and quality circle variables found in the previous results. In all three specifications both variables are statistically significant at the five-percent level and collectively they account for more than sixty percent of the mean CTD rate. Second, a comparison of the first and second stage estimates in Table 5 suggests that the Tobit model's assumption of structurally similar coefficients across the existence and extent equations is probably inappropriate. A striking example of this is the teams variable, which is positive and statistically significant in the first stage probit equations, but insignificant and usually negative in the second stage, selection-corrected regressions. Finally, the fact that the Inverse Mills ratio (i.e., the Lambda variable in the table) is statistically significant in all three specifications seems to confirm the fear that left-censoring of our

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[11] Cragg (1971) raises similar issues concerning the difference between the existence and extent equations.

dependent variable introduces bias in the OLS results. Interestingly, while correcting for this bias affects the point estimates for our workplace transformation variables, it does not, by and large, appear to affect the sign or statistical significance of the earlier OLS estimates. More important, if anything the OLS results appear to understate the quantitative importance of the effect of quality circles and just-in-time on the mean CTD rate.

Next we turn to a second set of specification concerns, namely whether our results are influenced by the omission of important control variables. As with most regression analyses, ours is constrained in the kinds of control variables to which we have access. However, in Table 6, we present estimated manufacturing CTD equations in which two specific omitted-variable bias concerns are addressed.[12] The specification in columns 1-3 adds controls for health benefits and sick leave. Workers may be more likely to report health and safety conditions if they possess private forms of compensation to cover them. This may be especially important in cases where employers contest employees' claims made through the workers compensation system. A case can also be made that these kinds of benefits are more likely to exist in workplaces that also happen to be undergoing transformation, thereby explaining the positive estimated coefficients on our workplace transformation variables as a form of omitted-variable bias. These results reveal little reason for concern in this regard.

In columns 4-6 we control for whether a given establishment resides in a state that mandates the existence of health and safety teams. Twelve states possessed such mandates in the survey year.[13] The "mandatory teams" dummy variable equals one if an establishment resides in

[12] Utilizing the other estimation techniques and various establishment size restrictions of our earlier analyses yielded very similar findings. We focus on the OLS results here in order to conserve space.

[13] We would like to thank Barbara Webster and Glenn Pransky at the Liberty Mutual Center for Disability Research for providing us with information on the states with safety and health team legislation. In point of fact, only four states, Minnesota, North Carolina, Oregon and Washington had safety team legislation on the books before 1993, the year of our survey. However in 1993, another eight states, Alaska, Connecticut, Florida, Montana, Nevada, Nebraska, New Hampshire, Pennsylvania, and Tennessee, passed safety team legislation. For caution's sake we

one of these twelve states. The concern that motivates the addition of this variable into the analysis is that the workplace transformation variables might be correlated with health and safety teams, and to the extent health and safety teams are themselves mandated because of high injury rates and health disorders, the positive estimated coefficients on the workplace transformation variables might be the result of a combination of omitted-variable and endogeneity bias. The results reveal little reason for concern, as the estimated coefficient on the mandatory teams variable is negative (although statistically insignificant), and its inclusion has virtually no impact on the estimated coefficients of the workplace transformation variables.[14]

Another specification issue involves the possible clustering of workplace transformation variables into unique workplace "systems." Prior research has been quite clear that many recent innovations in the workplace are introduced in clusters (e.g., Appelbaum and Batt 1994), and indeed some researchers have attempted to explicitly model these clusters or "systems" in their empirical work (e.g., Ickniowski et al. 1997). Would such an approach be appropriate in our case, and, if so, would it change our fundamental conclusions? Past research utilizing the SEPT data has addressed the first part of this question. Gittleman et al. (1998, pp. 105-106) ask, "Can establishments naturally be grouped into categories (in these data) based on their pattern of using alternative work practices?" Invoking a cluster analysis to explore this issue, the authors find that "(b)y the time the clustering algorithm reached a reasonable number of clusters, the clusters tended to be quite heterogeneous and thus difficult to characterize."

Our empirical attempts to discern clusters in the full data set yielded results similar to those of Gittleman et al. However, in the manufacturing sample the evidence of clustering is

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count all 12 as having safety teams in 1993, however we have run the results with only the first four states and they are substantively the same.

