Assessing OSHA Performance: New Evidence from the Construction Industry
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Source: *Journal of Policy Analysis and Management*, Vol. 20, No. 4 (Autumn, 2001), pp. 651-674
Published by: Wiley on behalf of Association for Public Policy Analysis and Management
Stable URL: http://www.jstor.org/stable/3325777
Accessed: 15-06-2017 02:39 UTC

Assessing OSHA Performance: New Evidence from the Construction Industry

David Weil

Abstract

The determinants of OSHA performance can be examined by breaking the regulatory process into three elements relating to enforcement, compliance behavior, and the adequacy of standards in addressing safety outcomes. This paper develops and applies this framework to the U.S. construction industry during the period 1987 to 1993. Enforcement activity among the firms in the sample was substantial, with firms facing a high probability of annual inspection. But, despite this significant enforcement effort, inspections have a modest effect on firm compliance with OSHA standards. Finally, the health and safety standards cited most frequently diverge from the major sources of fatalities and injuries on construction projects. These results suggest that historic enforcement policies toward construction make less sense as OSHA moves into its fourth decade of operation. More generally, the paper illustrates the problem of focusing enforcement resources on large, high-profile companies even though they often are not the major source of regulatory problems in an established area of public policy intervention. © 2001 by the Association for Public Policy Analysis and Management.

INTRODUCTION

Improving workplace safety by government intervention has historically proven a difficult task. The number of establishments regulated by the Occupational Safety and Health Administration (OSHA) surpasses 6 million, yet seldom have more than 2000 federal inspectors been devoted to enforcement. OSHA personnel have limited time to conduct inspections and during inspections they face competing claims for attention from workers, employers, and unions. Administrative procedures allow penalty payment and abatement orders to be delayed and often diminished.

Despite these difficulties, the "bottom line" for OSHA is its ability to reduce injuries and illnesses at the work site. Because workplace injuries and illnesses arise from a complex set of factors, assessing performance requires careful analysis of how OSHA has carried out its activities and what effect those activities have had on construction firms, given inherent regulatory difficulties.

This paper examines OSHA's performance in improving safety and health conditions in construction from 1987 to 1993. It evaluates regulatory performance by examining the elements that connect the OSHA statute as conceived in law to health and safety

Manuscript received July 1999; revise and resubmit recommended November 1999; revised May 2000; second revison recommended August 2000; second revision completed December 2000; accepted January 2001.

Journal of Policy Analysis and Management, Vol. 20, No. 4, 651–674 (2001)

Published by John Wiley & Sons, Inc.

outcomes at the workplace. The study applies this approach to OSHA regulation in a particular sector: very large-scale construction companies operating at the national level. This approach constitutes an alternative way of assessing labor market policies like OSHA that provides direct insight into how policy might be improved in the future.

The construction site has been and remains one of the most dangerous workplaces in the United States. In 1999, there were 1190 fatalities and 193,765 injuries involving days away from work in the construction industry. Although the rate of injury is substantially lower than it was a decade ago, it remains above that for the private sector as a whole. Industry averages also mask large variation within the industry. Construction laborers, for example, had the third highest number of fatalities of any occupational group and fatality rates for trades like ironworkers and operating engineers can be as much as 10 times higher than the industry average (Bureau of Labor Statistics, 1997, 1999b).[1] Not surprisingly, the industry has been a focus of OSHA policy for several decades.

The regulatory difficulties cited above describe the most general nature of OSHA's challenge. Efforts to improve workplace safety face additional complexities when applied to the construction industry. The construction work site is inherently dynamic: Construction requires the physical transformation of the workplace, thereby changing worker exposure to safety and health risks throughout the course of a project. In contrast to a fixed manufacturing location, a construction contractor's work site does not remain in place, making recourse to traditional regulatory mechanisms (e.g., follow-up inspections, site-specific penalties, and abatement plans) more problematic. This further reduces the effectiveness of the model of regulatory enforcement model embodied in U.S. labor policy.

