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OSHA ENFORCEMENT, INDUSTRIAL COMPLIANCE AND WORKPLACE INJURIES

Ann P. Bartel

Lacy Glenn Thomas

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ABSTRACT

This paper develops and tests a three-equation simultaneous model of OSHA enforcement behavior, industrial compliance and workplace injuries. The enforcement equation is based on the assumption that OSHA acts as a political institution that gains support through the transfer of wealth from firms to employees; the empirical results are largely consistent with this notion. Contrary to previous work, we find that OSHA enforcement efforts have, indeed, had a statistically significant impact on industrial compliance and, further, that this compliance has led to a statistically significant decrease in worker injuries. The point estimate of the elasticity of the lost workday rate with respect to the OSHA inspection rate is -.04.

Ann P. Bartel
Columbia University
Graduate School of Business
710 Uris Hall
New York, New York 10027
212-280-4419

Lacy Glenn Thomas
Columbia University
Graduate School of Business
724 Uris Hall
New York, New York 10027
212-280-5767

OSHA Enforcement, Industrial Compliance and Workplace Injuries

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I. Introduction

Passage of the Occupational Safety and Health Act in 1970 raised expectations that both the number and severity of injuries attributable to our nation's workplaces would be curtailed. One of the Act's authors was even so optimistic as to express hope that by 1980 injuries would be reduced 50 percent or more.[1] Unfortunately, existing evidence does not support so sanguine a view of regulatory effectiveness. In the first place, after a decline in the early 1970's, workplace fatalities have in recent years resumed an upward trend. Other injury data provide even more ambiguous implications for the efficacy of regulation; the ratio of injury cases to all workers has followed the trend in fatalities, falling then rising, while the ratio of lost workdays caused by injuries to all workers has actually increased every year since 1970.[2] More disturbingly, an extended series of professional studies have failed to find any statistically significant impact on national injury rates due to activities by the Occupational Safety and Health Administration, or OSHA.[3] Indeed, when these studies find occasional specifications which indicate statistically significant OSHA influence, that influence is as often estimated to increase injuries as it is to

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[1]Mendeloff (1979), p. 82.

[2]U.S. Department of Labor, Bureau of Labor Statistics, "Occupational Injuries and Illnesses: Summary," various years.

[3]DiPietro (1976), Mendeloff (1976, 1979), Smith (1976), and Viscusi (1979). Recent studies with more optimistic findings include Cooke and Gantschi (1981) and Smith (1979).

decrease them.[4] The authors of this series of studies have argued that any mid-1970's declines in injury rates were due not to regulation, but to labor market forces related to the contemporaneous recession. On the basis of these findings, an apparent consensus has emerged among economists that (in the words of Albert Nichols and Richard Zeckhauser):

> The evidence available to date is too weak to support a flat statement that OSHA has done nothing for occupational safety. It seems reasonably certain, however, that the gains have not been major, for had they been so, even the crude measures available would have been able to detect them.[5]

Two distinct explanations for the apparent failure of OSHA to affect injury rates have been put forward in the literature. The first is that, due to limited statutory and budgetary authority from Congress, OSHA is unable to compel industrial compliance with its own standards. Advocates of this position point to the pitifully small level of OSHA fines, and to the small number of firms that will actually be inspected. For example, in 1975, the average fine per violation amounted to only $26 while the average number of inspections per firm was only .02 implying an expected fine per violation of 52¢.[6] From this perspective then, noncompliance is the root of OSHA's failure. A second argument is that the OSHAct itself is flawed, emphasizing standards for capital equipment when most accidents in fact are caused by complex epidemiological interactions of labor, equipment, and the workplace environment. Since OSHA standards address only part of the problem, these standards can have at best minimal effect.[7]

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[4] See the discussion in Zeckhauser and Nichols (1978), pp. 215-216.

[5] Nichols and Zeckhauser (1977), p. 55.

[6] Zeckhauser and Nichols (1978), pp. 205-208.

[7] Mendeloff (1976), pp. 85-87 and Zeckhauser and Nichols (1978), pp. 189-191.

Despite the obvious policy importance of testing these two hypotheses, no economic analysis has yet been conducted of the nature, determinants, and consequences of industrial noncompliance with workplace safety standards. Previous studies of OSHA's impact on workplace safety have instead directly examined statistical links between OSHA enforcement and industrial accident rates, and are thus incapable of distinguishing among causes of the apparent regulatory inefficacy. We propose an alternate approach which explicitly addresses the issue of industrial noncompliance and allows consideration of three separate hypotheses: (a) that OSHA enforcement efforts generate compliance by firms and reduced injuries for workers, (b) that OSHA enforcement efforts lead to widespread compliance, but that conformance with what are mostly safety standards for equipment has little effect on injury rates, and (c) that OSHA attains neither compliance from firms nor reduced injuries.

There are several reasons for believing a reexamination of OSHA's impact on injuries to be fruitful at this time. In the first place several factors suggest that the "noncompliance hypothesis" discussed above may be misleading if not completely false. Alongside studies suggesting OSHA's failure to achieve compliance due to inadequate enforcement are other studies indicating that OSHA imposes enormous financial burdens on industry. One such report estimated OSHA compliance costs of almost $3.7 billion a year.[8] Clearly both sets of studies cannot simultaneously be correct. Further, the economy-wide frequency of inspections cited above is so low precisely because the bulk of our nation's five million workplaces is comprised of small retail and service establishments that are in little need of safety regulation. OSHA

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[8] Weidenbaum and DeFina (1978).

has sensibly concentrated its resources on more hazardous and larger firms, with the result that relevant firms face far higher probabilities of inspection. The average inspection rate for all manufacturing establishments in the sample used for this study was in fact about 30 percent during the mid-1970's. A single firm, General Motors, was actually inspected 614 separate times between 1972 and 1975.[9] Further, the average penalty per violation is so low only because about 70 percent of all violations are "non-serious," carrying average penalties of only $3. Serious and repeat violations carry average penalties of $450, while willful violations receive average penalties of $5400.[10] OSHA fines may thus prove quite substantial, as Dupont discovered in 1976 when during a single inspection it was cited for $21,000.[11] Apparently, OSHA enforcement is not quite the charade its most severe critics have portrayed, and the extent to which the agency achieves industrial compliance is an empirical, and open issue.

A second reason for reconsideration of OSHA's impact arises from a problem embedded in many previous studies of this issue--simultaneity of injuries and inspections. By its own accounts, OSHA does not randomly inspect industries but rather explicitly targets for enforcement those firms with high accident rates--a so-called worst-first strategy. This targeting of enforcement has also occurred in special OSHA procedures such as the Target Industry Program or TIP. In light of this pervasive targeting, any negative enforcement effects could well be swamped by positive accident effects on enforcement.

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[9] Business Week (1976).

[10] OSHA, "Report Number SPO3," mimeograph, May 22, 1979.

[11] Business Week (1976).