[14] Results are similar if we exclude entirely those establishments residing in states that mandate safety and health teams.

marginally greater. Looking only at simple correlations, for example, we find four correlations between workplace transformation variables that are larger than 0.3. The largest correlation (0.40) exists between just-in-time production and teams, followed by teams and quality circles (0.36), just-in-time production methods and job rotation (0.33), and teams and total quality management (0.33).

In Table 7, we present the results of an interactive specification of the CTD equation on the manufacturing sample, in which interaction terms are entered for the four workplace transformation interactions just mentioned. We also include an interaction term for just-in-time production and quality circles (although the correlation between them was only 0.21) because these two variables have been highly significant in prior findings.

These results are generally supportive of our earlier conclusion that just-in-time production methods and quality circles have positive and statistically significant effects on CTDs. The interactive results suggest, however, that these effects are most pronounced when the two practices are coupled rather than when they exist separately. Indeed, the uninteracted just-in-time and quality circles variables are rarely statistically significant, whereas their interactive term is statistically significant in most cases. These positive effects also have a quantitative impact on CTDs comparable to our earlier findings, accounting for an average of almost forty percent of the mean CTD rate across the nine specifications in Table 7.

Another set of results from the interactive specifications also merits discussion – namely those for the teams and total quality management variables. In Table 7 both uninteracted variables emerge as positive and statistically significant more frequently than in previous specifications, and their interactive term is consistently negative and statistically significant across all the models presented in Table 7. This suggests that establishments with either one or the other workplace feature suffer from heightened CTDs, and in some cases quite substantially. However, when these two features are coupled, there is a considerable mitigating effect on CTDs, as evidenced by the magnitude and sign of the interactive coefficient.

While these results are broadly suggestive of the more precise manner in which the various work practices affect CTDs, we feel that a good deal of caution is also warranted. For example, our data on workplace transformation do not appear rich enough to permit us to identify systems of work practices using the more sophisticated cluster analyses seen in the literature.[15] More importantly, the methods we have been able to employ – namely a series of dummy variable interactions – are likely to contribute to problems of multicollinearity, with the fragility this entails. Ultimately, this issue of the relationship between work systems and CTDs remains an area for future research.

The question that remains to be answered from the total array of findings we have presented thus far is what accounts for the relationships we observe between aspects of transformed workplaces and CTDs? Critics of workplace reform find in the existing case study evidence a convincing explanation – namely, that workplace transformation decreases worker control over the pace and timing of work. For example, a just-in-time approach to production eliminates buffer stocks and integrates more off-line production jobs into the main assembly line, thereby preventing a larger number of workers from working ahead or building up banks. This acts to reduce worker autonomy over the pace of production, forcing a similar and constant rhythm of work throughout the plant. In a plant studied by Klein, autonomous worker groups became disempowered in precisely this way with the introduction of just-in-time procedures (Klein 1989). Critics also contend that quality circles circumvent the ability of unions to

[15] For example Ichniowski et al. (1997) analyze up to 15 different human resource practices across the 36 production lines they study in order to identify their four systems of work practices.

influence shopfloor conditions, thereby undercutting workers' efforts to resist speedups and decreased cycle times, both of which are associated with cumulative trauma disorders. Quality circles are also seen by these critics as inclining workers to feel responsible for improving productivity and quality in production, perhaps at the cost of sacrificing health and safety (e.g., Parker 1985).

We believe that further case study analysis is required before we can reach any firm conclusions regarding the specific link between workplace reform and CTDs. Some of the explanations offered in the critical literature seem compelling to us, but there are nagging questions as well. Quality circles are viewed by many as mechanisms for employee involvement, which is seen as "best practice" in addressing problems of occupational safety and health. The critical literature disagrees, but its claims of reduced worker control have also been lodged against work teams and total quality management, and yet we find little consistent evidence that in the aggregate these aspects of transformed workplaces significantly affect CTDs. Why quality circles and just-in-time production in particular? The answer to this question may best be found in case study analyses which pattern themselves after the careful work of Ichniowski, Shaw, and Prennushi (1997), who have explored the relationship between workplace transformation and productivity. It is our hope that the findings of the present paper will spur scholars to undertake such an effort.

