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Promoting Safety Through Workers' Compensation: The Efficacy and Net Wage Costs of Injury Insurance

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Promoting safety through workers' compensation: the efficacy and net wage costs of injury insurance

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This article explores the effects of workers' compensation on fatality rates and wages using the 1982 Panel Study of Income Dynamics and the new occupational fatality data issued by the National Institute for Occupational Safety and Health. The fatality rate depends upon the workers' compensation benefit variables in a manner that suggests that the safety incentive effects of higher insurance premiums offset any moral hazard effects. The estimates imply that in the absence of workers' compensation, fatality rates would increase by over 20%. Premium levels substantially overstate the cost of workers' compensation, due primarily to a direct wage offset from higher benefits. An indirect wage offset resulting from the decrease in risk caused by workers' compensation augments the direct wage effects. The indirect offset is relatively small, equalling about 10% of the total.

1. Introduction

■ The fundamental interdependence of job risks and wages has been a focal point of the labor economics literature dealing with nonpecuniary job characteristics. Higher levels of risk cause workers to demand higher wages, and these wage-risk trade-offs, in turn, establish market incentives for safety.[1] The introduction of workers' compensation establishes an additional dimension. Higher levels of workers' compensation benefits should dampen the wage premiums for risk demanded by the workers, and the funding mechanism for workers' compensation should provide incentives for safety.[2]

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[1] See, for example, Brown (1980), Thaler and Rosen (1976), and Viscusi (1979, 1983). Also, see the reviews by Bailey (1980) and Rosen (1986).

[2] The overall structure of workers' compensation benefits is no doubt endogeneous, but state legislatures modify these programs so infrequently that this complication can be ignored for the time period covered by most data bases.

A key economic and regulatory issue pertains to the efficacy of different compensation mechanisms in promoting safety. The primary market mechanism of compensating differentials creates substantial incentives for safety. The Occupational Safety and Health Administration (OSHA) provides an additional institutional mechanism for the direct regulation of risks. OSHA policies have failed to fulfill their initial promise, however, as observed safety effects are statistically significant, but of small magnitude.[3]

Some economists advocate using an injury tax approach similar to the funding mechanism for workers' compensation as a substitute for regulatory policies.[4] In theory this approach could enhance safety levels; however, most formal statistical evidence documenting the workers' compensation-safety linkage indicates that the opposite is true—that the moral hazard effects dominate and that the increased benefits therefore lead to greater injury rates.[5]

In the case of compensating differentials, we have a dollar price tag in terms of risk premiums paid. This is also true of workers' compensation. However, we do not as yet have a definitive estimate of the ultimate safety effect of workers' compensation. Because premiums are not always fully experience rated, particularly for small firms, and because moral hazard problems may exist, the extent of the safety incentive effect of workers' compensation is not clearcut.[6]

One key to understanding the relationship between workers' compensation and accidents lies in the severity of the accidents considered. The majority of existing studies (Chelius, 1982; Chelius and Smith, 1987; Butler and Worral, 1983; Worral and Butler, 1985; Ruser, 1985; Krueger, 1988) have used a risk measure based largely on nonfatal accident rates, on some composite of fatal and nonfatal rates, or on measures of claims filed for nonfatal and fatal accidents. These studies all reached the same conclusion—that increased insurance benefits cause injury and claim rates to rise significantly.

This result reflects an obvious limitation of injury rate and claim data. That is, risk measures such as total injury rates or lost workday case rates include claims for injuries that may not, in fact, have occurred. This fact has led most researchers to conclude that moral hazard effects dominate the safety effects of injury insurance. Furthermore, it makes it impossible to distinguish whether there is any safety effect at all.

Evidence contrary to this finding is limited. However, it appears that when the risk measure more accurately captures the severity of accidents, benefit increases have a negative effect on risk levels for more severe risks. For example, Chelius (1976) found that the introduction of workers' compensation in the United States led to a decrease in fatality rates over the period 1900–1940. Chelius (1982) also found a significant negative relationship between benefit levels and lost workdays per case, a risk measure that varies with the severity of the injury.

This general result—that benefit increases increase the incidence of less severe accidents but decrease their severity—provides our motivation in this article. The most severe accidents should reflect very little moral hazard. Deaths cannot be falsely claimed, of course, and the high values that workers implicitly attach to the lives saved suggest that workers are not willing to substitute fatality benefits for their own lives. Therefore, if workers' compensation provides any safety incentives to firms, these will be reflected most strongly in the fatality rate data.

The primary objective of this article is, therefore, to assess the performance of workers' compensation in reducing fatality rates. Our estimates indicate a dramatic safety effect,

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[3] See Viscusi (1986) and the references contained therein for an assessment of OSHA's impact on safety.

[4] See, in particular, Smith (1976), Diamond (1977), and Viscusi (1983). Chelius (1976) and Fishback (1987) have examined the effects of changing from a negligence standard to a strict liability standard, such as workers' compensation.

[5] See, for example, Chelius (1977, 1982), Butler (1983), Ruser (1985), and Krueger and Burton (1989).

[6] Chelius and Smith (1987) and Ruser (1985) have explored the role of experience rating in determining costs and safety levels.

particularly when compared with the evidence regarding the impact of OSHA and the previous evidence on the effects of workers' compensation on nonfatal injuries. A related issue that we consider is the net dollar cost to firms of responding to these safety incentives. Examining the dollar premiums for workers' compensation is a useful starting point for such analyses; it does not, however, give a complete measure of the financial incentives, since workers will accept a wage reduction in return for the insurance coverage. Furthermore, if greater safety is promoted by workers' compensation, the required compensating wage differential for risk and the level of injury costs to the firm will both be reduced. Thus, workers' compensation has both direct and indirect effects on workers' wages, and these effects offset both the cost of the insurance premiums and the employer's expenditures on safety.

Our analysis extends the research on the labor market effects of workers' compensation in two important ways: it analyzes the joint determination of wages and risks in a structural hedonic model, and it computes the total effect of benefits on wages by taking the indirect effect into account. Our focus on fatality rates to minimize moral hazard problems is also new.