On the basis of the above considerations, we have chosen to estimate a three-equation model of OSHA enforcement of its safety standards, industrial compliance with these standards, and workplace injuries. This procedure at once corrects for the simultaneity problem of past studies while enabling separate testings of the "noncompliance" and "inefficacy" hypotheses advanced by OSHA critics. In Part II of the paper the model is developed, while Part III describes the data that were used to test the hypotheses. The results are presented in Part IV and conclusions and policy implications are given in Part V.

II. Model

A. OSHA Enforcement

The most basic function of OSHA inspections is to reallocate wealth. Inspections serve to force industrial compliance with OSHA standards, and this compliance reduces producer wealth while increasing the safety, hence total personal wealth of workers. OSHA's behavior in effecting this transfer should conform to that predicted by the economic theory of regulation, as developed by Peltzman, Stigler, and others.[12] Essential elements of this theory are expected diminishing political returns from wealth transfer (due to diminishing marginal support by workers and increasing marginal opposition by firms) along with the expectation that intensities of support and opposition vary directly with the organizational concentration of workers and firms (due to diseconomies in combination of numerous small groups). Effectively, we propose

[12] Peltzman (1976), Stigler (1971), Posner (1971), Jordan (1972), and Becker (1978).

that the relative intensity of OSHA enforcement efforts should conform to that predicted by the Peltzman theory, and thus that analysis of these patterns provides a test of validity for this theory.

OSHA will allocate inspections among industries in order to maximize net political support (NPS), defined as the difference between support of workers (SE) and opposition (or non-support) of firms (NF). For each industry, net political support per firm is a function of the probability that any firm, hence any collection of workers, will be inspected:

(1) $NPSF = EF \cdot SE(CE, OE, WE) - NF(CF, OF, WF)$

(2) $CE = CE\left(\frac{1}{EF} VF(IF, K), AE\right)$

(3) $CF = CF(VF(IF, K), K)$

where

NPSF = net political support per firm

EF = employees per firm

CE = cost of violations per worker

CF = cost of violation avoidance per firm

OE = extent of worker organization

OF = extent of firm organization

WE = worker wealth

WF = corporate wealth

K = a technology factor that measures the extent of "natural noncompliance"

AE = accidents per worker

$SE_{CE} < 0$ $NF_{CF} > 0$

$SE_{CECE} < 0$ $NF_{CFCF} > 0$

$CE_{VF} > 0$	$CF_{VF} < 0$
$CE_{VFVF} > 0$	$CF_{VFVF} > 0$
$CE_{AE} > 0$	$CF_{K} > 0$
$CE_{VF,AE} > 0$	$CF_{VF,K} < 0$
$SE_{CE,OE} < 0$	$NF_{CF,OF} > 0$
$SE_{CE,WE} > 0$	$NF_{CF,WF} < 0$

All variables defined as ·E are on a per employee basis and all variables defined as ·F are on a per establishment ("firm") basis.

Worker support for OSHA enforcement (SE) is a decreasing function of the violation rate, since more numerous violations increase (at an increasing rate) the cost imposed on workers from accidents (CE). Corporate opposition (NF) is also a decreasing function of violations since compliance costs (CF) decrease (but at an attenuated rate) as violations are allowed to increase. Support and opposition are functions additionally of organization and wealth in accordance with the economic theory of regulation, in ways that will be made explicit by the discussion below. We note in passing that efficient inspection rates would minimize the sum of worker and corporate costs of violations per firm (EF · CE + CF).

Measurement of either the support or opposition functions in some systematic cardinal procedure would represent an extremely difficult task. Fortunately, measurement of these political functions is unnecessary to generate predictions for relative enforcement efforts by OSHA. Using classic economic methodology, comparative statics results can be obtained simply by examination of first-order conditions for maximization of net political support in each industry:

(4) $$SE_{CE}CE_{VF}VF_{IF} = NF_{CF}CF_{VF}VF_{IF}$$

which is achieved by equality of marginal support and marginal opposition. Note that this specification of the first-order conditions presumes that politically optimal inspection frequencies are attained in each industry, hence for the economy as a whole. This will occur when the U.S. Congress adjusts OSHA enforcement resources so that maximization of net political support occurs without an artificial "budget" constraint. In view of the great annual variability of total OSHA inspections, the presumption of no artificial constraint would appear reasonable.

Several basic comparative statics results can be derived from this first order condition:

a) Firm Size

The concentration of employees into larger firms affects marginal political support in two ways. In the first place, increasing firm size, while holding violations per firm constant, dilutes the impact of these violations. The resulting lower violation rate on a per employee basis has lower marginal cost for workers and hence leads to lower marginal support. A second offsetting effect arises from the organizational effects presumed by the economic theory of regulation. Employees concentrated into a handful of firms are easier to politically organize than an equivalent number of employees that are scattered over numerous small firms. Because the likelihood of effective political support is greater from workers of large firms, marginal support generated by an inspection will be higher ceteris paribus for enforcement actions at these large firms. Using the implicit function theorem with equation (4), it can be shown that

$$(5) \qquad \varepsilon(IF, EF) = \frac{-\varepsilon(S', EF)}{\varepsilon(S', IF) - \varepsilon(N' - IF)}$$

where $\varepsilon(a,b)$ denotes the elasticity of a with respect to b, S' is defined as marginal political support for an inspection (the left hand side of equation (4)), and N' is defined as marginal political opposition (the right hand side of (4)). By the second order condition for maximization of (4), the denominator of (5) is negative. Because of the offsetting nature of the "dilution" effect and the "organizational" effect of increasing firm size, the numerator and hence ε(IF, EF) are unsigned. If the organizational effect dominates, then this elasticity will be positive.

b) Organization

A central conclusion of the economic theory of regulation is that organized interests receive the greatest per capita wealth transfer. From the worker side, an increase in effective or potential organization by employees shifts upwards the political support function, giving the elasticity:

$$(6) \qquad \varepsilon(IF, OE) = \frac{-\varepsilon(S', OE)}{\varepsilon(S', IF) - \varepsilon'(N', IF)}$$

which is unambiguously positive. Apart from firm size, relevant measures of existing or potential organization include:

- UE, the percentage of employees unionized
- GEOHRF, the geographic concentration of workers, measured by a herfindahl index across states
- OCCHRF, the occupational concentration of workers, measured by a herfindahl index across occupation categories.

An increase in any of these measures of concentration will increase marginal political support and thus the inspection rate. For previous use of worker herfindahl indices in a similar context, see the study by Borjas (1980). While comparable comparative statics results for the extent of corporate organization exist, we have been unable in the context of this study to measure the independent organization of firms (as opposed to the simultaneous concentration of both firms and employees).