OSHA PERFORMANCE

The past decade has witnessed a steady decline in the rate of occupational injuries and illnesses in the U.S. construction industry. Between 1987 and 1997, the rate for the private sector went from 8.3 to 7.1 injuries per 100 full-time workers, a 14.5 percent reduction; injury rates in construction went from 14.7 to 9.5, a 35.4 percent reduction. In fact, during this period the overall rate of injuries went from substantially exceeding that of the manufacturing sector in 1987 to being below that sector by 1997 (Bureau of Labor Statistics, 1999a; Conway and Svenson, 1998).

Many factors influence injury rates outside of the regulatory activities of OSHA. These include employer's practices and investments in safety; worker training and activities at the work site; management of the work site as a whole; the role of unions on and off the site; the effect of technology; and work practices. In addition, other government programs and regulations influence the benefits and costs of workplace safety. Workers' compensation policies have an important effect on the costs employers face in terms of the workers' compensation rates they pay, and on workers in terms of the benefits they do—or do not—receive (Burton and Chelius, 1997). Other regulations—like prevailing wage laws for public sector work, overtime standards, and environmental regulations—affect exposure to safety and health risks. Given the

[1] In 1994, the fatality rate for the construction industry was 12.3 deaths per 100,000 workers. For ironworkers (occupational code 597) the rate was 120.1; for operating engineers the rate was 105.6. Figures are calculated in Chen and Fosbroke (1998) based on the National Traumatic Occupational Fatalities surveillance system. See also Pollack et al. (1996) for a discussion of fatality rates in the construction industry.

influence of these other factors, how much has OSHA contributed to the overall decline in injuries?

One method of examining the effects of OSHA on outcomes is to model the determinants of injury rates including measures of OSHA activity. Studies have been numerous, going back almost to OSHA's inception, that have used a variety of econometric methods to attribute the relative effect of OSHA interventions (e.g., Cooke and Gautschi, 1981; Gray and Scholz, 1993; Kneiser and Leeth, 1995; McCaffery, 1983; Mendeloff, 1979; Ruser and Smith, 1991; Scholz and Gray, 1990; Smith, 1979, 1992; Viscusi, 1979, 1986). These studies—which have generally concluded that OSHA's effects have been positive but small—provide insight into the aggregate effect of OSHA, but do not make clear the specific factors that account for OSHA's modest effects.

An alternative method for evaluating the performance of OSHA-or any workplace regulation-is to decompose the sequence of relationships that implicitly underlie regulatory systems embodied in legislation like the Occupational Safety and Health Act. Although legislation typically cites public policy objectives at the outset, achieving the desired labor market outcomes connected to those objectives usually requires a series of intermediary steps that connect legislation, on one hand, to the policy objectives of concern, on the other (Figure 1).

First, achieving desired safety and health outcomes depends on the relation of labor statutes, as described in law, to enforcement, as carried out in practice (arrow A in Figure 1). In particular, this raises the question of which contractors are actually inspected and the nature of that enforcement activity. Examining this relationship for the construction industry requires measuring enforcement characteristics at two levels: the contractor[2] (or company) level, and the work site (or project) level.

Second, achieving policy outcomes requires that enforcement activities alter the willingness of firms to comply with safety and health regulations. Relating enforcement to compliance (arrow B in Figure 1) requires connecting the effect of OSHA to both contractor- and work site-level activity. OSHA may alter a contractor's compliance behavior by assessing fines, providing information or technical assistance, or other attempting to influence the contractor's calculation of benefits and costs of safety and health expenditures.

