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Abstract

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Several studies have examined how the ISO 9001 Quality Management System standard affects organizational outcomes such as profits. This is the first large-scale study to examine its effects on employee outcomes such as employment, earnings, and health and safety. We analyzed a matched sample of nearly 1,000 companies in California. ISO 9001 adopters subsequently had far lower organizational death rates than a matched control group of non-adopters. Among surviving employers, ISO adopters realized higher rates of growth of sales, employment, payroll, and average annual earnings. Injury rates also declined slightly at ISO 9001 adopters, although total injury costs did not. These results have implications for organizational theory, managers, and public policy.

Key words: ISO 9001; quality management; standards; occupational health and safety; wages; labor; empirical; California

1. Introduction

Nearly 900,000 organizations in 170 countries have adopted the ISO 9001 Quality Management System standard,[1] a remarkable figure given the lack of rigorous evidence regarding how the standard actually affects organizational practices and performance. Implementing a quality management system

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[1] International Organization for Standardization, The ISO Survey of Certifications: 2006, available at http://www.iso.org/iso/iso_catalogue/management_standards/certification/the_iso_survey.htm (accessed May 21, 2008).

that conforms to ISO 9001 requires companies to document operating procedures, training, internal auditing, and corrective action procedures. It also requires companies to implement procedures to improve existing procedures.

Proponents claim quality programs such as ISO 9001 improve both management practices and production processes and that these improvements, in turn, will increase both sales and employment (unless productivity gains outweigh sales increases). The latter benefits are magnified if customers use the adoption of ISO 9001 or other quality programs as a signal of high quality products or services. To the extent that greater employee skill and training are required to develop and implement procedures to improve procedures, the theory of human capital suggests that employees' earnings should rise as well. Finally, ISO 9001 can improve worker safety through the identification and elimination of potentially hazardous practices, development of a formal corrective action process, and institutionalization of routine audits and management reviews. Some critics point to the potential for quality programs such as ISO 9001 to harm employees by formalizing and documenting work practices. Such routinization may reduce skill requirements and increase cumulative trauma disorders (e.g., Brenner, Fairris, and Ruser 2004).

In this paper, we report the first large-scale empirical evaluation of how ISO 9001 affects workers, focusing in particular on employment, total payroll, average annual earnings, and workplace health and safety. We also examine several outcomes of vital importance to company managers and owners, including whether ISO 9001 is associated with subsequent sales growth and longer company survival. We examined single-plant firms across an array of industries in California, comparing ISO 9001 adopters to comparison groups of non-adopters matched on industry, location, size (baseline sales, employment, and total payroll), and pre-adoption injury rates. We employed a difference-in-differences approach that accommodates common shocks that affect each industry. When appropriate, we also control for company characteristics that vary over time such as size and changes in occupational mix.

We find ISO adopters to have higher rates of corporate survival, sales and employment growth, and wage increases than the matched control groups of non-adopters. While we find that adopters become more likely to report no injury rates (as measured by workers' compensation claims) in the years following adoption, we find no evidence that a firm's total or average injury costs improved or worsened subsequent to adoption.

2. Literature

In this section, we review the literature that has addressed how ISO 9001 predicts changes in outcomes of interest to owners and managers, such as profitability, and then discuss the much smaller literature on how ISO 9001 affects changes in outcomes of interest to employees, such as employment and injury rates.

2.1 Organizational outcomes

A few careful empirical studies have examined how implementing the ISO 9001 quality management standard affects employers' outcomes and practice.[2] Most of these studies examine the impact of ISO 9001 on manufacturers in the United States. Terlaak and King (2006) find that plants that adopt ISO 9001 typically increase their rate of production growth. Others find ISO 9001 certification to be associated with subsequent abnormal returns along a host of financial metrics including stock prices (Corbett, Luca, and Pan 2003; Sharma 2005). Various studies find benefits strongest among small firms (Docking and Dowen 1999; McGuire and Dilts 2008) and among those with a modest level of technological diversity, and/or early adopters (Benner and Veloso 2008). King and Lenox's (2001) finding that adopting ISO 9001 leads plants to reduce waste generation and toxic chemical emissions suggests that implementing the quality management standard has positive spillover effects that can improve environmental management practices. Naveh and Erez (2006) deduce from survey data that ISO 9001 adoption enhances worker productivity and workers' attention to detail, but impedes worker innovation. Interestingly, we found no prior research that examines how the ISO 9001 quality standard affects product or process quality, nor how it affects employees. Similarly, albeit outside the realm of ISO 9001, a number of event studies find that financial performance, as measured by stock price and operating income, improves after firms win a

[2] A much larger literature examines why firms adopt the ISO 9000 standard. See Corbett, Montes-Sancho and Kirsch (2005) for a comprehensive review.

quality award and implement Total Quality Management programs (Easton and Jarrell 1998; Hendricks and Singhal 1996, 1997, 2001a, 2001b).[3]

Several studies have found ISO 9001 adopters' financial performance to be superior to that of peers *prior to*, but not *after*, registration (see Heras, Gavin, and Dick 2002 for evidence from Spain; Häversjö 2000 for Denmark; and Simmons and White 1999 for the United States). These studies are consistent with a positive selection effect, but do not suggest that any causal benefits are associated with ISO registration. We return to the distinction between correlation and causality in the subsequent analyses.

2.2 Employee outcomes

We found almost no prior research that examines how the ISO 9001 quality management standard affects key outcomes of interest to employees, such as employment and earnings.[4] Among the few studies that have examined how other quality programs affect occupational health and safety is Adler, Goldoftas, and Levine's (1997) case study of a General Motors automobile plant. They found that the plant's suspension of job rotation subsequent to the adoption and implementation of the Toyota Production System's quality principles precipitated a dramatic rise in cumulative trauma disorders (CTDs), leading the authors to conclude that Toyota Production System principles such as short cycle times, standardized work methods, and minimizing worker idle time increase the risk of CTDs. These findings are consistent with those of Wokutch's (1992) study of Japanese auto transplants in the United States. Adler *et al.* (1997) further found that other Toyota Production System principles such as employee focus on continuous improvement could help reduce injury rates, provided employees were empowered to focus on safety and health issues.

A few larger-scale studies have examined the relationship between quality management practices and worker injuries. Lean production practices such as faster work pace and reduced cycle time have been

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[3] See Wayhan and Balderson (2007) for a comprehensive review of studies that examine how implementing Total Quality Management affects financial performance.

[4] In a suggestive small study (45 ISO adopters), O'Connor (2005) finds that Oregon employers with ISO certification increased employment more rapidly than peers in their industry. That analysis did not control for employer size and did not test for statistical significance.

found to be positively associated with worker stress (Conti *et al.* 2006) and quality circles and job rotation with CTDs (Brenner *et al.* 2004). But these studies' reliance on data collected simultaneously for workplace practices and illness/injury rates precludes distinguishing selection from causal effects.[5]

Naveh and Marcus's (2007) analysis of the road safety experience of 40 ISO 9002 adopters in the trucking industry found the number of accidents post adoption to be reduced faster by certified firms than by their peers. Presumably due to the modest sample size, the results are not consistently statistically significant.

This paper reports the results of the first large-scale study to examine the effects of ISO 9001 on employee outcomes. Among the worker-level outcomes on which we focus are wages and the frequency and magnitude of worker injuries. We also examine the effects of ISO 9001 on a number of organizational outcomes including sales, employment, and company survival. Our empirical approach of constructing and analyzing a panel dataset of plant-level data on a wide array of worker outcomes overcomes the small sample sizes and/or lack of longitudinal data that have plagued previous studies. Because ISO 9001 is typically adopted at the plant-level and outcome data typically available only at the firm level, we focus on single-plant firms. Our data and methods enable us to clearly distinguish the effects of selection on observables from causal effects. Moreover, whereas prior studies of safety and health have largely relied on self-reported survey data, we measure the frequency and cost of injury using workers' compensation data, which render our measures of occupational health and safety outcomes less susceptible to measurement error and potential bias arising from *ex post* rationalization by the managers who decided to invest in the quality management practices being evaluated.

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[5] For example, Brenner, Fairris, and Ruser (2004) interpret the positive association of unions with cumulative trauma disorders as selection effects of unionization, the positive association of job rotation with cumulative trauma disorders as reverse causality (whereby high rates of repetitive motion injuries lead plants to introduce job rotation), and the positive association of quality circles and just-in-time production with cumulative trauma disorders as causal effects of the work practices. Attempting to address causality by analyzing panel data, Fairris and Brenner (2001) found that CTD rates in *their industry* declined after plants adopted self-directed work teams or Total Quality Management, but *average industry* CTD rates increased after plants implemented quality circles or job rotation. Because they could link workplace practices only to industry-level (3-digit SIC codes) CTD rates, it is difficult to interpret these results.