A stylized summary of our findings is as follows: increases in fatality rates increase wages, while increases in workers' compensation benefits lower both wages and fatality rates. This risk reduction, in turn, has an additional wage effect, equal to about 10% of the direct benefit effect.

The general spirit of these results is to document the constructive economic functions served by workers' compensation. These findings run counter to the consensus in the literature as summarized on page 197 of the 1987 *Economic Report of the President:* "A growing body of research has found that workers' compensation benefits have unfavorable effects on safety. Higher benefits appear to increase both the frequency of work injuries and the number of compensation claims filed." In contrast, our results indicate that workers' compensation generates truly dramatic reductions in workplace fatalities.

2. Overview of the economic relationships

■ Our empirical analysis focused on two equations—a risk equation and a wage equation. Neither of our equations was unprecedented in the literature, although they had typically been analyzed separately.[7] All of the variables of interest in the fatality rate (risk) equation are related theoretically to workers' compensation. The funding mechanism for workers' compensation creates safety incentives for firms that should increase the safety level provided. Even for relatively small firms that are not perfectly experience rated, the insurance underwriting procedures should lead to some link between workplace conditions and insurance premiums.

A potentially offsetting influence is that of moral hazard, as more generous benefit levels lead workers to decrease their levels of care. This aspect of worker behavior is just as unambiguous theoretically as the opposite safety incentive effect for employers. Furthermore, a number of studies have indicated that more generous benefits lead to more extended periods of recovery and to the possible overreporting of injuries.[8] These abuses are likely to be more responsive to the benefit level than to the fatality rate, which is the subject of this study. Although one cannot rule out the possibility of a dominant moral hazard effect on theoretical grounds, the high estimated value of life that workers receive through wage-risk trade-offs suggests that workers would not endanger their lives to a substantial degree to receive a more generous *ex post* compensation that will benefit their surviving heirs. In addition, a worker's ability to report a fatality when one has not occurred is obviously quite

[7] Butler (1983) and Garen (1988) are exceptions to this.

[8] See Butler and Worral (1983, 1985), Kniesner and Leeth (1989, 1988), and Krueger (1988).

limited. Our working hypothesis was that higher benefits lower fatality risk levels; therefore, the workers' compensation variable was expected to have a negative sign in the fatality rate equation.

The second variable of interest—the square of the workers' compensation variable—pertains to the nonlinearity of the effect of workers' compensation on fatality rates. This relationship is highly complex once all feedback effects, such as moral hazard, are taken into account. We therefore included a quadratic term to capture the nonlinearities.

The third workers' compensation variable captures the interaction between workers' compensation and firm size. The cost of an accident to a firm in terms of increased insurance premiums depends crucially on the degree to which firms are experience rated.[9] Large firms, particularly those that self-insure, will be rated according to their own accident experience and feel the full impact of accidents on their insurance premiums. Thus, the safety incentives should be greater in larger firms.[10]

The variables included in the wage equation represent less complex influences. Wages should increase with the risk level, following Adam Smith's proposition that hazardous jobs will command compensating differentials. For economically similar reasons, higher levels of workers' compensation should lead to a wage reduction; *ex post* compensation for job risks should decrease the level of *ex ante* compensation required. The extent of the offset depends on the attractiveness of the insurance provided, which is determined by factors such as the degree of insurance loading and the risk level.

3. The sample and the variables

■ Our primary data source in this study was the University of Michigan Panel Study of Income Dynamics (PSID). The PSID is a longitudinal survey of worker characteristics and their employment experiences beginning in the year 1968. Our analysis focused on the 1982 wave of the data. We selected the 1982 wave of the PSID because it provided the detail necessary to enable a precise matching of our primary variables of interest—the job risk and workers' compensation variables—to the sample members. The time period covered by this wave of the survey was the most appropriate for the risk measure that we used. The PSID data have been used in previous applications of the compensating differential model, such as Viscusi (1979), Moore and Viscusi (1988a, 1988b, 1989, forthcoming), and Viscusi and Moore (1989).

The PSID data contain two subsamples. One includes a group of workers who were selected because their incomes fell below a specified poverty standard; the other consists of randomly selected individuals. To preserve the representativeness of our data, we excluded the poverty subsample. Our 1982 PSID subsample, which measures labor market outcomes for 1981, contains 1,173 observations after the exclusion of farmers and farm managers, workers who are not household heads, government employees (for whom no risk data were available), and cases with missing data. The sample is broadly representative of the working population, considering these exclusions. Table 1 defines the variables used in the empirical analysis and summarizes their means and standard deviations.

The primary focus of our empirical analysis was on the interrelationships among wages, hazardous working conditions, firm size, and insurance for job-related injuries. Because the PSID data does not include information on job risks, workers' compensation benefits, or firm size, we collected these measures from external published sources and matched the information to workers in the PSID.

The death risk data, which first became available in 1987, consist of data collected by the National Institute for Occupational Safety and Health (NIOSH) as part of its ongoing

[9] Ruser (1985) discussed these rating practices in detail.

[10] Chelius and Smith (1987) analyzed the combined role of compliance costs and premiums and found that costs per dollar of loss are U-shaped with respect to size. Our analysis provides empirical evidence on the total size-safety relationship below.

TABLE 1 Sample Characteristics

	Mean (Standard Deviation)	Variable Definitions
RISK	6.61 (8.54)	NTOF risk variable. Number of fatal accidents per 100,000 workers in the worker's industry on a state-specific basis.
WCMAX	239.58 (80.65)	Maximum benefit level for temporary total disability under state workers' compensation program.
SIZE	44.02 (75.74)	Firm size variable: Number of workers by state and industry.
WAGE	485.74 (215.97)	Computed weekly wage in 1981.
FEMALE	0.17 (0.38)	Sex dummy variable: 1 if worker is female, 0 otherwise.
BLACK	0.08 (0.27)	Race dummy variable: 1 if worker is black, 0 otherwise.
KIDS	1.00 (1.15)	Number of dependent children.
MARRIED	0.71 (0.45)	Marital status dummy variable: 1 if worker has ever been married, 0 otherwise.
HEALTH	0.07 (0.26)	Health status dummy variable: 1 if worker has a serious physical or nervous condition that limits the amount of work he can do, 0 otherwise.
EDUCATION	12.92 (2.51)	Number of grades completed.
EXPERIENCE	11.74 (10.53)	Years worked full-time since age 18.
JOB TENURE	5.08 (6.28)	Years worked on current job.
UNION	0.30 (0.46)	Union status dummy variable: 1 if worker's job is covered by a collective bargaining agreement, 0 otherwise.
BLUE COLLAR	0.55 (0.50)	Collar-color dummy variable: 1 if worker is in a blue-collar occupation, 0 otherwise.