An additional organizational effect, predicted less by the economic theory of regulation than by standard political science, arises from the fact that workers in the District of Columbia do not have direct representation by a voting member of Congress, and hence are incapable of direct political support for OSHA. The following variable should thus have a negative elasticity with the inspection rate:

- DC, percentage of workers in the District of Columbia

c) Noncompliance

Many industries would be largely in compliance with OSHA standards even in the absence of enforcement activity, simply because their technology involves little capital or few practices which can be regulated. For these "naturally complying" industries, the MC of compliance is relatively low and hence the extent of compliance is large. At equivalent inspection rates, a "naturally noncomplying" industry will provide greater wealth transfer than would a "naturally complying" industry, as in the latter industry practices will remain largely unchanged by OSHA. Any increase in noncompliance by an industry because of an exogenous shift upwards in the marginal cost of compliance implies an increase in the potential for wealth transfer due to regulation. Thus both marginal support and marginal opposition will increase as the extent of noncompliance increases due to exogenous factors. These political effects offset each other, and prevent signing of the elasticity of inspections with regard to K, a technology factor that measures the extent of "natural noncompliance." From (4) and the implicit function theorem, this elasticity is:

(7) $$\varepsilon(IF, K) = - \left[\frac{\varepsilon(S', K) - \varepsilon(N', K)}{\varepsilon(S', IF) - \varepsilon(N', IF)}\right]$$

Note that if marginal support and marginal opposition increase in the same proportions when noncompliance increases, then the elasticity in (7) will be zero.

d) Wealth Effects

A second distinctive implication of the economic theory of regulation (along with organizational effects) arises from the presumed diminishing marginal support and increasing marginal opposition to wealth transfer. If workers satiate in diminished accidents (increased wealth) due to OSHA enforcement and hence provide lower marginal support, then it is reasonable to expect such satiation and diminished marginal support if some other, exogenous factor decreases accidents. In his exposition of the economic theory of regulation, Peltzman adopts the implicit assumption that:

(8) $$\frac{dSE}{dCE} = - \frac{dSE}{dWE}$$

with a similar assumption for opposition per firm, corporate costs, and corporate wealth. This assumption is probably too strong as it is dubious that workers support OSHA simply because accident rates are low and oppose the agency because accidents occur frequently. Nonetheless, the effects in (8) should be of equivalent sign, even if not of the same magnitude. Hence we have:

(9) $$\varepsilon(IF, AE) = \frac{-\varepsilon(S', AE)}{\varepsilon(S', IF) - \varepsilon(N', IF)}$$

which is positive. Note from (9) that if $\varepsilon(S', AE)$ equals $\varepsilon(S', OE)$ then by comparison of (5) and (9) we would have

$$(10) \quad \varepsilon(IF, EF) = \varepsilon(IF, AE) = \varepsilon(IF, AF)$$

and OSHA will select relative inspection intensities on the basis of accidents per firm (AF), as has been suggested by previous research.[13]

Turning to the corporate side, just as firms satiate in regulatory relief if enforcement is cut back, so an exogenous increase in wealth should produce a shift (decrease) in marginal opposition comparable to that produced by enforcement reductions. In elasticity form:

$$(11) \quad \varepsilon(IF, WF) = \frac{\varepsilon(N', WF)}{\varepsilon(S', IF) - \varepsilon(N', IF)}$$

which is expectedly positive. The rate of return on assets (i.e. profits) will be used in this study as a proxy for corporate wealth.

e) Information

The probability of worker support in each industry will be greater if workers are informed about the nature of OSHA activities and the extent of potential wealth transfers. While worker information is endogenously produced, largely by worker organizations, in one case it is possible to directly measure the political knowledge of employees as regards OSHA mechanisms. By law, OSHA operates a formal complaint procedure whereby employees may trigger inspections if they report workplace hazards. Workers who use this procedure are at least moderately informed about OSHA, at least moderately value its activities, and are unafraid to seek input into decisions by a national agency. Such workers are exactly those most likely to provide effective political support for the agency. Therefore:

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[13] Zechauser and Nichols, p. 206.

$$(12) \quad \varepsilon(IF, CMP) = \frac{\varepsilon(S', CMP)}{\varepsilon(S', IF) - \varepsilon(N', IF)}$$

where CMP = complaints per employee.

By its own arguments, OSHA responds to virtually every complaint by conducting an inspection. If this is true, then note that:

$$(13) \quad (IF, CMP) = \frac{C}{I} + \frac{I - C}{I}\,\varepsilon\left(\frac{I - C}{F}, CMP\right)$$

where C/I = proportion of complaint inspections.

If OSHA does not adjust non-complaint inspections in response to the complaint rate, then ε(IF, CMP) will equal the proportion of complaint inspections (about .05). If instead, other inspections increase with the complaint rate, then ε(IF, CMP) will be larger.

B. Industrial Compliance with OSHA Standards

Firms will elect to violate OSHA standards whenever such noncompliance is profit-maximizing. Even apart from OSHA enforcement efforts, the level of noncompliance by a firm will have several distinct effects on profits. On the one hand, a movement towards compliance may require costly capital investments and changes in work patterns which add to production costs. On the other hand, greater compliance presumably results in fewer injuries and hence the firm should have increased profits from fewer lost or restricted work days and smaller wage premia to compensate for job-related risks. This implies that in the absence of OSHA enforcement activities, each firm will choose that level of compliance that maximizes its profits. OSHA's enforcement activities are geared towards penalizing firms that have not achieved the prescribed safety standards. The firm is assumed to find its optimal compliance level by maximizing the following expected profit function at any time t:

(14) $\pi = NET(VF) - (IF)(VF)(\rho)$

where NET = firm revenues minus all costs except those due to fines for violations of OSHA standards, ρ = penalty per violation, VF = violations per firm, IF = inspections per firm and NET" < 0.

An OSHA violation refers to one item of capital equipment that does not conform to OSHA's standards. Hence, if ten machines are not in compliance, then OSHA records ten violations. We use total industry violations divided by the number of firms in the industry as the measure of the "violation rate" of the average firm in that industry and total inspections in the industry divided by the number of firms as the measure of the average firm's inspection probability. The reason for this procedure is that our data set reports violations, penalties and inspections on the three-digit industry level only. Note that the specification in (14) assumes that firms have rational expectations about OSHA's enforcement activities.

The profit maximizing level of violations is given by:

(15) $NET'(VF) - (IF)(\rho) = 0$

We can use this equation to generate predictions about the determinants of the firm's violation rate:

a) <u>Enforcement</u>

Equation (15) indicates that an increase in the intensity of OSHA enforcement, as measured by the probability of inspection, will induce the firm to choose a lower violation rate. Another measure of OSHA's enforcement efforts is its use of "failure to abate" penalties, which are very large penalties that are assessed against firms that do not move into compliance after an inspector has issued a citation. We would expect that firms that had a high ratio of FTA penalties to general penalties in the previous period are more likely to be in compliance this period.

b) Compliance Costs

A primary determinant of NET' and, hence, the firm's compliance decision, is the firm's marginal cost of complying with OSHA standards. The marginal cost of compliance will differ across firms because of differences in their production processes and technologies. Because of these differences some firms will be "naturally complying" and others will be "naturally noncomplying." Several variables can be used to proxy for the marginal cost of noncompliance. For example, we would expect the injury rate and the worker complaint rate to be associated with the degree of noncompliance in the industry. Further, industries that find it difficult to comply will be more likely to contest fines and, hence, less likely to remit the assessed penalties. We have information on the percentage of penalties remitted and predict that this variable will be negatively correlated with the marginal cost of compliance. Finally, the Business Roundtable's 1979 Report on the Cost of Government Regulation documented the existence of large differences across industries in incremental costs attributable to OSHA regulations. The report showed that some industries, such as primary metals and chemicals, have significantly high marginal costs of compliance. In our empirical analysis, we will use dummy variables for these two industries.

c) Firm Size

Because of the definition of violations, a pure scale effect would produce a one-to-one relationship between firm size and violations per firm.