3. Theory and Hypotheses

Companies that implement a quality management system that conforms to ISO 9001 typically improve the documentation of operating procedures, training, and procedures for corrective action. To become certified to the ISO 9001 standard, a plant hires an accredited third-party auditor to certify that the plant has (1) written procedures for all significant operations, (2) training, monitoring, and other procedures in place to ensure that written procedures are followed, and (3) implemented procedures for continuously improving its other procedures. The latter requirement has implications for training, decision-making, and incentives with respect to low-level employees. The cost of implementing ISO 9001, which includes developing procedures, documentation, and training and hiring a third-party auditor, range from $97,000 to $560,000, depending on the size and complexity of the operation (Docking and Dowen 1999).[6]

3.1 ISO 9001 and changes in plant scale

The value of ISO 9001 certification lies in a combination of *learning, incentives*, and *signaling.* The *learning* channel operates if the ISO 9001 certification process teaches managers how to reduce costs or cost-effectively improve quality. The *incentives* channel operates if ISO 9001 certification increases customers' willingness to pay for quality, which, in turn, is an incentive for managers to improve product quality. The *signaling* channel, like the *incentives* channel, operates if, in the absence of ISO 9001, many customers cannot detect (and thus are unwilling to pay for) improvements in product or service quality. In such cases, certification could be a useful signal that enables buyers to distinguish higher- from lower-quality firms (Spence 1973). ISO 9001 can play this signaling role as long as adoption is more often profitable for firms that already had higher quality, as Terlaak and King (2006) argue.

All of these channels yield higher unit sales and/or higher prices. There is considerable evidence, moreover, consistent with these channels, that many industrial buyers use ISO 9001 certification to screen

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[6] Docking and Dowen's (1999) reported average cost estimates range from $71,000 to $409,000 in 1996 dollars, which we adjusted for inflation using the Inflation Calculator created by the U.S. Department of Labor's Bureau of Labor Statistics (available at http://www.bls.gov/; accessed June 7, 2008).

potential suppliers (e.g., Ferguson 1996).

All of these channels give rise to the same predictions.

HYPOTHESIS 1a: *ISO 9001 certification leads to higher rates of firm survival.*

HYPOTHESIS 1b: *ISO 9001 certification leads to higher sales.*

If the hypothesized increase in sales is due to increased unit sales (rather than merely increased prices) that cannot be accommodated by existing worker capacity, ISO 9001 certification would increase employment.

HYPOTHESIS 2a*: ISO 9001 certification leads to higher employment, but by less than sales increases.*

Survey data further reveals that ISO 9001 can enhance worker productivity (Naveh and Erez 2006). If so, employment growth will be proportionately less than sales growth, leading to:[7]

HYPOTHESIS 2b: *ISO 9001 certification leads to higher labor productivity.*

3.2 ISO 9001 and wages

ISO 9001 can have positive or negative effects on wages.[8] Helper, Levine, and Bendoly (2002) found that attempts to foster employee involvement led to higher wages because companies sought to compensate employees for exerting the incremental effort to achieve the requisite higher skill levels. Employees of firms that adopt ISO 9001 are often asked to perform many discretionary tasks such as documenting new procedures and offering quality improvement ideas. ISO 9001 plants must develop and deploy quality-related training to ensure that employees properly implement new procedures and develop the skills required to conduct internal audits and root-cause analyses and continuously improve the plant's other procedures. These tasks require specific skills and imply increased reliance on employees' discretionary efforts. The higher discretionary effort might require more skills (as in theories of human capital), lead firms to pay higher wages to induce higher effort (as in efficiency wage theories [Levine

[7] If the productivity gain is greater than the increase in unit sales, employment can fall, a case we do not consider further.
[8] These hypotheses are elaborated in Helper *et al.* (2002).

1992]), or increase employees' bargaining power (Lindbeck and Snower 1986). If greater human capital, efficiency wages, and/or bargaining power are important, we have:

HYPOTHESIS 3: *ISO 9001 certification leads to higher wages.*

Ensuring that written procedures are present and followed typically implies a fairly routinized workplace. Such routinization can reduce frontline workers' skills, discretion, and bargaining power. We discovered in the course of our field research, for example, a plant that was implementing ISO 9001 with the express purpose of documenting workers' tacit knowledge and procedures so that the plant could be replicated overseas using lower cost labor. When these forces prevail, we have:

HYPOTHESIS 3′: *ISO 9001 certification leads to lower wages.*

3.3 ISO 9001 and occupational health and safety

Adopting ISO 9001 can improve occupational health and safety in a variety of ways. In the process of formally documenting procedures, managers can identify and eliminate hazardous practices and add safety precautions. Moreover, by fostering more focused attention to detail (Naveh and Erez 2006), ISO 9001 adoption can reveal new "win-win" opportunities for improving quality or efficiency *and* occupational health and safety that were previously obscured by indirect and distributed costs and benefits (King and Lenox 2001). Additionally, serious accidents can be avoided by organizations that have processes in place that provide warning signals and prompt corrective action (Marcus and Nichols 1999). Finally, routine auditing and corrective action procedures required by ISO 9001 for addressing management system failures encourage root-cause analysis, which can identify problematic work practices that would otherwise lead not only to quality failures, but also to occupational health and safety concerns.

Indeed, departments charged with managing quality sometimes also manage health and safety, and companies are increasingly implementing integrated management systems that incorporate all these areas (Toffel 2000; Barbeau *et al.* 2004). Implementing ISO 9001 can improve occupational health and safety if the tools of continuous improvement that often accompany certification are applied to problems in this area. Employees who know how to identify root causes of quality problems, for example, also have the skills to identify root causes of safety problems. Exploiting these opportunities yields:

HYPOTHESIS 4: *Adopting ISO 9001 reduces the number and cost of occupational injuries.*

ISO 9001 emphasizes routinization and standardization of tasks, but high rates of repetition and increased monitoring can increase stress and repetitive motion injuries, potentially worsening the safety records of plants with quality programs (as argued by Brenner *et al.* 2004). Additionally, a number of studies have found ISO 9001 adopters to have higher equipment utilization (Koc 2007; Huarng, Horng, and Chen 1999). To the extent that this translates into reduced employee downtime, this could increase employee fatigue, a major cause of injuries (Williamson and Boufous 2007). New quality management procedures implemented in association with ISO 9001 also sometimes add inspection tasks to work processes optimized for production rather than inspection, which can result in poor ergonomic conditions that leave employees susceptible to injuries (Landau and Peters 2006). In the presence of these forces, we have:

HYPOTHESIS 4′: *Adopting ISO 9001 increases the number and cost of occupational injuries.*

4. Data

4.1 Sample

Because the typical scope of an ISO 9001 certification is a single plant, but injury data from the workers' compensation system are available primarily at the company level, we facilitate the linking of ISO certification data to injury data by restricting our sample to single-plant firms. Roughly 80% of manufacturing plants in California are single-plant firms, according to 2005 Dun & Bradstreet data.

We obtained the identity and certification dates of ISO 9001 adopters from the *ISO 9000 Registered Company Directory* produced by QSU Publishing Company. According to this source, 5,995 companies in California were certified to ISO 9001 at the end of 2005. Linking this list of company names and addresses with Dun & Bradstreet data yielded 1,846 single-plant firms in California that had adopted ISO 9001.

We obtained annual workers' compensation and payroll data for 1993 through 2003 (the latest year then available due to reporting lags) from the Uniform Statistical Reporting Plan database of the Workers'

Compensation Insurance Rating Board (WCIRB), a nonprofit association of all firms licensed to provide workers' compensation insurance in California. WCIRB, which collects and analyzes workers' compensation claims for all employers covered by worker's compensation insurance in California, linked 77% (1,418) of our single-plant firms that had adopted ISO 9001 to its database. This proportion is similar to the proportion of California firms from which WCIRB gathers workers' compensation data (i.e., firms that obtain workers' compensation insurance rather than self-insure).

WCIRB provided us the names and addresses of the 116,389 non-adopting firms that shared the same region-industry combinations as the adopters. We then linked as many as possible to Dun & Bradstreet data and were able to confirm that 20,777 of the non-adopters were single-plant firms.