V. Conclusion

This study – which links establishment-level survey data on quality circles, just-in-time production, work teams, and total quality management systems to data on the rates of cumulative trauma disorders in these same establishments – offers the best evidence yet available on the impact of workplace transformation on CTDs. The results are not heartening. In most of the results presented in this paper, just-in-time approaches to production and quality circles are both positively and statistically significantly associated with CTD rates across establishments. Moreover, their quantitative impact on CTD rates is sizeable, varying from 20 to 65 percent of the mean CTD rate depending on the sample analyzed and estimation technique employed.

We were spurred to pursue this research by case study findings, largely from the auto industry, which seemed to implicate workplace transformation in the rising problem of repetitive motion disorders. One finds in the case study literature suggestions as to why just-in-time production and quality circles are positively related to CTDs; the explanations are typically grounded in such things as reduced cycle times, speed-ups, ill-fitting parts, increased worker responsibility and reduced worker empowerment. However, the link between these changes in production and just-in-time inventory controls or quality circles is not fully transparent. Thus, future research should be directed at establishing a better understanding of the present findings. Case study analyses first raised the possibility of a connection between workplace transformation and cumulative trauma disorders. It is ultimately to this type of analysis that we must return for a deeper understanding of precisely why the two appear to be so interrelated.

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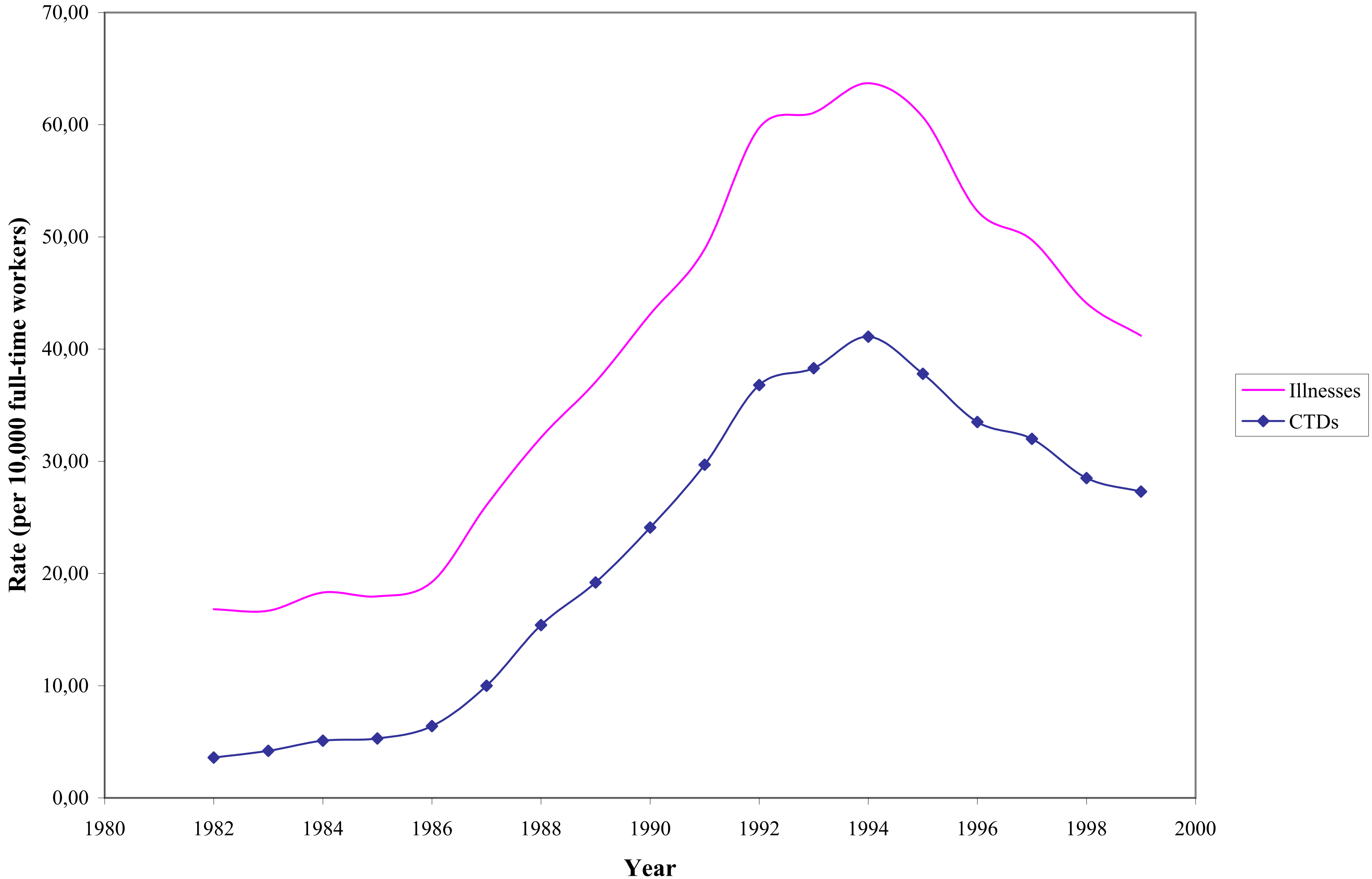
Figure 1. Rate of New Illnesses and New Cumulative Trauma Disorders, 1982-1999