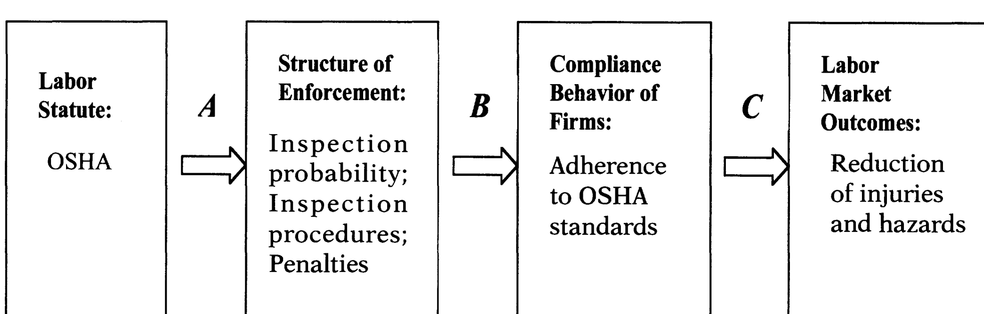


Figure 1. Model of regulatory performance.

[2] For simplicity, I use the term "contractor" throughout this paper to denote both general contractors and subcontractors (e.g., firms that undertake electrical work on a site under the direction of a general contractor or construction manager).

Finally, regulatory performance depends on the association between regulatory compliance and safety and health outcomes. Assessing the final arrow, C, in Figure 1 requires establishing which of the hundreds of pages of OSHA standards are most closely related to the reduction of physical hazards, injuries, and fatalities. Compliance with health and safety standards affects the bottom line of OSHA performance only if those standards relate to the real causes of workplace injuries.

This study compares the performance of OSHA among the largest construction contractors operating in the country from 1987 to 1993;[3] total revenues equal $184 billion. The study draws on data from the agency's Integrated Management Information System (IMIS) which contains the complete records of all workplace inspections conducted by OSHA. Each inspection record gives extensive information on enforcement activity and on characteristics and compliance practices of inspected firms.

Two additional sources of data are drawn upon in order to create longitudinal panel data for national contractors. A list of the top 2060 contractors was compiled by using the *Engineering News Record*'s annual publication of the top U.S. contractors for various segments of the construction industry. This list provides data on names, addresses and locations, and annual revenues.[4]

A matching process between the contractor data set and OSHA's IMIS data was conducted using the comprehensive list of major contractors as the universe of construction contractors. Data on inspections were matched against the contractor listings to create unique longitudinal records of each contractor's inspection history from 1987 to 1993. This process also allows identification of contractors who were not inspected during the study period.[5] Characteristics of enforcement and contractors for the sample are provided in Table 1.

FROM OSHA STATUTE TO OSHA ENFORCEMENT

Inspection Probability

The construction sector has been a central part of OSHA's enforcement program since the early 1980s.[6] Yet, because of the large number of construction work sites in any given year, the regulatory task of maintaining active oversight is difficult. In 1993, OSHA conducted 23,450 inspections in the construction industry. In that year, there

[3] The 1987-1993 period was chosen to create a comprehensive and consistent record of construction contractors. The IMIS data set does not contain all state records before 1987; the cutoff year of 1993 was chosen because OSHA substantially revised its targeting and enforcement procedures for the construction industry in 1994 (OSHA, 1998).

[4] Union status was assessed separately by checking records maintained by the Building Trades Department of the AFL-CIO concerning whether a contractor was signatory to a union agreement.

[5] A multi-step automated and manual matching procedure was employed to ensure minimal false positives (a spurious match of contractor and OSHA inspection record) and false negatives (omitting an inspection of a contractor listed in the contractor database).

[6] The proportion of inspection resources devoted to the construction sector increased dramatically in OSHA's first decade, and constitutes a large proportion of total enforcement activity: between 45 and 50 percent of all inspections. This can be seen in the following figures on enforcement from 1973 to 1993:

	Percentage of Inspections by Industry			
Year	Construction	Manufacturing	Maritime	All Other
1973	27.4	45.2	16.1	11.3
1983	49.3	42.8	1.2	6.7
1993	45.7	25.0	0.1	29.2

Source: Siskind (1993) and author's calculations based on OSHA IMIS data.

Table 1. Contractor characteristics: National contractors sample, 1987–1993.