Industries with a large average firm size, however, may have lower marginal costs of compliance if there are economies of scale. Holding the degree of hazards constant, large firms may find it easier to comply because of their greater probability of employing professional safety personnel (this is because safety staffs are largely an overhead expense). The existence of economies of scale would lower the coefficient on firm size below one and might even make it negative.

d) Past Compliance

Our model of the firm's compliance decision assumes that each period the firm decides whether or not to come into compliance with OSHA's standards. Since these standards are specifications that relate to the firm's capital stock, compliance in one period is likely to affect compliance in subsequent periods, i.e. if the firm modifies its equipment in order to achieve compliance, that modification is likely to be permanent. In other words, the firm's compliance decision is more correctly viewed in a dynamic context. Therefore, this period's compliance decision is likely to be a function of last period's compliance (i.e. last period's violation rate).

Given the predictions in (a) through (d), we can specify the violation rate as a function of the inspection rate, the proportion of failure to abate penalties, the injury rate, the complaint rate, the percentage of penalties remitted, two industry dummies, average firm size, and last year's violation rate. Note, however, that violations per firm are not directly observable. Violations of OSHA standards are much like victimless crimes in that they are not automatically reported, but rather must be uncovered and verified by inspections. Hence, not violations per firm (VF), but instead only registered violations R generated by inspections I are observable.

These variables are related as follows:

(16) $R = (VF) \cdot I$

We choose therefore to use registered violations per inspections (i.e. observed noncompliance) as a proxy for violations per firm (i.e. actual noncompliance).

An additional complexity arises in that OSHA registers several levels of violations of varying severity. For example, in the first quarter of 1979, nonserious violations received average penalties of $3, serious violations and nonserious failure to abate notices received average penalties of $450, repeat violations $550, serious failure to abate notices $2000, and willful violations $5500.[14] We have chosen to aggregate these numerous classes of violations by considering penalties per inspection (PI), rather than the various (RI) statistics. This penalty variable represents, in effect, a weighted average of noncompliance rates for each industry.

C. Industrial Injury Rates

The purpose of OSHA enforcement of its standards is, of course, to reduce industrial injury rates. In order to complete the model we need to specify the determinants of the industrial injury rate. The problem is to consider whether compliance with OSHA standards reduces the injury rate below what it would have been in the absence of OSHA. Recall from our discussion of the firm's compliance decision that each firm chooses a safety level that is based on the costs and benefits of workers being injured on the job. Given differences in technology and worker characteristics, some firms will be more hazardous places at which to work than others.

[14] OSHA Report Number SPO3, mimeograph, May 22, 1979.

Hence we need to model the firm's production function for worker safety. In view of our data constraints, we will model the average firm in each industry. A substantial literature on industrial safety exists, best summarized in Oi's 1974 survey article. In enumerating those characteristics that are relevant to the determination of the injury rate, our discussion relies, in part, on this literature.

(a) Firm Size

Oi has shown that the relationship between the injury rate and firm size is an inverted - U. This is because in small firms there is close supervision by the managers which reduces worker injuries while in very large firms, economies of scale in the use of professional safety staffs reduce injury rates below the levels experienced in midsize firms. The functional form we use to estimate this relationship is:

(17) $LOG(AE) = \alpha(EF) + \beta\, LOG(EF)$

where $\alpha < 0$ and $\beta > 0$. Note that the ratio $-\beta/\alpha$ gives the firm size at which the injury rate is maximized.

(b) Technology

Variables which proxy the degree of hazard to which workers are exposed belong in the industry's production function for safety. Following previous research, we use industrial characteristics such as percentage of production workers, percentage of male workers, percentage of unionized workers, percentage of professional employees, and the labor/capital ratio as measured by the ratio of labor costs (salaries plus fringes) to the value of shipments in the industry. We also use the worker complaint rate in this context.[15]

(c) Demographics

Characteristics of the workforce such as education, the rate of new hires and the wage rate have been found to be significant determinants of the injury rate because less educated and less experienced workers tend to be accident-prone. Furthermore, percent white has been found to be negatively correlated with injury rates because blacks' lower level of wealth increases their willingness to accept risks.

(d) Workpace

Workplace injury rates are likely to be correlated with the amount of overtime work since tired workers will be less careful in the operation of machinery.

(e) Workmen's Compensation

Finally, an analysis of worker injuries must take account of the role played by the workmen's compensation system. The benefit structure varies across states and over time, and previous research (see Butler and Worrall, 1982) has shown that reported injury rates are higher in those locations and those years when benefit formulas are the most liberal. As explained in Part III below, we construct two variables that capture the variation in the availability of workmen's comp benefits for workers in different industries.

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[15] We recognize that the relationships between the injury rate and percentage unionized, the labor/capital ratio and the worker complaint rate may be simultaneous, but we treat the latter three variables as exogenous to our model. Similarly, the wage rate is considered to be an exogenous variable.

(f) Violations

Having specified all of these elements of the firm's production function for safety, we can then measure the impact of compliance with OSHA standards by treating this variable as an additional input into the production process. If compliance with OSHA standards is, in fact, effective in reducing injury rates, then we should observe higher injury rates in industries with higher PI, ceteris paribus.

D. Summary

The structural equations for OSHA enforcement, industrial noncompliance and worker injuries are given below. A complete glossary of variables is given in Table 1 and predicted signs are indicated in parentheses underneath each variable.