Source: US Bureau of Labor Statistics, Occupational Injuries and Illnesses in the United States by Industry, various years.

Table 1. Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers) by Industry and Establishment Size, 1993

Number of employees	All industries		Manufacturing		Nonmanufacturing	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
All	0,24	1,54	1,20	3,64	0,07	0,45
	(n=1,848)		(n=735)		(n=1113)	
<50	0,04	0,44	0,00	0,00	0,04	0,46
	(n=206)		(n=35)		(n=171)	
50-249	0,07	0,47	0,38	1,17	0,04	0,27
	(n=479)		(n=148)		(n=331)	
250-499	0,68	2,99	1,96	5,02	0,08	0,31
	(n=275)		(n=127)		(n=148)	
500-999	0,86	1,75	1,41	2,29	0,44	1,00
	(n=265)		(n=152)		(n=113)	
1000+	1,02	3,41	2,66	5,53	0,23	0,75
	(n=623)		(n=273)		(n=350)	

Table 2. Sample Statistics, Weighted by Number of Employees

Independent Variables	All Industries					
	All Sizes		More than 50 Employees		More than 250 Employees	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Total quality management (yes=1)	0,54	0,09	0,63	0,10	0,57	0,03
Just in time (yes=1)	0,16	0,04	0,16	0,05	0,25	0,02
Teams (yes=1)	0,25	0,05	0,29	0,08	0,50	0,03
Quality circles (yes=1)	0,10	0,03	0,12	0,04	0,17	0,02
Job rotation (yes=1)	0,19	0,04	0,19	0,05	0,30	0,03
Safety and health training (yes=1)	0,62	0,11	0,62	0,17	0,91	0,02
Employment	533	97	828	224	2141	179
Percent inexperienced	21,33	1,27	21,89	1,02	19,28	1,23
Percent part-time	17,78	1,59	16,87	1,46	15,69	1,67
Percent union	9,71	2,03	12,61	3,67	18,74	1,57
	n=1848		n=1666		n=1163	
	Manufacturing					
	All Sizes		More than 50 Employees		More than 250 Employees	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Total quality management (yes=1)	0,56	0,04	0,59	0,04	0,68	0,03
Just in time (yes=1)	0,43	0,04	0,48	0,03	0,51	0,03
Teams (yes=1)	0,47	0,04	0,52	0,03	0,66	0,03
Quality circles (yes=1)	0,20	0,03	0,21	0,02	0,25	0,02
Job rotation (yes=1)	0,39	0,04	0,43	0,04	0,44	0,03
Safety and health training (yes=1)	0,90	0,02	0,92	0,02	0,96	0,02
Employment	1 036	125	1 300	149	1958	210
Percent inexperienced	13,14	1,07	12,73	0,91	11,23	1,20
Percent part-time	3,47	0,49	2,78	0,36	2,70	0,31
Percent union	23,60	2,78	28,10	2,97	30,08	2,23
	n=735		n=700		n=552	

Table 3. OLS Regression Results
Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers)
All Industries and Manufacturing