We then obtained annual employment and sales data for 1993-2005 from the National Establishment Time-Series (NETS) database, a compendium of Dun & Bradstreet data, for most of the ISO adopters and potential matches: 1,079 adopters and 18,480 non-adopters. Cleaning the data to eliminate firms with missing values and outliers (see details in the next section) reduced our sample to 916 adopters and 17,849 non-adopters. We used this sample for our selection analysis. Sample characteristics are provided in Table 1. As described below, we identified subsets of these firms to create matched samples for the analyses of the effects of ISO registration.

4.2 Measures

We measure each company's annual ***injury rate*** as the number of injuries it reported to claim workers' compensation, using WCIRB data. In our models, we employ the log of one plus the injury rate. We also obtained from WCIRB data each company's total annual workers' compensation ***injury costs*** (in dollars) and annual ***total payroll***[9] (in dollars). To reduce the effect of outliers, we took the log of these injury costs after adding $1,000. We also obtained from WCIRB data each company's location in one of 15 ***industries*** and 8 California ***region*** (both of which are listed in Table 1).

For each firm-year, we calculated ***average occupation riskiness*** as a weighted average of workers'

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[9] Our payroll measure is what WCIRB calls "exposure," which equals total payroll after subtracting overtime pay, shift premiums, and a few other minor adjustments for each of 500 occupational class codes.

compensation Pure Premium Rates across the firm's employment across 500 occupation codes.[10] To understand the intuition behind this measure, if an employer in a given year has a workforce that is in occupations that, on average, have twice the state-wide workers' compensation costs, *average occupational riskiness* for that firm-year would be twice the state average. For each year, we calculated each firm's ***average wage*** as annual total payroll (from WCIRB) divided by annual establishment employment (from Dun & Bradstreet).

We then cleaned the dataset as follows. We recoded sales of zero to missing. We omitted firm-years with less than $5,000 in payroll. To avoid confounding our analysis with rapidly growing or shrinking firms, we included only observations in which a firm's payroll in a given year was between half and twice its previous year payroll (provided the previous year's payroll data existed), and did the same for employment. We also sought to exclude firms that operated only part of the year by omitting firm-years for which the average wage was below $7,020 (what a half-time worker would earn at California's minimum wage in 2002). To reduce the effect of outliers, we analyzed the log of payroll, average occupational riskiness, employment, average wage, and sales after adding a small amount to deal with zeros and other small values.

Summary statistics are provided in Table 2.

5. Analysis and Results

5.1 Selection model

The main goal of this paper is to identify any causal effects of ISO 9001 adoption for employees and employers. ISO 9001 adoption could correlate with outcomes, but not cause them, if a factor such as good management led to both ISO adoption and good outcomes. If this form of self-selection is important, then

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[10] Pure Premium Rates are established by WCIRB based on historical workers' compensation costs for each occupation.
We calculated a firm *f*'s average occupational hazardousness in a given year *t* as:

$$\text{average occupational hazardousness}_{\text{ft}} = \frac{\sum_{c} \text{payroll}_{cft} \times \text{Pure Premium Rate}_{c}}{\text{payroll}_{\text{ft}}}$$

where Pure Premium Rate_c is the 2007 workers' compensation Pure Premium Rate per $100 of payroll for occupation class code *c* and *payroll* is the measure of total payroll defined as in the previous footnote.

we anticipate ISO adopters had good outcomes prior to ISO adoption as well as after. To understand the self-selection process, we estimate the selection model:

1) $\boldsymbol{ISO_{it} = F(Y_{it\text{-}1\&\text{-}2}\,,\, year_t\,,\, industry_i\,,\, region_j\,,\, u_{it})}$

where F(.) is the probit function, $Y_{it\text{-}1\&\text{-}2}$ is the average of 1- and 2-year lagged levels of injury rates and costs, payroll, employment, wages, sales, and average occupational riskiness, $year_t$ is a complete set of year dummies, $industry_i$ is a set of 15 industry dummies, and $region_j$ is a set of eight California region dummies. Because we are interested in the determinants of adoption, we drop adopters from the sample after their adoption year. We report robust standard errors clustered by firm to account for heteroscedasticity and non-independence among a firm's observations across years.

5.2 Results of selection analysis

The main result on selection is that larger firms adopt ISO 9001 more often. For example, median sales and payroll of adopting firms are \$3.48 million and \$1.04 million, whereas these figures are \$0.78 million and \$0.16 million, respectively, for non-adopters. We examine this issue more carefully with the adoption probit regression. Larger firms (in terms of sales and total payroll) adopted ISO 9001 at a higher rate than other firms in their industry, year, and region (see Table 3). If one employer has one log point (roughly 1 standard deviation) higher sales and payroll than average, for example, the coefficients predict a 0.054 percentage point above-average probability of ISO 9001 adoption per year, with most of that effect due to higher payroll. This increase is roughly equal to 10% of the mean of the sample, which is 5.4 out of a thousand firms adopting each year. Because adoption requires fixed costs—including learning about the standard's requirements and developing policies, procedures, and training programs—it is not surprising that larger firms are more likely to make this investment.

The sales coefficient is statistically significant and economically meaningful after controlling for both payroll and employment. Thus, ISO adopters had above-average labor productivity prior to adopting ISO 9001. Note that the marginal effect of payroll (0.046, $p < 0.01$) is higher than the marginal effect of employment (0.009, n.s.), suggesting that ISO 9001 adopters paid above-average annual wages prior to ISO adoption (or that WCIRB data on payroll is more precisely measured than D&B data on employment). If higher wages correlate with higher skills and higher skills with higher quality, this result suggests that ISO adopters may already have been producing above-average quality prior to ISO adoption (compared to their industry and region).

ISO 9001 adopters also had slightly lower workers' compensation injury costs, so that 1 log point lower injury costs (a bit less than one standard deviation) predicts 0.005% higher adoption of ISO 9001 in the next year ($p < 0.05$). Our statistically insignificant coefficient on injury rates, and its tiny marginal effect, provides no evidence that adopters differed from non-adopters in annual number of injuries prior to adoption.

5.3 Estimating the effects of ISO 9001 certification

To examine the causal effects of ISO 9001, we conduct a difference-in-differences analysis whereby we compare the changes in payroll, employment, wages, sales, average occupational riskiness, and injury rates and costs among ISO-certified firms relative to those of a matched set of control firms. This method permits each firm to have its own baseline level of each outcome. To ensure a valid comparison, we developed a matched control group.

5.3.1 Developing matched samples

Matching is widely used to construct a quasi-control group based on similar characteristics to those of the treatment group (Heckman, Ichimura, and Todd 1998). Intuitively, we want to compare companies that adopt ISO to peers in their industry that, prior to adoption, had similar sales, employment, payroll, injury rates, and other observable factors.

Matching on the propensity score, the probability of receiving the treatment conditional on covariates, is as valid as matching on a series of individual covariates (Rosenbaum and Rubin 1983). The identifying assumption is that the assignment to the treatment group is associated only with observable "pre-period" variables, and that all remaining variation across the groups is random. This assumption is often referred to as the "ignorable treatment assignment" or "selection on observables."

When used to evaluate job training programs, propensity score matching methods have performed well in replicating the results of randomized experiments under three conditions: (1) the same data sources are used for participants and non-participants; (2) an extensive set of covariates is employed in the program-participation model used to estimate propensity scores; and (3) participants are matched with non-participants in the same local labor market (Smith and Todd 2005). Conversely, Heckman , Ichimura, and Todd (1997) note that substantial bias can result if: (4) controls are included for which propensity scores are off the support of the participants' propensity scores (that is, if some of the controls differ substantially from any of the treatments); (5) the distributions of the participants and non-participants' propensity scores differ; or (6) unobservable factors influence both participation and outcomes.

We address these six potential sources of bias as follows. First, we use identical data sources for all facilities (adopters and non-adopters). Second, we include an extensive set of adoption covariates. Third, we ensure that adopters and non-adopters operate within the same markets by including industry and region as matching criteria. We address the fourth and fifth concerns by implementing nearest neighbor matching with a "caliper" restriction to preclude matching when the propensity scores differ by more than a fixed threshold (as explained below).

The sixth concern addresses selection on unobservables. For example, in the context of ISO 9001, it is possible that managers in facilities with a "safety culture" (which we do not observe in our data) might be both more likely to insist upon strong safety performance and more inclined to adopt ISO 9001. We address this concern in two ways: (1) we control for such unobserved factors that are stable over time by including a fixed effect for each employer; and (2) we control for differences in levels and trends by including in our matching criteria lagged levels and trends of sales, employment, earnings, and injury rates and costs.