$$(18)\quad \ln(IF) = \alpha_0 + \underset{(+)}{\alpha_1 \ln(PI)} + \underset{(+)}{\alpha_2 \ln(AE)} + \underset{(+)}{\alpha_3 \ln(EF)}$$

$$+ \underset{(+)}{\alpha_4 \ln(CMP)} + \underset{(+)}{\alpha_5 \ln(1 + UE)} + \underset{(+)}{\alpha_6 \ln(GEOHRF)}$$

$$+ \underset{(+)}{\alpha_7 \ln(OCCHRF)} + \underset{(+)}{\alpha_8 \ln(1 + PRFT)} + \underset{(-)}{\alpha_9 DC} + \underset{(+)}{\alpha_{10} D302}$$

$$+ \alpha_{11}(YRDUM) + \varepsilon_1$$

$$(19)\quad \ln(PI) = \beta_0 + \underset{(-)}{\beta_1 \ln(IF)} + \underset{(+)}{\beta_2 \ln(AE)} + \underset{(-)}{\beta_3 \ln(1 + FTA)}$$

$$+ \underset{(<1)}{\beta_4 \ln(EF)} + \underset{(+)}{\beta_5 \ln(CMP)} + \underset{(-)}{\beta_6 \ln(REMIT)}$$

$$+ \underset{(+)}{\beta_7 PMETAL} + \underset{(+)}{\beta_8 CHEM} + \underset{(+)}{\beta_9 \ln(PI)_{-1}} + \underset{(-)}{\beta_{10} \ln(1 + UE)} + \beta_{11} YRDUM + \varepsilon_2$$

$$(20)\ \ln(AE) = \gamma_o + \underset{(+)}{\gamma_1 \ln(PI)} + \underset{(+)}{\gamma_2 \ln(EF)} + \underset{(-)}{\gamma_3 (EF)}$$

$$+ \underset{(+)}{\gamma_4 \ln(CMP)} + \underset{(+)}{\gamma_5 \ln(PROD)} + \underset{(+)}{\gamma_6 \ln(MALE)} + \underset{(-)}{\gamma_7 \ln(PROF)}$$

$$+ \underset{(+)}{\gamma_8 \ln(1 + UE)} + \underset{(-)}{\gamma_9 \ln(LCR)} + \underset{(-)}{\gamma_{10} \ln(WHITE)} + \underset{(-)}{\gamma_{11} \ln(EDUC)}$$

$$+ \underset{(+)}{\gamma_{12} \ln(1 + NHR)} + \underset{(+)}{\gamma_{13} \ln(OVER)} + \underset{(-)}{\gamma_{14} \ln(HREARN)} + \underset{(+)}{\gamma_{15} \ln(BEN)}$$

$$+ \underset{(-)}{\gamma_{16} \ln(WAIT)} + \gamma_{17} REGION + \gamma_{18}\ YRDUM + \underset{(+)}{\gamma_{19}\ DIST} + \varepsilon_3$$

III. Data

In order to estimate the behavioral relationships derived in the previous section, we require data on the enforcement activities of OSHA, industrial injury rates and economic and demographic characteristics of the industries. In this section we describe the data sources and variable definitions.

A. OSHA Enforcement Activities

Enforcement data for this study were obtained under contract from OSHA, cover the years 1972 through 1979, and are restricted in the following

Table 1

Key to Variables

Variable Name	Definition
IF	Inspections per firm[1]
PI	Penalties per inspection
AE	Lost workdays per work
EF	Employees per firm
CMP	Complaints per employee
UE	Percentage of employees that are unionized
GEOHRF	Geographic "Herfindahl index" ΣS_i^2 where S_i = the share of employees in state i.
OCCHRF	Occupational "Herfindahl index" ΣS_i^2 where S_i = the share of employees in occupation i.
PRFT	(Value added minus labor costs)/assets
REMIT	Ratio of penalties remitted to penalties assessed
FTA	Ratio of failure to abate penalties to other penalties in the previous period
HREARN	Average hourly earnings
DC	Percentage of industry employees in District of Columbia
MALE	Percentage male employees
PROD	Percentage production workers
PROF	Percent professional employees
LCR	Labor cost ratio = labor costs/value of shipments
WHITE	Percent white employees
EDUC	Average education of employees
NHR	New hire rate
OVER	Average weekly overtime hours
BEN	Expected workmen's compensation benefit (see text)
WAIT	Expected waiting period for Workmen's compensation benefits (see text)
PMETAL	Dummy variable for primary metals industries
CHEM	Dummy variable for chemicals industries
D302	Dummy variable for SIC302--Rubber and plastics footwear
YRDUM	Dummy variables for the various years
DIST	Distributional variable for A/E equation: (see text)

[1]In our data set, the number of firms is actually measured by the number of establishments.

three ways. First, only safety inspections and violations of safety standards were tabulated. Health inspections and violations of health standards were excluded. Since the link between occupational illness and workplace characteristics is very difficult to establish because of time lags and multiple causations of illness, we believe it is appropriate to focus on OSHA's activities that pertain to occupational injuries. Inasmuch as the vast majority of all lost workdays are accounted for by injuries (97 percent in 1977) and the vast majority of OSHA inspections have been performed by safety inspectors, the exclusion of health variables should not be viewed as overly restrictive.[16] Secondly, enforcement data are restricted to firms located in the 22 states where safety regulations have been directly enforced by OSHA during the entire 1972-1979 period.[17] Under provisions of the OSHAct of 1970, states may retain responsibility for development and enforcement of OSH standards. State standards must be "at least as effective" as national standards, and adequate personnel must be assigned to enforcement. OSHA must delegate the authority to those states submitting an acceptable program to the Secretary of Labor, whereupon the Department of Labor may reimburse up to 50 percent of State administrative and enforcement costs. Unfortunately, there are substantial differences in the relative vigor of federal and state enforcement efforts. Data provided by OSHA for this study indicate that

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[16] Bureau of Labor Statistics, Occupational Injuries and Illnesses in 1977: Summary, U.S. GPO, Washington, D.C., 1978.

[17] Those states are Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Idaho, Kansas, Louisiana, Maine, Massachusetts, Mississippi, Missouri, Nebraska, New Hampshire, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Texas and West Virginia.

federal inspectors each visit 60 percent more workers than do state inspectors, that federal inspections are almost 3 times as likely to cite firms with serious violations as are state inspections, and that federal fines per violation within comparable classes of violation are almost twice the rate assessed at the state level.[18] In light of these profound differences between federal and state jurisdictions we have elected to concentrate only on those states subject to the more vigorous federal enforcement.

The OSHA data set contains the following information for each of the 3-digit industries for each of the years 1972-79 inclusive:

(1) Number of inspections

(2) Number of serious, willful and repeat violations

(3) Number of nonserious violations

(4) Total penalties for serious, willful and repeat violations

(5) Total penalties for nonserious violations

(6) Failure-to-abate penalties

(7) Penalties remitted

Table 2 provides some summary statistics from the OSHA data pertaining to manufacturing industries. In examining Table 2, it should be noted that the 1972 data only refer to enforcement activity for the last six months of the year since records of activities during the first half of the year were not maintained. As Table 2 demonstrates, the annual number of OSHA inspections peaked in 1974 and by 1979 had declined to half that level. As columns (2) and (3) show, however, total penalties and, therefore, average

[18]OSHA, "Report Number SPO3," mimeograph, May 22, 1979.

penalties per inspection, rose consistently through 1978. The explanation for this upward trend in penalties can be seen in columns (4) through (6). Violations that are classified as serious receive dramatically larger penalties than violations that are classified as nonserious. Beginning in 1976, OSHA upgraded a large number of violations from the nonserious status to the serious status; in addition, a number of nonserious violations were no longer recorded.