Independent Variables	All Industries		Manufacturing					
	All Sizes		All Sizes		More than 50 Employees		More than 250 Employees	
	(1)		(2)		(3)		(4)	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Total quality management (yes=1)	0,017	0,12	0,177	0,39	0,092	0,16	0,319	0,42
Just in time (yes=1)	0,304	2,54	0,782	3,06	0,766	2,75	0,942	2,28
Teams (yes=1)	0,047	0,57	0,089	0,33	0,088	0,20	-0,515	0,70
Quality circles (yes=1)	0,215	1,32	0,754	1,71	0,921	1,86	1,258	2,02
Job rotation (yes=1)	0,219	1,93	0,680	2,55	0,811	2,56	1,542	3,66
Percent inexperienced	0,005	1,65	0,025	2,15	0,019	1,14	0,017	0,63
Percent part-time	-0,004	2,04	-0,029	1,65	-0,026	1,19	-0,014	0,41
Percent union	0,004	1,84	0,009	1,46	0,008	1,21	0,012	1,35
Safety and health training (yes=1)	-0,008	0,05	-1,185	1,01	-1,413	0,88	-4,766	1,17
Employment*	0,470	1,80	9,893	3,40	8,320	2,78	5,434	1,87
Employment Squared*	-0,167	1,76	-9,370	3,09	-8,090	2,63	-5,870	1,97
Industry Controls**	Yes		Yes		Yes		Yes	
	R-squared=0.18 n=1848		R-squared=0.19 n=735		R-squared=0.18 n=700		R-squared=0.22 n=552	

* Employment in this table represents the number of employees divided by 10,000.
** 2-digit SIC controls.

Table 4. Tobit Regression Results
Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers)
Manufacturing

Independent Variables	All Sizes (1)		More than 50 Employees (2)		More than 250 Employees (3)	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Total quality management (yes=1)	0,523	0,58	0,402	0,46	0,567	0,60
Just in time (yes=1)	1,078	1,75	0,875	1,51	1,058	1,85
Teams (yes=1)	1,300	1,89	1,091	1,50	-0,133	-0,15
Quality circles (yes=1)	1,067	1,40	1,488	2,18	1,376	1,90
Job rotation (yes=1)	1,408	2,38	1,467	2,73	2,190	3,80
Percent inexperienced	0,063	2,27	0,041	1,58	0,027	0,82
Percent part-time	-0,092	-2,32	-0,065	-1,76	-0,021	-0,42
Percent union	0,032	3,12	0,023	2,30	0,022	2,02
Safety and health training (yes=1)	-1,725	-0,75	-1,868	-0,75	-5,862	-1,29
Employment*	25,03	4,15	18,08	3,78	10,75	2,80
Employment Squared*	-20,06	-3,67	-14,65	-3,32	-9,012	-2,50
Industry Controls**	Yes		Yes		Yes	
	n=735		n=700		n=552	

* Employment in this table represents the number of employees divided by 10,000.
** 2-digit SIC controls.

Table 5. Heckman Two-Step Regression Results
Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers)
Manufacturing

Panel A - First Stage Probit Results

Independent Variables	All Sizes (1)		More than 50 Employees (2)		More than 250 Employees (3)	
	Coefficient	Z-Statistic	Coefficient	Z-Statistic	Coefficient	Z-Statistic
Total quality management (yes=1)	0,102	0,78	0,100	0,79	0,169	1,11
Just in time (yes=1)	0,105	0,72	0,008	0,06	-0,002	-0,01
Teams (yes=1)	0,312	2,14	0,330	2,34	0,223	1,30
Quality circles (yes=1)	0,037	0,24	0,199	1,32	-0,062	-0,37
Job rotation (yes=1)	0,274	2,07	0,346	2,71	0,541	3,58
Percent inexperienced	0,013	3,03	0,008	1,83	0,003	0,57
Percent part-time	-0,023	-2,69	-0,017	-2,08	-0,009	-0,86
Percent union	0,008	3,83	0,006	3,12	0,006	2,56
Safety and health training (yes=1)	-0,138	-0,66	-0,096	-0,46	-0,671	-1,98
Employment*	14,00	9,69	9,978	7,65	6,546	5,12
Employment Squared*	-10,08	-8,21	-6,944	-6,10	-4,275	-3,51
Industry Controls**	Yes		Yes		Yes	
	Log Likelihood=-305.05 n=735		Log Likelihood=-321.29 n=700		Log Likelihood=-237.66 n=542	