	National Contractors		
Contractor-level characteristics	All Companies in Sample	Inspected Companies	Companies not Inspected
Total # contractors	2060	1574	486
Size—revenue in million 1994 dollars (s.d.)	$130.6 (646.9)	$132.1 (698.3)	$124.6 (371.8)
Union status of contractor			
nonunion	1030 (50%)	752 (48%)	278 (57%)
union	927 (45%)	768 (49%)	159 (33%)
mixed or not identified	103 (5%)	54 (3%)	49 (10%)
Construction segment			
SIC 15 (commercial, residential, industrial)	664 (32%)	537 (34%)	127 (26%)
SIC 16 (heavy & highway construction)	267 (13%)	206 (13%)	61 (13%)
SIC 17 (specialty contractors)	897 (44%)	710 (45%)	187 (39%)
Other or no SIC	232 (11%)	121 (8%)	111(23%)

were a reported 598,255 construction establishments[7] (U.S. Bureau of Census, 1993), making the annual probability of inspection on a given construction site about 0.039. Inspection probability calculated in this way does not capture the fact that a large contractor may have hundreds of individual construction sites operating at one time. As a result, the probability that a contractor received an inspection on any of its sites during the study period are considerably higher than the 3 in 100 figure indicates.

Table 2 presents overall inspection probability for the national contractors. Of the 2060 contractors in the database, 1574 received at least one inspection on one of their sites during the 1987–1993 period, for an overall inspection probability of 0.76. On an annual basis, a contractor in this group faces about a 50/50 chance of receiving an inspection on at least one construction site.[8] Size, measured in 1994 total revenue, of the contractor is not highly correlated with the probability of enforcement (the annual probability of inspection for contractors broken into four groups according to annual revenues varies between 0.49 and 0.53).[9] Overall inspection probability for the largest subset of contractors in the national contractor group (the top revenue

[7] The Commerce Department definition of establishment is related, but not identical to a construction work site in that it pertains to a physical site (e.g., trailer) where a construction company bases its operations. Thus, a contractor may have a number of establishments that in turn may be responsible for several sites in an area. In this paper, I use the individual site and the overall contractor (company) as the bases of analysis.

[8] The annual probability is only slightly higher for the largest of this already large set of national construction firms. Analysis of a sub-sample consisting of the top 25 percent of these contractors in terms of annual sales results in an annual inspection probability that ranges from 0.54 to 0.63 over the study period.

[9] There is considerable variation in the size of contractors in the sample, ranging from less than $1 million in annual revenue to more than $1 billion. Nonetheless, the overall probability of inspection is not correlated with size.

Table 2. Inspection probabilities and characteristics of enforcement, 1987–1993.

	Overall	Union	Nonunion
Overall probability of inspection faced by contractor at any construction site	0.76	0.828	0.729
Annual probability by year			
1987	0.488	0.561	0.436
1988	0.490	0.541	0.455
1989	0.504	0.550	0.475
1990	0.504	0.553	0.471
1991	0.519	0.583	0.475
1992	0.522	0.582	0.478
1993	0.516	0.554	0.489
Average annual probability by contractor size (annual revenues)			
0–$15 million	0.512	0.572	0.470
$15–$36 million	0.486	0.552	0.443
$ 36–80 million	0.526	0.568	0.505
$ 80+ million	0.497	0.553	0.465
Number of inspections per contractor			
mean	19.4	20.6	18.0
median	11.0	12.0	10.0
minimum	1	1	1
maximum	245	245	189
Duration of inspections (hours)			
per inspection	29.3	31.3	26.9
per contractor (accumulated)	433	533	352
Total penalties (1987$s)			
per inspection	$711	$697	$708
per violation	$174	$176	$166
per contractor (accumulated)	$10,511	$11,873	$9264
Violations per inspection			
overall	1.55	1.56	1.54
serious	0.66	0.69	0.64
Inspection type (percentage of total)			
programmed	68.1	66.9	69.2
complaint	7.2	7.6	6.8
follow-up	2.8	2.8	2.8
fatality or catastrophe	2.7	2.7	2.6
Frequency of walkaround inspections (percentage of total)	18.2	25.0	10.4
Total number of inspections, 1987–1993	30,466	15,799	13,512

size quartile with annual revenues above $80 million) is comparable with the sample as a whole.