National Traumatic Occupational Fatality (NTOF) project. The NIOSH initiated the NTOF study to provide a more accurate assessment of fatality risks and, as a by-product, to reconcile differences in existing sources of risk data—primarily the occupational fatality data provided by the Bureau of Labor Statistics (BLS), the National Safety Council (NSC), and the National Center for Health Statistics (NCHS). The discrepancies in the perspectives on job risks provided by these sources are large. In 1984, for instance, the estimated numbers of fatalities in the BLS, NSC, and NCHS data were 3,750, 11,500, and 4,960, respectively, while the NTOF five-year average for the period 1980–1984 was approximately 7,000 fatalities per year. Some of the discrepancies can be explained by differences in the coverage of each survey. The NSC, for instance, is the only source that includes government workers, small firms, and self-employed individuals. It is doubtful, however, that inclusion of these omitted groups would triple the BLS death rate and thus bring it more into line with the NSC estimate.

The NTOF data have a major advantage for any study of workers' compensation, since they are available by state, which is the degree of disaggregation that is required to sensibly analyze the state-run workers' compensation programs. Previously published risk data do not reflect state differences, creating potentially serious comparability problems.[11] Using

[11] In those studies that have analyzed the impact of workers' compensation on injury rates, Butler (1983) used time series data on risks and benefits within a single state (South Carolina) to circumvent this problem. Chelius (1982) used unpublished data on two-digit (SIC) manufacturing industries for 36 states, and Ruser (1985) used unpublished BLS injury data for 25 three-digit manufacturing industries across 41 states. Of the three studies, only

the national level BLS risk data to analyze the relationship between wages and insurance benefits creates an obvious source of error, since the national risk data ignore interstate variation in risks within industries.[12] The sampling error inherent in the BLS survey and the interindustry risk variation lost as a consequence of aggregation create substantial measurement error problems.

The NTOF data are not plagued by these same problems. Fatality rates in the currently available data were constructed from a census of occupational fatalities during the years 1980–1984 and are classified by state and industry. As a consequence, there is no sampling error due to survey techniques, and both interstate and interindustry risk variations are captured by the data. One limitation of the NTOF data base is that it does not provide information on nonfatal injury rates.

Since the NTOF data have only recently been released, the implications of the new risk data for our understanding of the role of job risks in the labor market have not yet been fully explored. The first study to compare the implications of using the NTOF data rather than the BLS data is Moore and Viscusi (1988b). This research indicates that there exists a substantial amount of measurement error across industries in the BLS data and that using the BLS data lowers the estimated value of life by over one-half. Furthermore, in all of the wage equation specifications we tested for this study, the NTOF data yielded much stronger statistical results.

The second key variable we used is the measure of workers' compensation benefits. Previous analyses have utilized a range of measures, including the weekly wage replacement rate (Viscusi and Moore, 1987; Moore and Viscusi, 1988b, 1989; Chelius, 1982; Arnould and Nichols, 1983), weekly benefits (Ruser, 1985), annual payments by industry (Butler, 1983), and workers' compensation premium rates (Dorsey and Walzer, 1983). In most cases, benefits for the most frequent type of claim—temporary total disabilities—have been used as a proxy for all types of benefits, including those for temporary total, permanent total, and permanent partial disabilities, and for fatality benefits. Butler, however, did attempt to separately identify the effects of each type of benefit with some success and constructed a benefit index using principal components analysis. Viscusi and Moore (1987) documented the high correlations among the various benefit categories that make separation of their effects difficult. We based the benefit measure used here on the temporary total disability category.

State workers' compensation benefits are determined by a formula that specifies both a minimum benefit amount and a benefit cap. If two-thirds of the worker's pretax wage falls between these limits, the benefits paid equal two-thirds of the wage. The average pretax wage replacement rate in our sample is lower than .67, since many workers' wages exceeded the cap.[13] Because of their mechanical dependence upon the wage, specific measures of an individual's workers' compensation benefits create endogeneity problems in the estimation of wage and risk equations. In previous wage equation studies, instrumental variables estimation has been used to solve this problem.[14]

Butler attempted to analyze the combined impact of benefits on both injury rates and wages. Butler's results are not conclusive however, and the restricted scope of the South Carolina data limits the generalizability of his results.

[12] In the NTOF data, the average risks within one-digit SIC industry classifications are typically two to five times the size of their standard errors, so the interstate risk variation is more pronounced for some industries than for others.

[13] Workers who qualified for the minimum benefit constitute a small portion of the sample (1%). We treated these workers as if they were above the minimum for estimation purposes. We attempted to add a switching variable similar to the variable d, but it was not possible to estimate a first-stage probit equation to construct the selectivity variable corresponding to workers whose wage put them below the minimum benefit level. Even the simplest models, containing only a few of the variables in the probit equations described in the text, did not work.

[14] Butler (1983) and Garen (1988) used primarily instrumental variables to estimate the risk equations in their studies.

As an alternative, in this study we focused our attention on the role that changes in benefit ceilings (*WCMAX*) play in the determination of fatality risks. This approach has two desirable features. First, the benefit ceiling is one of the key workers' compensation policy variables and varies widely across states. Second, benefit ceilings are set by state boards and are less likely to be endogenous in the risk and wage equations.