We implemented propensity score matching in three steps. In the first, we generated propensity scores by estimating a probit model for adoption status during 1994-2005. We included a full set of year dummies, 15 industry dummies, and eight California geographic region dummies. We also included lagged levels of each of our outcome variables: injury rates and costs, payroll, employment, wages, sales, and average occupational riskiness. We employed a highly flexible functional form by including the average level of the prior two years as well as the log and square of this average. Table A1 in the On-line

Appendix contains descriptions and summary statistics of the variables we used in the matching process. Because we are interested in the determinants of adoption, we drop adopters from the sample after their adoption year. The results of this probit are reported in Table A2 in the On-line Appendix. The predicted probability of adoption estimated from this probit model is our estimated propensity score.

In the second step, we matched each adopter during its certification year to the non-adopter in the same industry with the most similar (nearest) propensity score, and that had at least one year of post-adoption data. We refer to the absolute difference between the two propensity scores in a matched pair of firms as the "match distance." Of the 892 adopters for which we had estimated propensity scores, we successfully matched 550 adopters to 550 controls.

In the third step, we assessed the quality of these matches and refined our matched sample. To confirm whether our matching process resulted in a highly comparable set of adopters and non-adopters, we compared the two groups' lagged levels of seven outcome variables: number of injuries, injury costs, payroll, employment, wages, sales, and average occupational riskiness. The identifying assumption of the difference-in-differences approach is that the treatment group's trend during the post-period would have been indistinguishable from the control group's trend, had treatment not occurred.

To examine the plausibility of this assumption, we compared the two groups' performance trends in the period prior to ISO adoption (as in Barber and Lyon 1996; Dehejia and Wahba 1999; Eichler and Lechner 2002). We did so using two measures of pre-adoption trends, (1) the percent change in lagged performance comparing three-and-four-year lagged average to a one-and-two-year-lagged average, and (2) the difference in the log of these two averages (we added a small constant before taking the log). T-test results indicated statistically significant differences at the 10% level for nine of the 21 comparisons we made for either levels or trends, far more than would be expected by chance. Thus, the first stage of matching does not yield a very credible comparison group.

To improve the match quality, we dropped pairs for which the propensity scores of the ISO adopters and potential matches exceeded a given caliper size. A smaller caliper means ISO adopters and their matches are more similar, but reduces the sample size. After trying various values, we settled on a caliper of 0.07, which yielded a closely matched (but slightly smaller) set of 471 pairs of adopters and controls. In the caliper-restricted matched sample, t-tests indicated that the groups differed along only 1 of the 21 metrics at the 5% level and 4 of the 21 metrics at the 10% level (see Table A3 in the On-line Appendix). We ran our evaluation model on this matched sample (see Table 4 for summary statistics).

We followed a slightly modified version of the matching process described above to develop the matched sample for the survival analysis. When generating propensity scores and matching firms, we no longer excluded firms that lacked data after the match year, and also matched firms that had adopted as late as 2003. These modifications resulted in 622 pairs of adopters and non-adopters being included in our matched sample for the survival analysis.

5.3.2 Organizational survival

We use both nonparametric methods and duration models to examine the survival rate of our matched pairs of adopter and non-adopter firms. Because our dataset extends through 2003 and the matching was done in a specific year for the ISO adopter and its matched firm, data on both firms in the pair were right censored after the same number of years at risk of firm death. We employ a conservative definition of "firm death" by counting a firm as dead only if it disappears from both the D&B and WCIRB datasets.

Among the 622 pairs of firms that constitute our matched sample for the survival analysis, 0.5% of the adopters and 7.1% of the controls had disappeared from both our Worker's Compensation (WCIRB) and Dun & Bradstreet (D&B) datasets by 2003. A t-test confirmed that survival rates of adopters were statistically significantly higher ($p<0.01$).

Although the analyses of raw survival rates use a matched sample, there are still small differences within each pair in observable factors. In Table A4 in the On-line Appendix, we present the results of a cross-sectional logit model, a conditional logit (with a conditional fixed effect for each pair), and stratified Cox proportional hazard models (with each pair its own strata). These models enabled us to condition on numerous observable factors such as pre-adoption sales and employment. As expected, the large survival advantage of ISO adopters persists in these specifications. These results provide robust support for Hypothesis 1a that ISO adoption increases a company's survival rate.

5.3.3 Evaluation model

To assess the impact of adoption, we conduct a difference-in-differences analysis by estimating the following model for each outcome Y_{it} at firm i in year t:

$$(2) \qquad Y_{it} = \alpha_i + \beta \cdot ISO_{it} + \Sigma_j\, \gamma_j \cdot X_{jit} + \delta_t \cdot year_t + \varepsilon_{it}\,,$$

where α_i is a complete set of firm-specific intercepts. The variable ISO_{it} is an indicator variable coded one in years after a firm is ISO-certified. Of primary interest is its coefficient β*,* the estimated effect of achieving certification. We also include a full set of year dummies ($year_t$). Depending on the outcome variable being estimated, we include in X_{jit} controls for the firm's current log of: payroll, employment, sales, average occupational riskiness, or number of injuries (see Tables 5 and 6).

We also employ a variation of this specification that refines our ability to measure the effects of certification. In Equation 2, the single post-certification dummy variable estimates an overall average change in outcome levels, pre- to post-adoption. But such improvements might be large in the first few years after adoption and then attenuate, or take several years to emerge. To estimate potential effects each period after certification, we include dummies coded 1 for adopters "one to three years after certification," "four to six years after certification," and "seven to nine years after certification."

Employer outcomes. The results for the difference-in-differences evaluation model of employment and sales are presented in Table 5. All results employ the matched sample, using years in which both the ISO adopter and match survived. Employment is about 10 percentage points higher in ISO-certified workplaces after certification (column 1, b= 10.3%, $p < 0.01$) than at the comparison firms. These results strongly support Hypothesis 2a, which predicted higher employment growth at ISO 9001 firms. Column 2 reveals that this increase appears to grow over time, from 6.1% (SE = 1.8%, $p < 0.01$) in years 1-3, to 22.5% in years 4-6 (SE = 2.9%), to a quite large 32.5% in years 7-9 (SE = 6.3%). Because only 62 of our 471 matched ISO 9001 adopters (13%) adopted seven or more years prior to the end of the matched dataset used for these models, results in this category are typically not precisely estimated. Nevertheless, the high employment growth in years 7-9 is statistically significant from the average effect ($p < 0.01$) and from the effect in years 1-3 (Wald test F=17.70, $p<0.01$), though not from the effect in years 4-6.

Sales are almost 9 percentage points higher at ISO 9001 firms than at comparison firms (column 3), which supports Hypothesis 1b. Column 4 reveals that this advantage does not show up until year 4 and beyond (effect size in years 4-6 = 25%, SE = 4.0%; which is statistically indistinguishable from the effect size in years 7-9 of 17%, SE = 8.8%, $p < 0.10$).

This increase in sales is roughly what would be expected from the higher payroll at ISO-certified firms (column 5). At the same time, there is suggestive evidence of growth in sales conditional on payroll in years 4-6 after certification (column 6, b = +13.2%, $p < 0.01$). In contrast, the coefficient is small, less than 2% in absolute value, and not statistically significant in years 1-3 or years 7-9. Thus, Hypothesis 2b, predicting gains in labor productivity, is not supported. In results not shown, sales also did not increase statistically significantly faster at ISO adopters if we controlled for employment instead of payroll; that is, total sales rose at adopters relative to matched non-adopters, but not sales per employee.

Employee outcomes. The results of our evaluation model for employee outcomes are presented in Table 6. Column 1 reveals that total payroll at ISO firms grew about 17.7% more than at our matched control firms (SE = 1.7%, $p < 0.01$). This increase grew steadily over time from 14% in years 1-3 to 36% in years 7-9 (column 2). Nearly a third of this increase in payroll (measured using workers' compensation records) appears to be due to higher employment (measured using D&B data). That is, conditioning on employment, payroll at ISO-certified firms grew about 13.5% more than at comparison firms (SE = 1.6%, $p < 0.01$, column 3). This growth increased steadily over time from 11.7% in years 1-3 to 22% in years 7-9. It is plausible that the correlation of total payroll and employment would be higher if they were measured from a common data source.[11]

Recall that we measured wages as total payroll from workers' compensation records divided by employment data from D&B. Keeping in mind all the caveats necessary for such a measure, we see that annual wages grew to be about 7.5% higher at ISO firms than at their matches (column 5), which supports Hypothesis 3 (and thus refutes Hypothesis 3′ that ISO adoption lowers wages). Although the point

[11] In addition, because ISO adopters had lower death rates, the results on sales, employment, and total payroll would be slightly more positive for ISO adopters if we included non-surviving firms in the analysis.

estimates decline over time, we cannot reject that the coefficients are constant over time (column 6).