Hence, as column (6) shows, prior to 1977, between 1 and 5 percent of recorded violations were serious while in 1977 the proportion rose to .18 and continued to rise to .27 in 1978 and .3 in 1979. It is this shift in policy that is responsible for the increase in the average penalty per inspection in recent years. It is also responsible for the time trend in compliance rates (defined as the percentage of inspections without any recorded violations) shown in column (7). Note that the post-1976 compliance rate is above that of earlier years because some nonserious violations were no longer recorded. In sum, the data in Table 2 show that, over time, OSHA's inspection rates dropped while the average penalty per inspection and the compliance rate both rose as a result of a significant change in OSHA's policy of recording violations.

B. Occupational Injury Rates

The Bureau of Labor Statistics is responsible for collecting and disseminating data on occupational injury rates. At our request, the BLS prepared a special tabulation of injury rates by three-digit SIC category, for 1972 through 1978, just for firms in the 22 states we were analyzing.[19]

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[19] At the time we made our data request, 1978 was the latest year for which these disaggregated data were available.

Table 2

OSHA Inspections and Penalties in Manufacturing Firms Located in Federally-Enforced States*

	Total Inspections	Total Penalties	Average Penalty Per Inspection	Average Penalty Per Serious Violation	Average Penalty Per Nonserious Violation	Proportion of Violations That Are Serious	Compliance Rate
1972	2,858	$ 318,176	$111	$625	$ 15	.01	39.8%
1973	13,106	1,193,086	91	580	13	.01	37.5
1974	23,657	1,610,655	68	467	12	.01	43.5
1975	21,682	2,053,877	95	359	9	.02	42.6
1976	15,838	2,307,815	146	343	8	.05	42.0
1977	14,536	2,966,755	204	246	4	.18	56.9
1978	11,960	3,884,009	325	288	2	.27	62.1
1979	11,101	3,410,918	307	257	2	.30	57.1

*Safety-related inspections and penalties only. All of the penalty data are in constant dollars using 1972 as the base.

Table 3 presents aggregated data from this file. Column (1) shows the case rate, or the number of occupational injury cases per 100 full-time workers. Column (2) shows the incidence rate for lost workday cases only. Note that while the total case rate in 1978 is below that of 1972, the lost workday case rate is higher in 1978 than in the early years of OSHA enforcement activities. The decline in this measure (and the total rate) that occurred around 1975 has been attributed to labor market forces associated with the recession (e.g. layoffs of inexperienced accident-prone workers). As the data in column (3) show, lost workday cases accounted for 41 percent of all cases in 1978 compared to 30 percent back in 1972. And, according to column (4), in 1978 manufacturing industries lost 87 days per 100 full-time workers because of occupational injuries; in 1972, the loss was considerably smaller. In sum, the data in Table 3 show that the decline in workplace injuries that occurred in the mid-70's was reversed by a strong upward trend.[20]

C. Industrial Characteristics

Data on attributes of workers and firms have been collected from several sources. First, from the Employment and Earnings files of the Bureau of Labor Statistics, we have obtained information for the 1972-78 period for each three-digit manufacturing industry, on percent production workers, percent male workers, average hourly earnings, average overtime hours, and the new hire rate. As it proved impossible for BLS to restrict these variables to just the 22 states of our study, national values are, of necessity, used.

[20] It should be noted that a comparison of the data in Table 3 with national injury rate data indicates that in every year the figures for the total case rate were lower in the region of federal enforcement than for the nation as a whole, while the opposite is true for the lost workday rate.

Table 3

Occupational Injuries in Manufacturing

Industry Averages[a,b]

Year	Total Case Rate	Lost Workday Case Rate	Proportion of Cases Involving Lost Workdays	Lost Workdays Rate
1972	14.29	4.19	.29	63.19
1973	14.67	4.44	.30	70.68
1974	14.31	4.58	.32	73.93
1975	12.74	4.37	.34	77.08
1976	13.09	4.76	.36	81.32
1977	13.05	4.97	.38	84.70
1978	13.23	5.40	.41	87.68

[a]Data are only for firms located in the 22 federally-enforced states.

[b]Rates are calculated per 100 full-time workers.

Second, from the Current Population Survey, the following data on worker characteristics were obtained: percentage unionized, the age distribution of employees, average education, percent white, and the occupational distribution of employees for each industry. At our request, the Bureau of Labor Statistics prepared a special tabulation of these data to include only those individuals who reside in the 22 states we are studying. Since the CPS uses the Census industry codes we have matched these codes with the SIC codes used in our other data sets.

Third, from the Census Bureau's County Business Patterns tapes, we obtained data on the number and size distribution (by employees) of establishments for each 3-digit SIC industry, for the relevant 22 states, and for 1974 through 1978. Note that limited availability of this data required our study to commence with 1974. Because of data limitations, the number of employees in each industry and year had to be estimated using the following formula:

$$(21)\quad \text{Total number of workers} = \sum_{i=1}^{7} F_i M_i$$

where F_i = number of establishments in size class i

M_i = average ratio of workers to establishments in size class i.

For the largest size class (with more than 1000 workers in each establishment), we assumed that M_i equaled the average number of employees for national firms of comparable size in that industry. Note that M_i is constant across all industries except in the largest size class. The industry-varying national average firm size for the largest size class was obtained from the published volumes of County Business Patterns.

The County Business Patterns data are also useful for correcting for potential aggregation bias. Since all of our data are at the three-digit industry level rather than at the establishment level, we would like to be able to correct for the variation of establishment characteristics around the mean value for the industry. Only for the variable, average firm size, do we have any information regarding the variation around the mean. In view of the postulated relationship between firm size and the injury rate, aggregation bias is most likely to be present in the lost workday equation. Using the postulated relationship for each "firm":

(22) $AE_i = (EF_i)^{\alpha}\exp(-\beta EF_i)$

where i refers to a size class we can derive the aggregated relationship for the industry as:

(23) $\ln AE = \alpha\ln(EF) - \beta EF + DIST$

where DIST is given by the following expression:

(24) $$DIST = \ln\left[\sum_i (E_i/E)\left(\frac{EF_i}{EF}\right)^{\alpha}\exp(-\beta(EF_i - EF))\right]$$

Finally, two additional sources provided data on industrial characteristics. They are the Census Bureau's Annual Survey of Manufacturers, which contains information on labor costs, value added, value of assets, and value of shipments, and The Business Roundtable's Cost of Government Regulation Study conducted by Arthur Andersen & Co. This report contains information on the incremental costs incurred by companies in different industries in complying with OSHA regulations.

D. Workmen's Compensation Data

One of the variables we use to capture variations in the workmen's compensation program is the expected benefit variable that was constructed by Richard Butler and John Worrall and used in their 1982 paper. Their variable, which is calculated for each of the 22 states in each of the years 1974 through 1978, is an expected (as opposed to the actual) benefit measure for a representative wage earner with a spouse and two children who files a claim for a temporary total disability.[21] We created an expected benefit measure for each of the three-digit industries by calculating a weighted average of the Butler-Worrall variables using the geographic distribution of the employees in the industry as the weights. Our second measure of variations in the workmen's compensation program is a weighted average of the waiting period for receipt of benefits again using the geographic distribution to create the weights.