The benefit ceiling will affect wage and risk levels of all workers when each worker's weekly wage is uncertain. In this case, increases in benefit ceilings increase the spread of potential benefits. Furthermore, increases in benefit ceilings are typically accompanied by increases in benefit floors. Consequently, benefit ceilings act as a proxy for *ex ante* expected benefits, and increases in these ceilings will benefit all workers. It is likely, however, that variations in the ceiling will have a larger effect for workers for whom the ceiling acts as a constraint. We allowed for these differences by estimating a switching regression model, where the switching variable is defined as

$$d_i = \begin{cases} 1 & \text{if} \quad (2/3)WAGE_i \geq WCMAX_i \\ 0 & \text{if not.} \end{cases}$$

We describe the risk and insurance variables that were our principal focus at the top of Table 1. The variable *RISK* is the average number of fatalities per 100,000 workers for the years 1980–1984, as measured by the NIOSH. The overall fatality rate in our sample of 6.6 deaths per 100,000 workers is approximately 30% higher than the BLS death rate for this period. The benefit ceiling variable, *WCMAX*, equals the maximum benefit level for which the worker qualifies, based on weekly insurance benefits for temporary total disability as reported annually by the United States Chamber of Commerce (1982). We matched the *RISK* variable to workers by their reported state and industry and matched *WCMAX* by state.

The third variable that we collected externally is the firm size variable, *SIZE*. Since the PSID data does not include such a measure, we matched average firm size data from United States Department of Commerce (1984) to workers in the sample by state and one-digit industry. Workers in the transportation, utilities and sanitary services, and the finance, insurance, and real estate industries were excluded from our sample in the matching process because size data were not available for these industries.

A secondary issue is the use of state dummy variables as regressors in the risk equation. State dummies were used by Ruser (1985) and Krueger (1988) to control for interstate differences in the types of injuries that firms are required to report. The inclusion of state dummies makes it difficult to estimate the workers' compensation effects, however, since these vary primarily by state. Fortunately, this problem did not arise for the risk variable considered here. Firms in all states must report on-the-job fatalities, and the definition of what constitutes a fatality is certainly clear-cut.

The primary measure of pecuniary compensation that we used is the worker's weekly wage (*WAGE*) for 1981, the year covered by the 1982 PSID data. The explanatory variables in the *WAGE* equations consist of a group of measures representing personal characteristics, location measures, and characteristics of the worker's job, including the job risk and workers' compensation. Personal background variables include the worker's sex (*FEMALE* dummy variable) and race (*BLACK* dummy variable). Although these variables primarily reflect tastes, they can also represent the effects of market discrimination or the effects of worker traits that are unobservable to the firm, but are correlated with these characteristics. The human capital variables are standard for wage equation studies and reflect productivity limitations (*HEALTH*), years of formal schooling (*EDUCATION*), and acquired training that is either general (*EXPERIENCE*) or specific (*JOB TENURE*) in nature. We included state dummy variables as indicators of interstate wage differentials due to differences in the cost of living and local labor market demand conditions. The job variables available in the

PSID data set include a dummy variable for the worker's collective bargaining status (*UNION* dummy variable) and the collar-color dummy variable (*BLUE COLLAR*) that indicates whether a worker is in a blue-collar occupation. This latter variable captures the role of omitted job characteristics that are correlated with blue-collar occupations.

4. Estimation procedure

■ To determine the effect of the benefit maximum on fatality risk levels, we regressed the variable *RISK* on the three benefit variables, *WCMAX*, $WCMAX^2$, and (*WCMAX*)(*SIZE*). We also included industry dummy variables and *SIZE* as control variables in the vector X_R.[15] The *RISK* equations estimated are

$$RISK_{1i} = \alpha_1' X_{Ri} + \alpha_b^1 WCMAX_i + \alpha_{bb}^1 WCMAX_i^2 + \alpha_{bs}^1 (WCMAX_i)(SIZE_i) + \epsilon_{1i} \quad (1)$$

and

$$RISK_{0i} = \alpha_0' X_{Ri} + \alpha_b^0 WCMAX_i + \alpha_{bb}^0 WCMAX_i^2 + \alpha_{bs}^0 (WCMAX_i)(SIZE_i) + \epsilon_{0i}, \quad (2)$$

where the indicators 1 and 0 identify whether the worker is above or below the benefit ceiling.

Consistent estimates of the parameters in equations (1) and (2) require that

$$E[\epsilon_{1i} | d_i = 1] = E[\epsilon_{0i} | d_i = 0] = 0.$$

As shown by Heckman (1979), Maddala (1983), and others, these expectations equal

$$E[\epsilon_{1i} | d_i = 1] = -\sigma_{1u} \lambda_{1i}$$

and

$$E[\epsilon_{0i} | d_i = 0] = \sigma_{0u} \lambda_{0i},$$

where

$$\lambda_{1i} = \frac{\phi(\gamma' Z_i)}{\Phi(\gamma' Z_i)}$$

and

$$\lambda_{0i} = \frac{\phi(\gamma' Z_i)}{1 - \Phi(\gamma' Z_i)},$$

and where ϕ_i and Φ_i denote the standard normal density and distribution functions. The covariance terms, σ_{ju}, represent the covariances between the ϵ_{ji} and the normalized error term, u, in the reduced form selection equation:

$$\begin{aligned} Prob[d = 1] &= Prob[(2/3)WAGE - WCMAX \geq 0] \\ &= Prob[-\gamma' Z \leq u]. \end{aligned}$$

Candidates for variables to include in the vector Z include any variables that cause variation in either the wage or in the maximum benefit level. However, since the wage is endogenous in the risk equation, any variable that is not independent of the individual, specific component of the wage does not qualify as an instrumental variable. Consequentially, we focused our attention on variables that cause variation in *WCMAX* instead. In particular, we used a model developed by Danzon (1988) that explains the variation in *WCMAX* and, therefore, in d. Our instruments in the probit equation included the percentage of the

[15] The industry categories include mining, construction, manufacturing, communication, wholesale trade, retail trade, and services. The services dummy was excluded for estimation purposes.

residents in each state whose age is less than 65 years, the percentage of blacks, the percentage of females, and the percentage of those with less than 12 years of schooling as demographic mix variables. The percentage of firms with more than 100 employees, the percentage of firms with less than 20 employees, and the percentage of workers in each one-digit industry served as industrial mix variables. We took these as our minimal instrument set (i.e., the set of instrumental variables in which we had the most faith) and experimented with adding other variables that affect *WCMAX* in order to increase the precision of our estimates. Our final instrument set included variables representing the individual worker's number of dependent children and marital status and a regional dummy variable for the southeast, in addition to the minimal set. We assumed that these variables are exogeneous with respect to risk in the sense that if the proportion of any one of the demographic mix variables or any one of the industrial mix variables within a state should change, then there should be no change in the underlying riskiness of the job that is not accounted for by the exogenous variables in the risk equation.