Panel B - Second Stage Selection-Corrected Regression Results

Independent Variables	All Industries					
	All Sizes (1)		More than 50 Employees (2)		More than 250 Employees (3)	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Total quality management (yes=1)	0,152	0,28	0,231	0,41	0,339	0,52
Just in time (yes=1)	1,559	2,82	1,543	2,70	1,522	2,31
Teams (yes=1)	-0,010	-0,02	0,198	0,29	-0,507	-0,67
Quality circles (yes=1)	1,090	2,05	1,307	2,33	1,632	2,62
Job rotation (yes=1)	1,141	2,36	1,349	2,60	2,021	3,16
Percent inexperienced	0,050	2,47	0,052	2,52	0,040	1,59
Percent part-time	-0,029	-0,69	-0,033	-0,79	-0,010	-0,21
Percent union	0,022	2,68	0,024	2,81	0,025	2,50
Safety and health training (yes=1)	-3,299	-3,25	-3,343	-3,24	-6,264	-4,44
Employment*	12,69	2,95	14,66	3,21	10,67	2,34
Employment Squared*	-10,67	-3,18	-11,78	-3,38	-8,636	-2,54
Lambda	2,173	2,08	3,660	2,57	4,376	2,13
Industry Controls**	Yes		Yes		Yes	
	R-squared=0.20 n=451		R-squared=0.21 n=451		R-squared=0.24 n=406	

* Employment in this table represents the number of employees divided by 10,000.
** 2-digit SIC controls.

Table 6. Regression Results with Additional Controls
Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers)
All Manufacturing

Independent Variables	**OLS** (1)	**Tobit** (2)	**Heckman** (3)	**OLS** (4)	**Tobit** (5)	**Heckman** (6)
Total quality management (yes=1)	0,167	0,471	0,144	0,179	0,517	0,154
	0,38	*0,54*	*0,26*	*0,39*	*0,58*	*0,28*
Just in time (yes=1)	0,774	1,049	1,555	0,752	1,016	1,545
	3,01	*1,73*	*2,81*	*2,93*	*1,66*	*2,78*
Teams (yes=1)	0,110	1,390	-0,042	0,108	1,299	-0,006
	0,43	*2,08*	*-0,06*	*0,40*	*1,89*	*-0,01*
Quality circles (yes=1)	0,742	0,985	1,072	0,713	0,973	1,055
	1,66	*1,29*	*2,02*	*1,62*	*1,28*	*1,97*
Job rotation (yes=1)	0,668	1,336	1,085	0,710	1,502	1,178
	2,40	*2,22*	*2,23*	*2,67*	*2,51*	*2,39*
Health Benefits	0,050	0,213	0,302	-	-	-
	0,17	*0,15*	*0,23*			
Sick Leave	0,210	1,286	0,480	-	-	-
	0,47	*1,22*	*0,68*			
Mandatory Teams	-	-	-	-0,433	-0,948	-0,325
				-1,14	*-1,10*	*-0,50*
Percent inexperienced	0,026	0,068	0,050	0,025	0,060	0,049
	2,16	*2,40*	*2,46*	*2,17*	*2,25*	*2,42*
Percent part-time	-0,029	-0,094	-0,027	-0,028	-0,088	-0,027
	-1,66	*-2,38*	*-0,66*	*-1,64*	*-2,28*	*-0,65*
Percent union	0,008	0,031	0,021	0,009	0,032	0,022
	1,33	*2,89*	*2,56*	*1,51*	*3,15*	*2,69*
Safety and health training (yes=1)	-1,234	-1,970	-3,366	-1,179	-1,728	-3,307
	-0,99	*-0,83*	*-3,29*	*-1,02*	*-0,76*	*-3,26*
Employment*	9,631	23,832	11,716	9,86	25,03	12,76
	3,28	*4,05*	*2,76*	*3,41*	*4,18*	*2,95*
Employment Squared*	-9,144	-18,981	-9,910	-9,39	-20,14	-10,745
	-2,97	*-3,51*	*-2,99*	*-3,11*	*-3,70*	*-3,19*
Lambda	-	-	1,994	-	-	2,191
			1,89			*2,09*
Industry Controls**	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0,19	-	0,20	0,19	-	0,20
Number of Observations	735	735	451	735	735	451

* Employment in this table represents the number of employees divided by 10,000.
** 2-digit SIC controls.