Unlike the previous outcomes, our estimates of the effect of ISO 9001 on injury rates and costs are conditioned on employment, payroll, sales, and average occupational riskiness. We find that trends in the total value of injury costs (columns 7 and 8) and average cost per injury (columns 9 and 10) are unrelated to ISO 9001 certification (among pairs of firms where both had at least one injury).

The number of injuries, a count variable, is analyzed with a negative binomial regression model with conditional firm effects. For technical reasons, the estimation sample of this negative binomial model uses only firms with a positive number of injuries in at least one year. To ensure an appropriate comparison, we included in this sample only those pairs of employers where the adopter and matched non-adopter both reported at least one injury. The results indicate that adoption did not predict a higher or lower number of injuries (Table 6, columns 11 and 12, conditioning on employment and other control variables).

As an extension, we also ran a probit model to predict which employers reported zero injuries (technically, zero workers compensation claims) in all years after the match year, using the full set of 471 matched pairs of firms. To do so, we collapsed our panel data into a cross section, coding the dependent variable "1" for firms that reported no injuries all years after the match year, and "0" for firms that reported at least one injury after the match year. We included the following as controls: the log of each firm's average employment and average payroll for post-match years, region dummies, and industry dummies. Recall that the matched set of adopters and non-adopters used in this regression (and all regressions reported in Tables 5 and 6) had similar (and statistically indistinguishable) injury rates during the years prior to the match. In contrast to the negative binomial results discussed above, the results of this cross-sectional probit analysis indicate that ISO 9001 adopters were subsequently 5 percentage points more likely to report no injuries (Table 7), a large effect given that the mean of the dependent variable is 28%. Taken as a whole, these three sets of results provide limited support for Hypothesis 4 that ISO adoption lowers injury costs and rates, but no support for Hypothesis 4' that ISO worsens these measures of occupational safety and health.

As an extension, we examined whether adopters and non-adopters subsequently differed in two particular types of injury rates: *serious sudden-onset injuries* (as typically occur following industrial accidents) and, separately, *serious cumulative injuries* (which could result from more repetitive work). This sub-analysis is motivated by the concern that ISO adoption may lead to more repetitive work and, thus, more cumulative injuries. WCIRB data only categorizes "serious" injuries, which are those associated with at least $2,000 in costs. These conditional fixed effects negative binomial models include controls for employment, payroll, sales, average occupational riskiness, calendar years, and dummies to denote the number of years until or since the match year. The results (not shown to conserve space) indicate no change in sudden-onset injury rates (b = -0.064; SE = 0.087) between adopters and their matched controls. However, the regression predicting the number of serious cumulative injuries yields an incident rate ratio of 0.61 (b = -0.495; SE = 0.314) for *has adopted ISO 9001*, which is economically meaningful decline among adopters, but not statistically significant. Further research is warranted to explore the circumstances under which ISO 9001 adoption may help reduce serious cumulative injuries.

The workers' compensation data show a small shift to safer occupations at firms that become ISO 9001 certified. That is, the average worker in a post-certification firm works in an occupation for which workers' compensation costs are almost 5% lower than at the comparison firm (b = -0.047, SE = 0.009, $p < 0.01$) (column 13 of Table 6).

6. Conclusion

Our results are readily summarized:

- ISO adopters had far lower organizational death rates than matched firms within their industries.
- Sales and employment grew substantially more rapidly post certification at ISO 9001 adopting firms than at matched firms.
- Total payroll and (to a lesser extent) annual earnings per employee grew substantially more rapidly post certification at ISO 9001 adopting firms than at matched firms.
- ISO 9001 adopters already had slightly lower than average injury costs at the time of adoption,

and we found no evidence that this gap widened or narrowed after adoption. Adopters were more likely to report no injuries for workers' compensation at all in the years following adoption. When comparing pairs of adopters and matched comparison firms that each had a positive number of injuries, we found no differences in their number of injuries.

Our finding that ISO 9001 certification benefits employers bolsters prior research that reported other such benefits associated with implementing ISO 9001 (e.g., Corbett *et al.* 2005; Terlaak and King 2006) and TQM as well as winning quality awards (e.g., Hendricks and Singhal 1996, 1997, 2001b). Our results are particularly credible because we analyze a larger sample of ISO certifications than almost any previous study, we have performance data at the workplace level (unlike many previous studies that study how ISO certification at a single plant affects financial performance at a multi-plant organization), we measures performance using third-party data (rather than self-reported data), and we develop carefully matched sets of non-adopters. Our results regarding the benefits of ISO 9001 certification for employment, payroll, and average annual earnings are new.

A concern with the causal interpretation of these results is that employers with better growth prospects might both adopt ISO 9001 and have higher post-adoption growth rates. We have two reasons to doubt the importance of this alternative causality. First, we control for employer fixed effects, industry-specific time trends, and a host of observable characteristics (via the matched comparison group). Second, although we do not match on pre-adoption trends in sales in ISO adopters and comparison firms, the pre-adoption trends are quite similar. Thus, we have no evidence that adopting firms had better growth prospects prior to ISO 9001 adoption.

Some critics of ISO 9001 and related programs have expressed concern that benefits to employers derive largely from the deskilling and routinizing of tasks. They hypothesize that employer gains come at the expense of employees' earnings. Our results showing that total payroll rises even faster than employment, which implies an increase in average annual earnings, do not provide evidence of deskilling.

Our results have implications for managers, organizational scholars, and public policy. For managers, the lessons are that the process of ISO 9001 certification appears to be valuable to most adopters. We cannot be sure how broadly these lessons apply to non-adopters, but the extremely large benefits of adoption (e.g., roughly 10% increases in sales) suggest that far more employers could benefit from ISO 9001 adoption than currently have.

The extremely large benefits of adoption also have lessons for organizational scholars. Some academics have criticized quality programs such as ISO 9000 as management fads that are unlikely to help the employer or employees (see Abrahamson 1996 and the citations in Staw and Epstein 2000). Fashion may well play a role in the adoption of many management practices, but our results indicate that ISO 9000 appears to deliver value for many organizational stakeholders.

We would not anticipate the large benefits we measure if potential customers could already see product or service quality, if managers already understood how to achieve higher productivity and quality cost-effectively, and if managers could capture the returns to any improvements in quality or productivity (Levine 1995, ch. 3). The large increases in employment, total payroll, and sales we estimate are consistent with at least one of these market imperfections slowing the spread of quality programs. As such, these results also support arguments that public policy should promote quality programs; for example, by subsidizing employee training or educating managers about the value of quality programs (e.g., Helper and Levine 1995).

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Table 1.
Sample characteristics

	Entire sample for adoption models		Matched sample for survival models		Matched sample for treatment models	
Panel A. Industry	**Firms**	**%**	**Firms**	**%**	**Firms**	**%**
Agriculture industry	22	0.1	2	0.2		
Construction or erection industry	1,042	5.6	10	0.8	8	0.9
Manufacturers of electronic & electrical products	960	5.1	360	28.9	256	27.2
Manufacturers of final metal products	1,461	7.8	250	20.1	204	21.7
Manufacturers of food products	22	0.1				
Manufacturers of intermediate metal products	401	2.1	142	11.4	110	11.7
Manufacturers of paper products	363	1.9	22	1.5	18	1.9
Manufacturers of plastic & rubber products	277	1.5	84	6.8	62	6.6
Manufacturers of textile, cloth & leather products	199	1.1	18	1.5	12	1.3
Manufacturers of wood products	61	0.3	4	0.3	2	0.2
Manufacturers, other	433	2.3	72	5.8	62	6.6
Mercantile industry	2,009	10.7	132	10.6	106	11.3
Other industry	1,427	7.6	58	4.7	34	3.6
Professional & clerical services industry	10,088	53.8	90	7.2	68	7.2
Total firms	**18,765**	**100%**	**1,244**	**100%**	**942**	**100%**

Panel B. Geographic Region	**Firms**	**%**	**Firms**	**%**	**Firms**	**%**
Bay Area region	3,501	18.7	231	18.6	178	18.9
Central Coast region	1,402	7.5	94	7.6	63	6.7
Central Valley region	1,338	7.1	24	2.0	15	1.6
Los Angeles Basin region (outside LA County)	2,754	14.7	315	25.3	248	26.3
Los Angeles County region	5,649	30.1	417	33.5	322	34.2
Other California region	933	5.0	21	1.7	12	1.3
Sacramento region	1,001	5.3	19	1.5	16	1.7
San Diego County region	2,187	11.7	123	9.9	88	9.3
Total firms	**18,765**	**100%**	**1,244**	**100%**	**942**	**100%**