To test the sensitivity of our results to this assumption, we estimated an alternative *RISK* equation in which the variables in Z were included as regressors. The results discussed below, which are based on *RISK* equations with the Z variables excluded, are not sensitive to the exclusion restrictions, particularly in the ln *RISK* equation, where the signs and significance levels remain unchanged. Furthermore, the main findings discussed below also survive the relaxation of this restriction when *RISK* is converted to the log-odds form.

We therefore estimated the equations

$$RISK_{1i} = \alpha'_1 X_{Ri} + \alpha^1_b WCMAX_i + \alpha^1_{bb} WCMAX_i^2 + \alpha^1_{bs}(WCMAX_i)(SIZE_i) - \sigma_{1u}\hat{\lambda}_{1i} + \epsilon^*_{1i} \quad (3)$$

and

$$RISK_{0i} = \alpha'_0 X_{Ri} + \alpha^0_b WCMAX_i + \alpha^0_{bb} WCMAX_i^2 + \alpha^0_{bs}(WCMAX_i)(SIZE_i) + \sigma_{0u}\hat{\lambda}_{0i} + \epsilon^*_{0i}, \quad (4)$$

where $\hat{\lambda}_{ji}$ was estimated in a first-stage probit equation.

Combining equations (3) and (4) yields the single *RISK* equation

$$\begin{aligned} RISK_i = {} & \alpha'_0 X_{Ri} + (\alpha'_1 - \alpha'_0) X_{Ri}\Phi_i + \alpha^1_b WCMAX_i\Phi_i + \alpha^0_b WCMAX_i(1 - \Phi_i) \\ & + \alpha^1_{bb} WCMAX_i^2\Phi_i + \alpha^0_{bb} WCMAX_i^2(1 - \Phi_i) + \alpha^1_{bs}(WCMAX_i)(SIZE_i)\Phi_i \\ & + \alpha^0_{bs}(WCMAX_i)(SIZE_i)(1 - \Phi_i) + (\sigma_{0u} - \sigma_{1u})\phi_i + \epsilon^*_i. \quad (5) \end{aligned}$$

Combining equations (3) and (4) in this manner allows a test of the restriction $\alpha'_1 = \alpha'_0$. If this restriction is not rejected, its imposition increases the efficiency of the estimation, giving more precise estimates of the workers' compensation effects.[16] On the other hand, the standard errors estimated in equation (5) are suspect, since estimation of a single, combined equation such as this imposes the restriction that the variances of the error terms in equations (3) and (4) be equal. We adjusted the standard error estimates by using the formula in Maddala (1983) to correct for this problem.

As discussed in Section 2, our hypothesized effects of workers' compensation on *RISK* were $\alpha^j_b < 0$, $\alpha^j_{bb} > 0$, and $\alpha^j_{bs} < 0$. If moral hazard offsets the safety incentive effect, the net effect of workers' compensation will be to raise the fatality risk. Our results therefore provide a direct test of the net incentive effect of workers' compensation. Based upon our interpretation of *WCMAX* as a proxy for expected benefits, we also expected $|\alpha^1_k| > |\alpha^0_k|$ for $k = b, bb, bs$.

[16] There were no significant differences between these coefficients when the models were estimated separately.

5. *RISK* equation estimates

■ Table 2 presents least squares estimates of the *RISK* and ln *RISK* equations described above. The coefficient estimates reported represent the coefficients multiplied by Φ or $(1 - \Phi)$ to facilitate the comparison of the effects between workers above and below the maximum. The variable *SELECTIVITY* denotes the Mill's ratio variable. The total effects of the key explanatory variables are presented at the bottom of Table 2.

The results given in Table 2 indicate that workers' compensation serves on balance as a safety incentive mechanism. The *WCMAX* variable has a negative sign and very strong statistical significance in all four cases, indicating a large negative benefit impact on fatality levels. The nonlinearity of the *WCMAX* effect is also very strong, as evidenced by the significant positive coefficients for $WCMAX^2$. The negative effect of $(WCMAX)(SIZE)$, which is statistically significant in the *RISK* equation for workers above or below the maximum, indicates that rating firms more in line with their experience serves to reinforce the dampening effect of workers' compensation on risks. Furthermore, the $(WCMAX)(SIZE)$ interaction is jointly significant with the *SIZE* variable in both equations. The total *SIZE* effect is negative in both cases, which is consistent with the previous findings in the literature. Both economies of scale in the production of safety and experience rating exert downward pressure on risk levels.

The finding that workers' compensation benefits exert a significant negative effect on fatality rates in unprecedented in the literature. Of the major studies that have identified

TABLE 2 **Estimates of the Risk Equations Coefficients and Standard Errors**

	Dependent Variable	
Coefficient (Variable)[a]	*RISK*	ln *RISK*
$\alpha_s(SIZE)$	0.012	−1.14E-3*
	(0.009)	(0.70E-3)
$\alpha_b^1(WCMAX\|d = 1)$	−1.26E-2**	−2.56E-3**
	(0.50E-2)	(0.55E-3)
$\alpha_b^0(WCMAX\|d = 0)$	−0.78E-2**	−1.47E-3**
	(0.31E-2)	(0.38E-3)
$\alpha_{bb}^1(WCMAX^2\|d = 1)$	2.03E-5**	3.52E-6**
	(1.01E-5)	(1.07E-6)
$\alpha_{bb}^0(WCMAX^2\|d = 0)$	1.54E-5*	2.56E-6**
	(0.81E-5)	(1.23E-6)
$\alpha_{bs}^1((WCMAX)(SIZE)\|d = 1)$	−4.15E-5*	−1.67E-6
	(2.51E-5)	(2.66E-6)
$\alpha_{bs}^0((WCMAX)(SIZE)\|d = 0)$	−2.27E-5*	−1.14E-6
	(1.26E-5)	(1.42E-6)
$(\sigma_{2u} - \sigma_{1u})(SELECTIVITY)$	7.197*	1.364**
	(4.136)	(0.453)
R^2	0.769	0.702
Total Effects of Explanatory Variables[b]		
WCMAX	−6.09E-3	−8.40E-3
$\chi^2(WCMAX, d.f. = 3)$	16.9**	42.5**
SIZE	−3.41E-3	−1.81E-3
$\chi^2(SIZE, d.f. = 2)$	10.5**	107.7**