Table 7. Interactive Regression Results
Cumulative Trauma Disorders (Per 100 Full-time Equivalent Workers)
Manufacturing

	OLS			Tobit			Heckman		
Independent	All	>50	>250	All	>50	>250	All	>50	>250
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total quality management (yes=1)	0,916	0,929	2,012	1,952	1,868	2,948	1,444	1,672	2,530
	1,30	*1,15*	*1,92*	*1,41*	*1,46*	*2,11*	*1,80*	*2,01*	*2,44*
Just in time (yes=1)	0,071	-0,174	-0,399	1,464	0,386	-0,387	0,634	0,619	-0,034
	0,13	*-0,29*	*-0,38*	*1,14*	*0,31*	*-0,26*	*0,63*	*0,61*	*-0,03*
Teams (yes=1)	0,858	0,887	1,034	3,372	2,844	1,980	1,123	1,459	1,097
	1,89	*1,52*	*1,14*	*2,93*	*2,63*	*1,56*	*1,05*	*1,30*	*0,92*
Quality circles (yes=1)	-0,092	-0,257	-0,536	2,702	1,699	0,437	0,120	0,350	-0,818
	-0,22	*-0,52*	*-0,66*	*2,59*	*1,67*	*0,36*	*0,10*	*0,28*	*-0,55*
Job rotation (yes=1)	0,519	0,492	0,778	2,768	2,168	2,053	0,549	0,904	0,864
	1,41	*1,14*	*1,52*	*3,38*	*2,88*	*2,74*	*0,69*	*1,05*	*0,86*
Just in time * Teams	0,558	0,635	0,415	0,584	0,904	1,221	0,106	0,235	0,297
	1,07	*1,15*	*0,45*	*0,46*	*0,77*	*0,92*	*0,09*	*0,20*	*0,21*
Quality circles * Teams	0,110	0,187	0,594	-3,462	-2,394	-0,514	-0,025	-0,444	1,065
	0,22	*0,33*	*0,65*	*-2,80*	*-2,15*	*-0,40*	*-0,02*	*-0,28*	*0,62*
Just in time * job rotation	0,314	0,642	1,455	-2,330	-1,117	0,349	1,049	0,725	1,613
	0,49	*0,89*	*1,60*	*-2,00*	*-1,02*	*0,32*	*0,97*	*0,64*	*1,31*
Total quality management * teams	-1,709	-1,826	-3,046	-3,162	-3,106	-4,226	-2,193	-2,543	-3,576
	-2,05	*-1,98*	*-2,72*	*-2,03*	*-2,15*	*-2,75*	*-2,03*	*-2,26*	*-2,74*
Quality circles * just in time	1,363	1,679	2,097	1,967	2,623	2,116	1,591	1,997	2,344
	1,79	*2,15*	*2,06*	*1,45*	*2,19*	*1,69*	*1,32*	*1,58*	*1,77*
Percent inexperienced	0,023	0,018	0,013	0,050	0,035	0,018	0,045	0,046	0,030
	1,99	*1,08*	*0,46*	*1,98*	*1,37*	*0,55*	*2,25*	*2,27*	*1,23*
Percent part-time	-0,030	-0,029	-0,017	-0,087	-0,062	-0,023	-0,026	-0,028	0,008
	-1,66	*-1,26*	*-0,51*	*-2,19*	*-1,64*	*-0,47*	*-0,64*	*-0,67*	*0,16*
Percent union	0,010	0,008	0,013	0,033	0,024	0,024	0,023	0,024	0,022
	1,70	*1,28*	*1,63*	*3,16*	*2,38*	*2,32*	*2,77*	*2,88*	*2,42*
Safety and health training (yes=1)	-1,235	-1,164	-4,445	-1,800	-1,662	-5,375	-2,890	-2,957	-5,562
	-1,08	*-0,78*	*-1,19*	*-0,80*	*-0,70*	*-1,27*	*-2,82*	*-2,84*	*-4,29*
Employment*	9,919	7,911	4,797	24,82	18,02	10,34	11,78	13,36	6,426
	3,39	*2,74*	*1,77*	*4,22*	*3,87*	*2,82*	*2,84*	*3,04*	*1,55*
Employment Squared*	-9,110	-7,399	-4,934	-19,75	-14,27	-8,301	-9,694	-10,57	-5,480
	-3,06	*-2,54*	*-1,82*	*-3,70*	*-3,33*	*-2,45*	*-2,96*	*-3,12*	*-1,75*
Lambda	-	-	-	-	-	-	2,183	3,315	2,187
							2,12	2,49	1,22
Industry Controls**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0,21	0.20	0,25	-	-	-	0,23	0,23	0,28
Number of Observations	735	700	552	735	700	552	451	451	406

* Employment in this table represents the number of employees divided by 10,000.
** 2-digit SIC controls.