Panel C. Adoption Year	**Firms**	**%**	**Firms**	**%**	**Firms**	**%**
1994	15	0.1	12	1.0	12	1.3
1995	24	0.1	24	2.0	24	2.6
1996	34	0.2	30	2.4	26	2.8
1997	47	0.3	43	3.5	41	4.4
1998	81	0.4	71	5.8	66	7.0
1999	79	0.4	70	5.7	65	6.9
2000	90	0.5	75	6.1	68	7.2
2001	161	0.9	118	9.6	105	11.2
2002	129	0.7	83	6.7	64	6.8
2003	152	0.8	96	7.8		
2004	70	0.4				
2005	34	0.2				
Total adopters	916		622		471	
Non-adopters	17,849	95.1	622	49.5	471	50.0
Total firms	**18,765**	**100%**	**1,244**	**100%**	**942**	**100%**

Table 2.
Descriptive statistics of entire sample (used in selection analysis)

Variable	Description	Mean	SD	Min	Max
Adopted ISO 9001 this year	Dummy coded "1" in the firm-year in which a firm adopted ISO 9001, and "0" otherwise.	0.0054	0.0731	0	1
Log injury costs $_{-1\&-2}$	Natural log of $1000 plus the average of one- and two-year lags of total annual workers' compensation injury costs, in dollars. To reduce the effect of outliers, we took the log of injury costs after adding $1,000.	7.51	1.23	6.91	17.14
Log injury rate $_{-1\&-2}$	Natural log of 1 plus the average of one- and two-year lags of the annual number injuries reported for workers' compensation.	0.33	0.60	0	8.33
Log payroll $_{-1\&-2}$	Natural log of the average of one- and two-year lags of annual payroll, in dollars. *To minimize the impact of outliers, we omitted very small annual payroll values (less than $5,000) and instances of rapid growth or shrinkage in payroll (as when the ratio of current exposure to its one-year lag was outside the range of 0.5 to 2).*	12.13	1.29	8.52	21.50
Log employment $_{-1\&-2}$	Natural log of the average of one- and two-year lags of number of employees. *To minimize the impact of outliers, we omitted instances of rapid growth or shrinkage in employment (as when the ratio of current employment to its one-year lag was outside the range of 0.5 to 2).*	2.07	1.01	0	8.71
Log sales $_{-1\&-2}$	Natural log of the average of one- and two-year lags of annual firm sales, in dollars.	13.63	1.32	0	19.82
Log average occupational riskiness $_{-1\&-2}$	Natural log of the average of one- and two-year lags of a firm's average annual hazard per payroll dollar. A firm's annual average hazard is the sum across all occupation classes of the following: the payroll dollars in each occupation class multiplied by the WCIRB pure premium rate for each occupation class. We divide this sum by the firm's payroll that year.	0.47	0.90	-1.71	3.12

N = 158,170 firm-year observations. The sample includes all non-adopters in all years and all adopters before and during their adoption year, provided they have observations with complete data for the model. Variables subscripted $_{-1\&-2}$ are averages of 1- and 2- year lags.

Table 3.
Predicting adoption of ISO 9001

Dependent variable: Adopts ISO 9001 this year (dummy)

	Probit coefficients	100 × marginal effects [a]
Log sales $_{-1\&-2}$	0.0961***	0.01580***
	[0.0202]	
Log payroll $_{-1\&-2}$	0.2775***	0.04560***
	[0.0264]	
Log employment $_{-1\&-2}$	0.0054	0.00088
	[0.0277]	
Log injury costs $_{-1\&-2}$	-0.0318**	-0.00522**
	[0.0146]	
Log injury rate $_{-1\&-2}$	0.0128	0.00211
	[0.0311]	
Log average occupational riskiness $_{-1\&-2}$	-0.3468***	-0.05704***
	[0.0350]	
Observations (firm-years)	158,170	
Firms	18,765	
Pseudo R squared (McFadden's)	0.29	
Wald Chi squared	1696.53***	

Brackets contain robust standard errors clustered by firm. *** p<0.01, ** p<5%, * p<0.10. Variables subscripted $_{-1\&-2}$ are averages of 1- and 2- year lags. Additional controls include year dummies (1995-2005), 7 region dummies, and 14 industry dummies. Sample includes adopters before and in their adoption year and all years for non-adopters.

[a] 100 × marginal effects = change in % adopting each year associated with a 1 point increase in the independent variable.

Table 4.
Summary statistics of matched sample used for analysis of treatment

Variable	Description	Mean	SD	Min	Max
Has adopted ISO 9001	Dummy coded "1" if the firm has adopted ISO 9001 in a previous year, and "0" otherwise.	0.19	0.39	0	1
Has adopted ISO 9001 × post-years 1/2/3	Dummy coded "1" if the firm initially adopted ISO 9001 1 to 3 years ago, and "0" otherwise.	0.12	0.33	0	1
Has adopted ISO 9001 × post-years 4/5/6	Dummy coded "1" if the firm initially adopted ISO 9001 4 to 6 years ago, and "0" otherwise.	0.05	0.22	0	1
Has adopted ISO 9001 × post-years 7/8/9	Dummy coded "1" if the firm initially adopted ISO 9001 7 to 9 years ago, and "0" otherwise.	0.01	0.10	0	1
Injury costs	Annual workers' compensation injury costs in dollars.[a]	22,129	65,434	0	1,340,663
Log injury costs	Natural log of $1000 plus total annual workers' compensation injury costs, in dollars.[a]	8.25	1.72	6.91	14.11
Injury rate	Annual number of injuries reported to workers' compensation.[a]	3.55	8.72	0	256
Log injury rate	Natural log of 1 plus the injury rate.[a]	0.92	0.96	0	5.55
Log payroll	Natural log of annual payroll, in dollars.[b,c]	13.72	1.03	10.08	17.99
Log employment	Natural log of the number of employees.[c]	3.28	0.98	0	6.21
Log wage	Natural log of the ratio of payroll to employment.[d]	10.44	0.77	8.86	16.80
Log sales	Natural log of annual firm sales.	14.92	1.14	9.24	19.52
Log average occupational riskiness	Natural log of firm's average annual hazard per payroll dollar. A firm's annual average hazard is the sum across all occupation classes of the following: the payroll dollars in each occupation class multiplied by the WCIRB pure premium rate for each occupation class. We divide this sum by the firm's payroll that year.	0.80	0.62	-1.51	2.04

N= 8420 firm-year observations from 942 firms during 1993-2003.

[a] Missing values for injury costs are converted to zeros if data exists for exposure in that year.

[b] To minimize the impact of outliers, we omitted very small annual payroll values (less than $5,000).

[c] To minimize the impact of firms that were rapidly growing or shrinking, we omitted instances in which the ratio of current year's value to its one-year lag was outside the range of 0.5 to 2.

[d] To minimize the impact of outliers, we omitted firm-years with very low average annual wages (less than $7,020, calculated as 20 hours per week * 52 weeks per year * $6.75 [California minimum wage as of Jan 2002]).

Table 5.
Employer outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	***Log employment***		***Log sales***		***Log sales***	
Has adopted ISO 9001	0.103***		0.089***		0.013	
	[0.017]		[0.024]		[0.023]	
Has adopted ISO 9001		0.061***		0.040		-0.020
× post-years 1/2/3		[0.018]		[0.026]		[0.024]
Has adopted ISO 9001		0.225***		0.253***		0.132***
× post-years 4/5/6		[0.029]		[0.040]		[0.038]
Has adopted ISO 9001		0.325***		0.169*		0.015
× post-years 7/8/9		[0.063]		[0.088]		[0.084]
Log payroll					0.432***	0.429***
					[0.015]	[0.015]
Constant	3.011***	3.011***	14.485***	14.485***	8.770***	8.809***
	[0.029]	[0.029]	[0.041]	[0.041]	[0.201]	[0.201]
Observations	8420	8420	8420	8420	8420	8420
Firms	942	942	942	942	942	942
R-squared	0.23	0.23	0.25	0.26	0.33	0.33
Wald test ($\beta_{123}= \beta_{456}$)		30.79***		26.05***		14.81***
Wald test ($\beta_{123}= \beta_{789}$)		17.70***		2.12		0.18
Wald test ($\beta_{456}= \beta_{789}$)		2.41		0.87		1.87
Wald test ($\beta_{123}= \beta_{456}= \beta_{789}$)		20.55***		13.15***		7.46***

Brackets contain standard errors. *** p<0.01, ** p<5%, * p<0.10. All models estimated on the matched sample, using OLS. Additional controls include firm fixed effects, year dummies (1993-2003), and dummies denoting 9 years before through 9 years after the match year. Reported R-squares are within-firm measures. Wald tests report F statistics.