* Statistically significant at the 5% confidence level, one-tailed test.
** Statistically significant at the 1% confidence level, one-tailed test.
[a] Also included as control variables were seven industry dummy variables.
[b] Evaluated at the sample means.

statistically significant effects, Chelius (1982) found a positive relationship between benefits and injury frequencies and Ruser (1985) found the same relationship between benefits and injuries that resulted in lost workday cases. Likewise, Butler and Worral (1985) found a positive effect of benefits on the claims rate for temporary total disabilities. Most recently, Krueger (1988) found a positive relationship between benefits and participation rates for workers' compensation programs, except for female workers. On the other hand, Chelius also found a negative relationship between benefits and injury severity as measured by total lost workdays, and Krueger and Burton found no relationship between workers' compensation costs and injury rates.

The most likely reason why our results run counter to those in the literature appears to be the nature of the risk variable. There are two aspects of moral hazard reflected in the injury rate studies—reduced care and the filing of spurious claims. The available evidence indicates that the latter effect can be substantial. Butler and Worral (1983, 1985) have documented a positive effect of benefits on both the filing of claims and their duration, and Smith (1989) has found that a large number of claims for sprains and strains occur on Monday mornings, which suggests that workers might postpone treatment for some injuries suffered at home in order to qualify for benefits. For two reasons, it is not likely that reduced care or the filing of false claims is reflected in our data. Evidence on workers implicit valuations of life suggests that increases in the risk of death are not adequately compensated for by increased benefits. More importantly, the ability to file a false claim is severely limited for fatalities.

Another important difference in our risk variable is the process by which the NTOF data were collected. Since the NTOF data represent a census of fatalities on the job, they are not subject to the sampling error that is inherent in the risk data collected by the Bureau of Labor Statistics and other agencies. Evidence presented by Moore and Viscusi (1988b) indicates that this error is not entirely random, which may also help to explain the differences in our results.

6. Wage equation estimates

■ The main result of the preceding section, i.e., that workers' compensation benefits exert strong downward pressure on injury rates, identifies a third linkage in the wage-risk-benefit model. The majority of the empirical research on wage-risk and wage-benefit trade-offs indicates that increases in job risks cause wages to rise, while increases in workers' compensation benefits generate wage reductions.[17] To the extent that benefit increases cause risks to fall, these previous analyses have understated the estimates of the wage-benefit trade-off by ignoring the indirect effect of benefits on wages through risks.

To explore the complete wage-risk-benefit model, we used the estimated risk-benefit trade-offs from Table 2 in conjunction with a standard compensating differential wage equation. Again, we estimated switching equations for workers above and below the maximum. Combining the wage equations yields

$$WAGE_i = \beta'_0 X_{Wi} + (\beta'_1 - \beta'_0) X_{Wi}\Phi_i + \delta^1_R RISK_i \Phi_i + \delta^0_R RISK_i (1 - \Phi_i) + \delta^1_b (RISK_i) \times (WCMAX_i)\Phi_i + \delta^0_b (RISK_i)(WCMAX_i)(1 - \Phi_i) + (\sigma_{2u} - \sigma_{1u})\phi_i + \nu^*_i . \quad (6)$$

The control variables in the vector X_W included state dummy variables, years of job tenure, experience, and education, *SIZE*, number of dependents, marital, health, and union status dummy variables, and the blue-collar occupation dummy variable. Squared values of job tenure and experience were also included.

[17] See, for example, Viscusi and Moore (1987).

State dummies were included in the wage equation to control for differences in the cost of living and in labor market conditions across states. The remaining control variables are standard in wage equations. We did not use a measure of city size in the results reported, since it was never close to statistically significant; its exclusion did not alter the results.

The coefficients in equation (6) should have the signs:

$$\delta_R^1, \delta_R^0 > 0; \qquad \delta_b^1, \delta_b^0 < 0; \qquad \text{and} \qquad |\delta_b^1| > |\delta_b^0|.$$

These coefficients, in conjunction with those in equation (5), can then be used to compute the effect of an increase in $WCMAX$ on $WAGE$. This effect equals

$$\begin{aligned}\frac{\partial WAGE}{\partial WCMAX} &= [\delta_R^1\Phi + \delta_R^0(1-\Phi) + (\delta_b^1\Phi + \delta_b^0(1-\Phi))WCMAX]\frac{\partial RISK}{\partial WCMAX} \\ &\quad + [\delta_b^1\Phi + \delta_b^0(1-\Phi)]RISK \\ &= \Delta_R\frac{\partial RISK}{\partial WCMAX} + \Delta_b RISK. \qquad (7)\end{aligned}$$

Using equation (5), we obtain

$$\begin{aligned}\frac{\partial RISK}{\partial WCMAX} &= \alpha_b^1\Phi + \alpha_b^0(1-\Phi) + 2(\alpha_{bb}^1\Phi + \alpha_{bb}^0(1-\Phi))WCMAX \\ &\quad + (\alpha_{bs}^1\Phi + \alpha_{bs}^0(1-\Phi))SIZE \\ &= \alpha_b + \alpha_{bb}WCMAX + \alpha_{bs}SIZE. \qquad (8)\end{aligned}$$

Combining equations (7) and (8) gives

$$\frac{\partial WAGE}{\partial WCMAX} = \Delta_R(\alpha_b + \alpha_{bb}WCMAX + \alpha_{bs}SIZE) + \Delta_b RISK. \qquad (9)$$

Previous estimates of wage-benefit trade-offs ignored the indirect effect represented by the first term in equation (9). If increases in the benefit ceiling reduce fatality rates, as indicated in Table 2, these previous findings understated the size of the trade-off, given $\Delta_R > 0$.