IV. Results

A. Methodology

Our model, expressed in equations (18), (19), and (20), has been estimated using pooled cross section/time series data for three digit SIC manufacturing industries in the period 1974-1978.[22] To facilitate pooling, year dummy variables have been included in each equation for each year except 1974, and penalties have been converted to a common 1974 base. The latter step is necessary because reclassification of violations by OSHA caused recorded penalties per inspection to increase each year since 1974, as was demonstrated in Table 2. To convert to a common penalty

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[21]Actual benefits should not be used because that would create a tautological relationship between injury rates and benefits.

[22]A Chow test of the null hypothesis of equality of coefficients across years could not be rejected for any equation at standard levels of significance.

structure, penalties in each year were divided by the following deflaters (based on average penalty per inspection as reported in Table 2):

1974	1.00
1975	1.40
1976	2.15
1977	3.00
1978	4.75

Estimation results are shown in Tables 4, 5, and 6. Variable definitions are in Table 1.

B. Inspections

The coefficient estimates in Table 4 are largely consistent with predictions of the economic theory of regulation. The most distinctive features of this theory--organizational and wealth effects--appear to be present and in some cases quantitatively important. The positive and significant coefficient on firm size indicates that the "organization" effect sharply dominates the "dilution" effect when the number of employees per firm increases, ceteris paribus. The findings for the herfindahl measures are mixed. The concentration of workers among professions has the expected positive effect on inspection rates, and is significant at the ten percent level, but geographic concentration has no significant effect and is improperly signed. A partial explanation for the failure of the geographic variable may be the positive correlation between geographic and firm size concentrations of workers (small firms are more readily dispersed).

The negative and significant effect of unionization on the inspection rate merits extended comment. This effect does not appear to be a

Table 4

Dependent Variable: ln(Inspections Per Firm)

Independent Variable*	Coefficient	t-value
AE	.4348	(6.98)
PI	.2179	(3.36)
EF	.5701	(17.56)
UE	-.0883	(-3.21)
GEOHRF	-.0314	(-.85)
OCCHRF	.1588	(1.62)
DC	-3.412	(-4.48)
PRFT	.1525	(1.65)
CMP	.3266	(9.62)
D302	2.357	(9.38)
D75	-.0484	(-.93)
D76	-.6517	(-11.59)
D77	-.8781	(-14.79)
D78	-1.091	(-16.99)
Constant	-6.116	(-6.63)
R^2	.82	

*All variables except DC, D302, D75, D76, D77 and D78 are in logs.

statistical aberration, as it is present in other OSHA enforcement activities. For example, a logit analysis of OSHA decisions to include or exclude a three-digit SIC industry in the Target Industry Program (TIP) which was the highlight of OSHA enforcement efforts in 1972 yields the following estimates:

$$(25)\quad TIP = \underset{(-1.62)}{-.627} + \underset{(3.01)}{.11}\ \ln(AE) - \underset{(-3.20)}{.041}\ UE - \underset{(-.40)}{.008}\ \ln(EF)$$

Again, OSHA targets less unionized industries with high accident rates. The explanation for this unexpected finding would appear to lie in a dual role of OSHA--to directly transfer wealth to workers by enforcement actions in their own industries and to indirectly transfer wealth by preserving union safety gains. The relatively greater inspection of nonunionized industries would raise the operating costs of those industries to the level incurred by unionized industries that have noncompetitively determined safety levels. Thus OSHA in part acts like the minimum wage to preserve the noncompetitive gains of collective bargaining.

Both expected wealth effects occur and are significant, although the profit effect is only significant at the ten percent level. The effect of the accident rate is positive as predicted and highly significant.

The less intense inspection of workers in the District of Columbia is as predicted. An interesting finding, which is not reported in Table 4, is that use of a complete set of state dummies (against Florida) in the inspection equation yielded estimates of almost exactly zero for each state variable, except for the predicted negative effect in D.C. and an odd, positive effect in South Dakota. A Chow test for the null hypothesis that all state dummies except these two were zero could not be rejected at any reasonable level of significance. In short, the pattern of OSHA inspections across states is, ceteris paribus, uniform. Any predictions (from some other model) which would be based on state-specific aspects, such as degree of liberalism or participation in certain Congressional oversight committees, thus could not be sustained by the data.[23]

Finally, note the positive and significant coefficient on the dummy variable for SIC302, rubber and plastics footwear. Although our equation standardizes for many of the determinants of the inspection rate, we still observe an extraordinarily high inspection rate for this industry. At present, we do not have a concrete explanation for this finding.

C. Penalty Equation

The major finding in Table 5 is the negative and significant coefficient on the inspection probability, IF , indicating the responsiveness of firms' compliance decisions to OSHA's enforcement efforts. Using the fact that lagged penalties are included in the equation, the coefficients indicate that the long run effect of a doubling of the inspection rate is to raise compliance by 47 percent. It should be noted that, as a consequence of corporate risk neutrality, doubling penalties per violation holding the inspection rate constant would produce the same 47 percent increase in compliance. Our second measure of OSHA enforcement efforts, last period's ratio of FTA penalties to general penalties, also has a negative effect on penalties, but barely achieves significance.

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[23] An interesting study of Federal Trade Commission behavior which did find effects of differential participation in Congressional oversight committees is Weingast and Moran (1981).

Table 5

Dependent Variables: ln(Penalties Per Inspection)

Independent Variable*	Coefficient	t-value
IF	-.3174	(-2.68)
AE	.4423	(5.43)
FTA	-.1968	(-1.30)
EF	.4189	(4.92)
CMP	.3107	(4.78)
REMIT	-.6291	(-7.24)
PMETAL	.2290	(1.53)
CHEM	.3045	(1.80)
UE	.0367	(.95)
$(PI)_{-1}$	.3287	(7.04)
D75	.0203	(.28)
D76	-.5283	(-4.51)
D77	-.8568	(-5.69)
D78	-1.2773	(-7.04)
Constant	.0742	(.10)
R^2	.53	

*All variables except PMETAL, CHEM, D75, D76, D77 and D78 are in logs.

As explained in Part II, a primary determinant of the firm's compliance decision is its marginal cost of complying with OSHA standards. We have used several variables to proxy this marginal cost and all of these variables have the expected effects. Note that compliance is lower in those industries with high lost workday rates, high worker complaint rates, and low percentages of penalties remitted. Furthermore, the industries singled out by the Business Roundtable report on the costs of government regulation, primary metals and chemicals, have significantly higher penalty rates.

The remaining results in Table 5 are generally consistent with our expectations. The coefficient on firm size is positive but significantly less than one, indicating the existence of economies of scale in compliance. The lagged penalty rate has a positive and significant coefficient on the current penalty rate; last period's modifications of the firm's capital stock will also affect this period's measure of compliance. Finally, note that the union variable has no effect on compliance.