Table 6.
Employee outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Dependent variable:	***Log payroll***		***Log payroll***		***Log wages***		***Log injury costs***		***Log injury costs***		***Injury rate***		***Log average occupational riskiness***	
	OLS		OLS		OLS		OLS		OLS		Negative binomial [a]		OLS	
Has adopted ISO 9001	0.177***		0.135***		0.075***		-0.016		0.003		-0.008		-0.047***	
	[0.017]		[0.016]		[0.019]		[0.061]		[0.050]		[0.040]		[0.009]	
Has adopted ISO 9001		0.142***		0.117***		0.081***		-0.003		0.020		-0.035		-0.044***
× post-years 1/2/3		[0.019]		[0.017]		[0.020]		[0.066]		[0.053]		[0.043]		[0.010]
Has adopted ISO 9001		0.282***		0.191***		0.057*		-0.066		-0.039		0.030		-0.058***
× post-years 4/5/6		[0.029]		[0.027]		[0.032]		[0.103]		[0.084]		[0.062]		[0.015]
Has adopted ISO 9001		0.358***		0.226***		0.033		0.004		-0.188		0.331**		-0.024
× post-years 7/8/9		[0.065]		[0.060]		[0.070]		[0.226]		[0.184]		[0.143]		[0.033]
Log injury rate									1.413***	1.413***				
									[0.023]	[0.023]				
Log employment			0.407***	0.405***			0.137**	0.138**	0.090**	0.093**	-0.036	-0.040	0.002	0.002
			[0.011]	[0.011]			[0.055]	[0.055]	[0.045]	[0.045]	[0.031]	[0.031]	[0.007]	[0.007]
Log payroll							0.604***	0.604***	-0.049	-0.048	0.916***	0.917***	-0.002	-0.002
							[0.044]	[0.044]	[0.037]	[0.037]	[0.030]	[0.030]	[0.006]	[0.006]
Log sales							-0.039	-0.038	0.000	0.000	-0.059**	-0.057**		
							[0.038]	[0.038]	[0.031]	[0.031]	[0.024]	[0.024]		
Log average occupational riskiness							0.233***	0.233***	0.017	0.017	0.384***	0.382***		
							[0.079]	[0.079]	[0.064]	[0.064]	[0.062]	[0.062]		
Constant	13.229***	13.229***	12.004***	12.011***	10.219***	10.219***	0.002	-0.016	7.049***	7.031***	-10.580***	-10.596***	0.863***	0.862***
	[0.030]	[0.030]	[0.043]	[0.043]	[0.033]	[0.033]	[0.688]	[0.689]	[0.571]	[0.571]	[0.494]	[0.494]	[0.081]	[0.081]
Observations	8420	8420	8420	8420	8420	8420	8420	8420	8420	8420	6995	6995	8420	8420
Firms	942	942	942	942	942	942	942	942	942	942	758	758	942	942
R-squared	0.31	0.31	0.42	0.42	0.05	0.05	0.06	0.06	0.38	0.38			0.01	0.01
Wald test ($\beta_{123}=\beta_{456}$)		20.99***		6.80***		0.55		0.35		0.47		1.03		0.81
Wald test ($\beta_{123}=\beta_{789}$)		11.13***		3.35*		0.47		0.00		1.28		6.53**		0.36
Wald test ($\beta_{456}=\beta_{789}$)		1.32		0.34		0.11		0.09		0.63		4.23**		1.01
Wald test ($\beta_{123}=\beta_{456}=\beta_{789}$)		13.65***		4.32**		0.43		0.19		0.75		6.85**		0.71

Brackets contain standard errors. *** p<0.01, ** p<5%, * p<0.10. Additional controls include firm fixed effects (conditional fixed effects for the negative binomial models), year dummies (1993-2003), and dummies denoting 9 years before through 9 years after the match year. Estimated for the matched sample. Reported R-squares are within firm measures. For Wald tests, F statistics provided for OLS models and chi-squared statistics for the negative binomial model.

[a] The negative binomial model with conditional fixed effects is estimated only for firm-pairs in which both firms had at least one injury reported for worker's compensation during the sample period.

Table 7.
Probability of reporting zero injuries for workers' compensation

Dependent variable: Zero Injuries Reported for Workers' Compensation After Match Year (dummy)

	(1) Probit coefficients	(2) Marginal effects
ISO 9001 adopter	0.178*	0.051*
	[0.106]	[0.030]
Log employment (average after match)	-0.187**	-0.053**
	[0.085]	[0.024]
Log payroll (average after match)	-0.707***	-0.201***
	[0.085]	[0.024]
Constant	8.665***	
	[1.153]	
Observations (firms)	942	
Pseudo R squared (McFadden's)	0.32	
Wald Chi squared	358.57***	

Brackets contain standard errors. *** p<0.01, ** p<5%, * p<0.10. The dependent variable is a dummy coded "1" for firms that reported no injuries for workers' compensation in all post-match years, and coded "0" for firms that reported one or more injuries. Employment and payroll variables are the log of each firm's average employment and payroll during all post-match years. Additional controls include 7 region dummies and 14 industry dummies. The sample is a cross section of all 471 pairs of matched adopters and non-adopters.

On-line Appendix (e-companion)

Table A1.
Description and summary statistics of variables used to generate propensity scores for the matching process (in addition to those in the paper's Table 2)

Variable	Description	Mean	SD	Min	Max
Adopts ISO 9001 this year (dummy)	Dummy coded "1" if the firm adopted ISO 9001 this year, and "0" otherwise.	0.006	0.08	0	1
Injury costs$_{-1\&-2}$	Average of the one- and two-year lags of total annual workers' compensation injury costs, in thousand dollars.[a]	7.95	112.88	0	27,765.74
Injury costs$_{-1\&-2}$, squared	Square of injury costs$_{-1\&-2}$, reported in billions of dollars.	12.80	2,606.84	0	770,936.30
Injury rate$_{-1\&-2}$	Average of one- and two-year lags of annual number of injuries reported for workers' compensation.[a]	1.08	18.78	0	4,149.00
Injury rate$_{-1\&-2}$, squared	Square of injury rate$_{-1\&-2}$, reported in thousands of injuries.	0.35	69.83	0	17,214.20
No injuries$_{-1\&-2}$	Dummy coded "1" if the firm reported no injuries in the prior two years, and "0" otherwise.	0.64	0.48	0	1
Payroll $_{-1\&-2}$	Average of one- and two-year lags of annual payroll, in millions of dollars.[b,c]	0.54	8.59	0.01	2,182.77
Payroll $_{-1\&-2}$, squared	Square of payroll $_{-1\&-2}$, reported in trillions of dollars.[b,c]	74.06	16,170.04	0.00	4,764,504
Employment$_{-1\&-2}$	Average of one- and two-year lags of employees.[c]	14.21	25.23	1	1800
Employment$_{-1\&-2}$, squared	Square of employment$_{-1\&-2}$, reported in thousands of employees.[c]	0.84	14.32	0.001	3240
Wage$_{-1\&-2}$	Average of one- and two-year lags of payroll/employment, reported in thousands of dollars.[d]	44.89	254.30	7.02	53,989.38
Log wage$_{-1\&-2}$	Natural log of wage$_{-1\&-2}$, reported in dollars.[d]	10.21	0.78	8.86	17.80
Wage$_{-1\&-2}$, squared	Square of wage$_{-1\&-2}$, reported in trillions of dollars.[d]	0.07	10.92	0.00	2,914.85
Sales$_{-1\&-2}$	Average of one- and two-year lags of annual firm sales, reported in millions of dollars.	2.15	5.54	0.00	329.35
Sales$_{-1\&-2}$, squared	Square of sales$_{-1\&-2}$, reported in quadrillions of dollars.	0.04	0.76	0.00	108.47
Average occupational riskiness$_{-1\&-2}$	Firm's average annual hazard per payroll dollar. A firm's annual average hazard is the sum across all occupation classes of the following: the payroll dollars in each occupation class multiplied by the WCIRB pure premium rate for each occupation class. We divide this by the firm's payroll that year.	2.24	1.74	0.18	22.73
Average occupational riskiness$_{-1\&-2}$,squared	Square of average occupational riskiness $_{-1\&-2}$.	8.08	12.57	0.032	516.65

N = 143,580 firm-year observations. Sample includes all non-adopters, and adopters before and in their adoption year, provided they have observations with complete data for the model.

[a] Missing values for injury costs are converted to zeros if data exists for exposure in that year. If one of the two lags is missing, the average will equal the non-missing lag.