Estimates of $\partial RISK/\partial WCMAX$ can be computed using the coefficients presented in Table 2. Using the estimates in either Column 1 or 2, we can see that a one dollar increase in $WCMAX$ causes $RISK$ to fall by about .006, when measured at the mean values of $WCMAX$ ($239.00) and $SIZE$ (44.0). To determine the total wage offset, we need only to use the estimated parameters of the wage equation.

□ **Estimates for equation (6).** Table 3 presents estimates of the parameters of equation (6) for a number of different specifications of the dependent variable. In each case, preliminary regressions were estimated to test the hypothesis $\beta_1' = \beta_0'$. Since this hypothesis was never rejected, we constrained these coefficients to be equal. Of these coefficients, we report only the compensating risk differential, δ_R. In each of the equations estimated, δ_R is positive and statistically significant at the 1% confidence level. Once again, we corrected the standard errors to allow for different variances in each regime.

The benefit variables also perform in the expected manner. Increases in the benefit ceiling cause wages to fall significantly for workers above the ceiling ($\delta_b^1 < 0$). Increases in the ceiling also cause wages to fall for workers for whom the maximum is not binding ($\delta_b^0 < 0$), and the amount of the decrease is less for these workers ($|\delta_b^1| > |\delta_b^0|$).

Although the δ_b^0 coefficients only approach significance at the 5% level, they are always jointly significant with the δ_b^1 coefficients and are significant at the 10% level in Column 3. This weak effect can be due to one of two things. As hypothesized, it might be the case that increases in the benefit maximum are not valued by workers whose wages fall below the

TABLE 3 **Estimates of the Wage Equations Coefficients and Standard Errors**

Coefficient (Variable)[a]	Weekly Wage	After-tax Weekly Wage	ln (Weekly Wage)	ln (After-tax Weekly Wage)
$\delta_R(RISK)$	5.20**	2.66**	1.12E-2**	8.13E-3**
	(1.95)	(1.08)	(0.42E-2)	(3.55E-3)
$\delta_b^1((RISK)(WCMAX)\mid d = 1)$	−1.22E-2*	−5.69E-3*	−2.45E-5*	−1.73E-5*
	(0.57E-2)	(3.19E-3)	(1.14E-5)	(0.97E-5)
$\delta_b^0((RISK)(WCMAX)\mid d = 0)$	−0.40E-2	−4.62E-3	−0.98E-5	−0.71E-5
	(0.32E-2)	(3.85E-3)	(0.64E-5)	(0.55E-5)
$(\sigma_{2u} - \sigma_{1u})(SELECTIVITY)$	−322.85*	−192.19*	−0.609*	−0.595*
	(155.87)	(86.86)	(0.336)	(0.284)
R^2	0.451	0.411	0.465	0.41

* Statistically significant at the 5% confidence level, one-tailed test.

** Statistically significant at the 1% confidence level, one-tailed test.

[a] Also included as explanatory variables were measures of the worker's sex, race, marital status, number of dependent children, health status, education, experience, job tenure, union status, firm size, and state dummy variables.

maximum. Alternatively, the lack of significance may be due to collinearity problems associated with the variables $WCMAX\Phi$ and $WCMAX(1 - \Phi)$.

The selectivity coefficients in Table 3 are all negative and significant. Since these coefficients measure the correlation between v_{ji} and u_i (the unobserved variables in the wage equation and the selection equation), the negative sign is not surprising: both σ_{1u} and σ_{0u} should be positive due to wealth effects. Empirically, it appears that $\sigma_{1u} > \sigma_{2u}$. The selectivity terms in the *RISK* equations, which are all positive and significant, also indicate the presence of wealth effects. Wealthier workers will buy off some risk and are more likely to have wages that exceed the maximum; therefore, the error terms in the risk equation and the selection equation should be negatively related.

7. Implications for market behavior

■ The most important implication of the results reported in Tables 2 and 3 is the perspective they give on the market effects of workers' compensation that extend beyond the payment of premiums and compensation. Consider first the safety incentive effect. Although the net impact of insurance benefits on *RISK* is theoretically indeterminate, the estimates of the *RISK* equations indicate empirically that benefit increases exert considerable pressure on firms to improve safety levels, thus reducing fatality risk levels. Indeed, using the estimates from Table 2, if benefits were nonexistent, the average fatality rate would rise by approximately 1.5 deaths per 100,000 workers, or an increase of 22%.[18] The Table 2 results also indicate that benefits exert downward pressure on injury rates that diminishes as benefits rise. Using the estimates in Column 1 of Table 2, the safety effect continues to dominate up to a weekly benefit maximum of \$325.00, or \$375.00 in 1988 prices.[19]

The second notable result concerns the wage-risk feedback effects of workers' compensation. If benefit increases cause fatalities to fall, as our results indicate, the net wage savings generated by the wage-benefit trade-off include an indirect effect due to the positive

[18] Using the risk-benefit trade-off in Column 2 of Table 2, the total effect of *WCMAX* on the fatality rate equals $(-0.0061)(240) = -1.5$ deaths per 100,000 workers. This result assumes that the point estimates are valid over the entire range of *WCMAX*, which may not be the case.

[19] Setting $\partial RISK/\partial WCMAX$ equal to zero and solving for *WCMAX*, at the mean *SIZE* = 44.0, yields this result. The price inflator used is 1.15.

relationship between wages and risks. Based on the estimates in the first column of Table 2, which indicate that a $1.00 increase in the weekly maximum benefit results in .006 fewer deaths per 100,000 workers, we can compute the portion of the total per week wage savings generated by risk reductions. The structural weekly wage equation estimates (Table 3, Column 1) indicate that one additional death per 100,000 workers results in a weekly wage increase of $1.31.[20] Thus, a $10.00 increase in benefits, which lowers the death rate by .06, causes weekly wages to fall by $.08 (($1.31)(.06)), or about $5.00 per worker annually in 1988 prices. This effect equals about one-tenth of the direct effect of benefits on wages, which equals $1.10 per week. Thus, compared to the direct effect, this indirect effect is relatively unimportant.