D. Lost Workday Equation

The major finding in Table 6 is the positive and significant coefficient on the penalty variable. This means that as compliance increases, the injury rate will drop. Note, however, that the magnitude of the coefficient on PI is quite small. A ten percent reduction in noncompliance would produce less than a one percent decline in injury rates. Furthermore, the penalty equation in Table 5 showed that this ten percent reduction in noncompliance could only be achieved if the inspection rate were increased by 21 percent. More importantly, if compliance were to double, i.e. a 100 percent reduction in penalties occurred as all firms

Table 6

Dependent Variable: Ln(Lost Workdays Per Worker)

Independent Variable*	Coefficient	t-value
PI	.0855	(2.01)
ln(EF)	.2184	(6.04)
EF	-.0017	(-6.67)
DIST	.1804	(2.69)
PROD	.8416	(9.97)
MALE	.8990	(14.06)
UE	.0677	(3.32)
PROF	-.0899	(-2.34)
LCR	-.0772	(-2.64)
CMP	.0856	(4.12)
EDUC	-.4495	(-1.91)
NHR	.2207	(6.09)
HREARN	-1.1731	(-2.26)
WHITE	-.1841	(-1.27)
OVER	.1553	(2.46)
BEN	.6256	(1.52)
WAIT	-.3278	(-1.31)
D75	.1405	(2.27)
D76	.0758	(1.26)
D77	.0646	(.90)
D78	.0809	(1.04)
Constant	12.5390	(3.73)
R^2	.82	

*All variables except EF, D75, D76, D77 and D78 are in logs. This equation also contains a vector of regional dummies.

moved into compliance, the injury rate would only fall by 8.5 percent. This number is consistent with the 1974 findings of a panel of engineers in the California Division of Industrial Safety that only 18.4 percent of workplace injuries could have been prevented by a fully effective government safety program.[24] And, as the coefficient on IF in Table 5 implies, a doubling of compliance would require a 213 percent increase in the inspection rate. In other words, to reduce the injury rate by a mere 8.5 percent, the inspection rate would have to triple. Moreover, since the estimated elasticities are only valid at the margin, this 213 percent is likely to be a minimal estimate of the necessary increase in inspections; in other words, as individual firms move into compliance, we would probably observe smaller and smaller reductions in the injury rate.[25]

The remaining coefficients in Table 6 are all consistent with our predictions. The relationship between the injury rate and firm size is an inverted-U with a peak at approximately 120 workers. Also, injury rates are positively correlated with percent production workers, percent male employees, the new hire rate, percentage unionized, overtime hours and the worker complaint rate. They are negatively correlated with the education of employees, percent professional employees, the wage rate, percent white and the labor/capital ratio. The workmen's compensation program is also an important determinant of reported injury rates. Injury rates are higher in those industries where the workers have access to more liberal benefit formulas and shorter waiting periods.

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[24]See the references in footnote 7.

[25]This assumes that the relationship between AE and PI for any given firm is convex while the observed relationship across industries is a concave locus of points from these individual curves.

V. Conclusions

This paper has developed and tested a model of OSHA enforcement behavior, industrial compliance and workplace injuries. As a result, we have expanded upon previous research on OSHA in two ways. First we have avoided the assumption that OSHA randomly inspects industries and instead found evidence that OSHA acts as a political institution that gains support through the transfer of wealth from firms to employees.

Second, by explicitly modelling compliance, the paper has been able to test two explanations for the apparent failure of OSHA to reduce workplace injury rates. The first explanation is that, due to limited statutory and budgetary authority from Congress, OSHA is unable to compel industrial compliance with its own standards. The second argument is that the OSHAct itself is flawed, emphasizing standards for capital equipment when most accidents in fact are caused by complex epidemiological interactions of labor, equipment and the workplace environment. The empirical results show that firms do indeed move towards compliance in response to OSHA's enforcement efforts. Increasing the inspection probability or the penalty per violation by ten percent would result in a statistically significant 4.7 percent increase in compliance. But the connection between compliance with OSHA standards and workplace safety was found to be weaker. For example, even if all firms were to move into compliance, the lost workday rate would only fall by 8.5 percent. Our findings show, therefore, that the elasticity of the lost workday rate with respect to the inspection probability is only -.04.

As discussed earlier, this estimated impact of OSHA enforcement is only valid at the margin. The presumed convexity of the VF-IF and the AE-VF relationships implies that the ratio of percentage reductions in lost workdays to percentage increases in inspections will actually be less than .04, especially for large increases in enforcement efforts. Conversely, the estimated -.04 elasticity understates the effects of initial inspections, representing only the marginal impact of the last few inspection visits. An important conclusion of the econometric work of this study then is that a 4 percent reduction in lost workdays (within the 22 state region) represents a minimal estimated achievement of the federal OSHA safety program.

While this finding is critical to any assessment of OSHA, it must be supplemented with additional information in order for comprehensive evaluation to be made. On the benefit side, the extent of OSHA impact on accidental deaths and minor injuries remains to be computed and the entire range of health benefits is currently unknown. As regards compliance costs for OSHA regulations, only fragmentary estimates are now available, mostly for nonrepresentative samples of firms.[26] An overall cost-benefit study of the OSHA program is thus far beyond the scope of our study.

For the sake of perspective, however, it is useful to place the estimated effect of OSHA on lost workdays within a rough cost-benefit framework. The crude and preliminary nature of our computations will

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[26]For a discussion of available data on compliance costs and its limitations, see Zeckhauser and Nichols (1978), pp. 216-220.

be immediately recognized, but this exercise both indicates the nature of additional data needed and the probable outcome of any proper assessment. Let us suppose that elimination of the OSHA program would, based on our estimates, result in a 4 percent increase in lost workdays in the manufacturing sector in the 22-state region under federal enforcement. If we value a lost workday at the average daily manufacturing wage, $48.00, then for 1977 we calculate the benefit from OSHA to be $10.8 million. The question remains as to the magnitude of compliance costs. We can approximate these costs by using the Business Roundtable's 1979 Report on the Cost of Government Regulation. That report estimated that in 1977, $94 million of incremental costs were incurred by participating companies in the study in order to comply with OSHA safety regulations.[27] Let us assume that the participating companies are predominantly in the manufacturing sector and hence, conservatively, represent the entirety of manufacturing compliance costs.[28] Then we divide the $94 million by three since the 22 states represent one-third of national employment. We, therefore, estimate that the costs due to OSHA safety regulations in 1977 were $31.3 million in the 22-state region.

While both benefit and cost estimates above are biased downwards, they suggest that the OSHA safety program in its current form has not been cost-beneficial. Promotion of workplace safety would be more effectively advanced at lower social cost through alternate strategies such as direct

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[27]This figure nets out costs due to toxic and hazardous substances regulations and occupational health and environment control.

[28]Note that only 48 companies participated in the study, accounting for 5 percent of national employment and 19 percent of national corporate assets. Hence, our estimate of manufacturing compliance costs is extremely conservative.

provision of information to workers, reform of worker compensation procedures, and an injury tax.

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