[b] To minimize the impact of outliers, we omitted very small annual payroll values (less than $5,000).

[c] To minimize the impact of firms that were rapidly growing or shrinking, we omitted instances in which the ratio of current year's value to its one-year lag was outside the range of 0.5 to 2.

[d] To minimize the impact of outliers, we omitted firm-years with very low average annual wages (less than $7,020, calculated as 20 hours per week * 52 weeks per year * $6.75 [California minimum wage as of Jan 2002]).

Table A2.
Probit results that generated propensity scores

Dependent variable: Adopts ISO 9001 this year (dummy)

	Coefficients	SE		Marginal Effects
Injury costs$_{-1\&-2}$	0.0008	[0.0004]	*	0.0000
Log injury costs$_{-1\&-2}$	-0.0458	[0.0187]	**	0.0000
Injury costs$_{-1\&-2}$, squared	0.0000	[0.0002]		0.0000
Injury rate$_{-1\&-2}$	-0.0015	[0.0081]		0.0000
Log injury rate$_{-1\&-2}$	0.0342	[0.0591]		0.0001
Injury rate$_{-1\&-2}$, squared	-0.0242	[0.0572]		0.0000
No injuries$_{-1\&-2}$	0.0590	[0.0547]		0.0001
Payroll$_{-1\&-2}$	-0.0273	[0.0093]	***	0.0000
Log payroll$_{-1\&-2}$	0.4671	[0.2719]	*	0.0007
Payroll$_{-1\&-2}$, squared	0.0001	[0.0000]	***	0.0000
Employment$_{-1\&-2}$	0.0015	[0.0010]		0.0000
Log employment$_{-1\&-2}$	-0.1558	[0.2734]		-0.0002
Employment$_{-1\&-2}$, squared	-0.0010	[0.0013]		0.0000
Wage$_{-1\&-2}$	0.0002	[0.0001]	***	0.0000
Log wage$_{-1\&-2}$	-0.1228	[0.2729]		-0.0001
Wage$_{-1\&-2}$, squared	-0.0022	[0.0009]	**	0.0000
Sales$_{-1\&-2}$	-0.0047	[0.0032]		0.0000
Log sales$_{-1\&-2}$	0.1008	[0.0294]	***	0.0002
Sales$_{-1\&-2}$, squared	0.0186	[0.0091]	**	0.0000
Average occupational riskiness$_{-1\&-2}$	-0.3368	[0.0556]	***	-0.0005
Log average occupational riskiness$_{-1\&-2}$	0.0263	[0.0881]		0.0000
Average occupational riskiness$_{-1\&-2}$, squared	0.0207	[0.0024]	***	0.0000
Constant	-8.3662	[0.4965]	***	
Observations	143,580			

Brackets contain robust standard errors clustered by firm. *** p<0.01, ** p<5%, * p<0.10.Additional controls include year dummies (1995-2005), 7 region dummies, and 14 industry dummies. Sample includes adopters before and in their adoption year, and non-adopters in all years.

Table A3.
Assessing the quality of the matched sample for the treatment analysis

Balancing test results

Variable	Matched non-adopters			Matched adopters			t-test p-value	t-test p-value
	N	Mean	SE	N	Mean	SE		
Log injury costs$_{-1\&-2}$	471	8.23	0.074	471	8.44	0.077	0.06	*
Percent change[a] in ratio of injury costs	268	-0.04	0.093	268	0.25	0.088	0.03	**
Log injury costs$_{-1\&-2}$ – log injury costs$_{-3\&-4}$	381	0.04	0.079	381	0.20	0.072	0.12	
Log injury rate$_{-1\&-2}$	471	0.90	0.042	471	0.98	0.045	0.20	
Percent change[a] in ratio of injury rate	268	-0.04	0.076	268	0.16	0.069	0.06	*
Log injury rate$_{-1\&-2}$ – log injury rate$_{-3\&-4}$	381	0.02	0.030	381	0.06	0.028	0.36	
Log payroll$_{-1\&-2}$	471	13.64	0.043	471	13.76	0.049	0.06	*
Percent change[a] in ratio of payroll	364	0.25	0.018	364	0.23	0.019	0.55	
Log payroll$_{-1\&-2}$ – log payroll$_{-3\&-4}$	364	0.28	0.024	364	0.26	0.023	0.54	
Log employment$_{-1\&-2}$	471	3.14	0.045	471	3.21	0.048	0.30	
Percent change[a] in ratio of employment	431	0.12	0.018	431	0.15	0.016	0.24	
Log employment$_{-1\&-2}$–log employment$_{-3\&-4}$	431	0.13	0.022	431	0.16	0.018	0.42	
Log wages$_{-1\&-2}$ [b]	471	10.50	0.033	471	10.55	0.040	0.27	
Percent change[a] in ratio of wages	328	0.08	0.022	328	0.05	0.022	0.30	
Log wages$_{-1\&-2}$ – log wages$_{-3\&-4}$	328	0.07	0.025	328	0.05	0.024	0.45	
Log sales$_{-1\&-2}$	471	14.85	0.049	471	14.88	0.053	0.72	
Percent change[a] in ratio of sales	431	0.20	0.019	431	0.21	0.019	0.71	
Log sales$_{-1\&-2}$ – log sales$_{-3\&-4}$	431	0.23	0.026	431	0.22	0.026	0.64	
Log average occupational riskiness$_{-1\&-2}$	471	0.74	0.029	471	0.76	0.029	0.58	
Percent change[a] in ratio of average occupational riskiness	364	-0.01	0.009	364	0.00	0.011	0.28	
Log average occupational riskiness$_{-1\&-2}$ – log average occupational riskiness$_{-3\&-4}$	364	-0.01	0.009	364	0.00	0.012	0.27	

*** p<0.01, ** p<5%, * p<0.10.

Variables subscripted $_{-1\&-2}$ are averages of 1- and 2- year lags, and $_{-3\&-4}$ are averages of 3- and 4-year lags.

[a] "Percent change" variables are constructed as the difference in the average value of the 3- and 4-year lagged values from the average value of the 1- and 2-year lagged values, divided by half the sum these values. This ratio approximates "percent change," but is robust to outliers; it ranges from -2 to +2.

[b] Wages are the ratio of payroll to employment. To minimize the impact of outliers, we omitted firm-years with very low average annual wages (less than $7,020, calculated as 20 hours per week * 52 weeks per year * $6.75 [California minimum wage as of Jan 2002]).

Table A4.
Survival analysis: regression results

Dependent variable: firm survival

	(1)			(2)		(3)
	Cross-sectional logistic model			Conditional fixed effects logistic model		Stratified Cox proportional hazards model
	Coefficients	Marginal effects	Odds ratios	Coefficients	Odds ratios	Hazard ratio
Adopter	2.842***	0.045***	17.156***	3.055***	21.224***	0.047***
	[0.605]	[0.010]	[10.374]	[0.853]	[18.095]	[0.040]
Log employment $_{t-1\&t-2}$	0.127	0.002	1.135	-0.067	0.935	1.069
	[0.268]	[0.003]	[0.304]	[0.974]	[0.911]	[1.042]
Log payroll $_{t-1\&t-2}$	-0.059	-0.001	0.943	1.830	6.236	0.160
	[0.229]	[0.003]	[0.216]	[1.688]	[10.527]	[0.271]
Log sales $_{t-1\&t-2}$	-0.415**	-0.005*	0.660**	-0.096	0.908	1.101
	[0.201]	[0.003]	[0.133]	[0.530]	[0.481]	[0.583]
Log average occupational riskiness $_{t-1\&t-2}$	1.302***	0.016***	3.678***	-0.965	0.381	2.624
	[0.383]	[0.006]	[1.409]	[2.523]	[0.961]	[6.621]
Region dummies	Included	Included	Included	Absorbed	Absorbed	Absorbed
Industry dummies	Included	Included	Included	Absorbed	Absorbed	Absorbed
Conditional fixed effects for (stratified by) matched groups				Included	Included	
Constant	10.609***					
	[3.969]					
Observations	1,244 firms			94 firms		5,040 firm-years

In these models, all independent variables are time-invariant, calculated as the log of average values over the two years prior to the match (adoption) year. Model 1 is cross-sectional, estimated on one observation per firm. Model 2 is also cross-sectional, but is stratified (grouped) by each match group (i.e., an adopting firm and its control firm). It drops all match groups in which both members survive through 2003 (when our sample is right censored), and is thus estimated only on match groups in which one or both members of the match group dies. Model 3 is a survival model estimated on firm-years, and is also stratified (grouped) by match groups.