One implication of these results is that safety expenditures induced by the benefit hikes are self-financed in part through wage reductions. To get an idea of the magnitude of the savings generated by risk reductions in 1982, the year covered by our sample, consider the effect of a 10% increase in the benefit maximum, which corresponds roughly to annual growth rates in workers' compensation premiums for the years 1977–1983.[21] At the mean value of *WCMAX* in our sample ($240.00), the implied increase of $24.00 would lower the death rate by .14, with a resulting decline in weekly wages of $.20 (($1.31)(.14)), or about $10.00 annually ($12.00 in 1988 prices). This figure, which measures the safety incentive effects of workers' compensation acting as an injury tax, dwarfs the OSHA fines per worker for the period of about $.50 per year. The $12.00 per worker wage reduction also equals approximately one-fifth the reported per worker expenditures on health and safety for the year 1981 of $57.00, expressed in 1988 prices.[22]

In addition to the self-financing aspect of the risk reductions caused by workers' compensation increases, there is also a substantial direct wage saving generated by the benefit increases. The direct effect of an increase in the benefit maximum equals approximately $.107 in weekly wages per dollar of benefits. Thus, if a worker is earning $486.00 per week (the mean in our sample) and is above the maximum, which equals, say, $240.00, a 10% increase in *WCMAX* of $24.00 will cause weekly wages to fall by about $2.57, or about $150.00 per year in 1988 prices.

A further implication of the estimated wage trade-off is that it can be used to estimate the degree of risk aversion exhibited by workers in our sample. Our estimates imply that a $2.40 increase in weekly benefits will reduce wages by $.20, or $10.00 per year. The expected value to the worker of this $2.40 weekly benefit increase, using a fatality rate of 6.6 deaths per 100,000 workers, 52 weeks worked, and 30 years of remaining life for the surviving spouse, equals $.24. Thus, the ratio of the cost to the expected benefit is quite high, as the cost exceeds the benefit by a factor of about forty. Based on this, one might conclude that the trade-off suggests extreme risk aversion. However, this large observed wage trade-off might indicate instead that the effective value of the benefit increase depends on the likelihood of any accident, not just fatalities. For example, using a nonfatal lost workday accident frequency of 4.0 deaths per 100 workers, which is close to the national average for the period and an average duration of 13 weeks, and assuming for simplicity that fatal and nonfatal accident probabilities are independent, the expected value of the $2.40 benefit increase equals about $1.50. Thus, workers give up $10.00 in annual wages for about $1.50 in expected benefits, which is much more plausible.

We do not have information on the changes in fatality insurance premiums per worker

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[20] $\partial WAGE/\partial RISK = 5.20 - (.0122 + .0040)(WCMAX) = \$1.31$.

[21] See Price (1984).

[22] Actual expenditures on employee safety and health in 1981 for all businesses, reported by McGraw-Hill (1986), were $5,120.4 million. The total civilian labor force in 1981 included 107 million workers, as reported by the council of Economic Advisers (1987). Safety expenditure data were taken from *The McGraw-Hill Survey of Investment in Employee Safety and Health* (1986).

that would arise due to a 10% increase in the benefit maximum. Therefore, we cannot determine what portion of this increase is paid for out of wage reductions. In the absence of benefits, annual wages would be $1,475.00 higher (in 1988 prices).[23] By way of comparison, total compensation per year for fatality risks, assuming a mean death rate of 6.6 deaths per 100,000 workers, equals about $500.00 in our results.

8. Robustness of the results

■ Given the particular estimation strategy followed in this article, our results do not appear to be sensitive to the form of the dependent variable in the risk or the wage equations. Furthermore, use of the before- or after-tax wage did not alter the results. The final specification issue (i.e., the robustness of our results to the specification and estimation approach chosen) does not appear to be a problem either. For instance, instrumental variable estimates reported in Moore and Viscusi (forthcoming) produce identical results in terms of sign and statistical significance of the workers' compensation variables in both the risk and the wage equations. We have also estimated a version of the model using the estimation strategy developed by Biddle and Zarkin (1988); once again, the qualitative nature of our results does not change.

9. Conclusion

■ The workers' compensation program has not enjoyed the most favorable reputation. In the past critics charged that benefit levels were not high enough to provide for full income replacement. States increased benefits beginning in the 1970s, but this improvement evoked cries of alarm regarding spiralling premium costs and abuses with respect to moral hazard problems, such as false claims and overextended periods of recovery from illnesses.[24]

Although the moral hazard problems are important, workers' compensation also plays a constructive role. The results presented in this article indicate that workplace fatalities would increase in the absence of this program. Workers' compensation represents by far the most influential governmental program for reducing workplace fatalities. This effectiveness suggests that if the current level of safety is considered too low, one might wish to assess the degree to which some of OSHA's responsibilities could be shifted to an injury tax approach.

Complaints voiced by firms with respect to escalating workers' compensation premiums may be overstated, since they neglect the substantial wage offset resulting both from the risk reduction induced by workers' compensation and the trade-off workers make between *ex post* insurance compensation and *ex ante* wage compensation. However, even though the net economic cost of workers' compensation to firms is considerably lower than the premium level (due to these offsets), firms may not be irrational in their complaints about rising premiums, since the costs of the marginal benefit increases are positive. (See Moore and Viscusi (1989).)

The favorable evidence presented here with respect to the performance of workers' compensation is not intended to lead observers to dismiss as unimportant the difficult causality problems raised by health risks, the litigation problems raised by permanent disabilities, and the continuing moral hazard problems with respect to nonfatal injury claims and their duration.[25] Nevertheless, our results do suggest that workers' compensation is more successful in promoting its intended objectives than was previously believed.

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[23] The weekly wage effect equals $.107 per dollar of benefits. Multiplying by *WCMAX* ($240.00) and by 50 weeks yields $1,280.00 per year, or about $1,475.00 in 1988 prices.

[24] See, for example, Smith (1989), Butler and Worral (1985), Kniesner and Leeth (1989, 1988), and Krueger (1988) for analyses of moral hazard problems.

[25] For an excellent discussion of the agenda for workers' compensation reform, see Weiler (1986).

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