Unions have been found to increase the level of OSHA enforcement in a number of other studies (e.g., Weil, 1991, 1992). Given the high level of unionization among contractors in the sample (45 percent), the interaction of union status and OSHA activity must be included in analyzing enforcement. The overall and annual probability of receiving an OSHA inspection is affected by union status of the contractor (Table 2). In each year between 1987 and 1993, the union/nonunion differential in inspection probability for a contractor was at least 0.10 (e.g., in 1992, the probability that a nonunion contractor in the data set received an inspection was 0.48 versus about 0.58 for a union contractor). Holding constant revenue size of the contractor does not diminish the spread of these differentials. For example, among contractors with more than $80 million in annual revenue the annual probability of inspection equaled 0.55 for union and 0.47 for nonunion contractors. The union/nonunion differences in inspection probabilities remain even after statistically controlling for the size of contractors and for the three- or four-digit construction sector in which the contractor is classified. Even after controlling for other factors correlated with inspection probability, union contractors have on average more than a 0.09 higher probability of inspection than comparable nonunion contractors.[10]

Other Enforcement Characteristics

The lower portion of Table 2 presents other characteristics of enforcement for those contractors receiving at least one inspection during the study period. OSHA devotes a great deal of time to inspections of the national contractor group: A typical inspection lasted about 29 person-hours, leading to an average accumulation of 433 hours per contractor between 1987 and 1993. Although penalties paid by contractors in the sample are fairly similar, regardless of union status or contractor size, the higher incidence of inspections received by union contractors result in their facing higher accumulated penalties over the study period (an average of $11,873 versus $9264 for nonunion contractors in 1987 dollars).

The intensity of inspections can also be affected by the cause of an inspection (e.g., whether it was initiated by OSHA, by a worker complaint, or by a fatality) and by the presence of a worker representative during the inspection. These aspects of enforcement are provided at the bottom rows of Table 2. The majority of OSHA inspections arise from randomized inspection protocols used to select contractors ("programmed" inspections); very few inspections arise from complaints of workers on sites. Few inspections conducted by OSHA include an employee representative (called a "walkaround"). Walkaround inspections can increase the likelihood that a violation will be detected. As a result, the higher frequency of walkarounds on unionized workplaces may affect compliance outcomes.

Distribution of Inspection Activity

The large number of inspections received by contractors requires further scrutiny. Because contractors operate many construction sites at any point in time, the frequent

[10] These estimates arise from a model of the annual likelihood that a contractor received an inspection at any work site as a function of contractor characteristics (including size, union status, specific construction sector, previous inspection history) as well as OSHA administrative effects. Models used to generate these estimates are available from the author.

inspections documented in Table 2 might reflect intensive inspection activity on individual sites of a contractor, or the accumulation of OSHA inspections across multiple sites of the contractor, with no single site receiving much scrutiny. Table 3 breaks down the distribution of inspection activity to clarify this issue.

The first column in Table 3 classifies the 2060 contractors in the sample according to the total number of inspections they received during the study period. It indicates that 486 contractors received no inspection between 1987 and 1993. At the same time, 127 contractors—6.2 percent of the entire sample—received more than 50 inspections over the same period. The second column of Table 3 classifies the 30,469 inspections conducted over the study period according to their sequence number-coded according to the day an inspection was initiated—at the contractor level. That is, of the total number of inspections conducted, 1328 (4.4 percent) represented the third inspection received by a contractor at any site it controlled, while 4805 represented the 6th through the 10th inspection of a contractor during the study

Table 3. Distribution of inspections, 1987–1993.

	Number of Inspections (percentage of all inspections)		
Total Inspections Received by Contractor	Total Received by Contractor	Frequency of Contractor Inspections[a]	Frequency of Site Inspections[b]
0	486 (23.6%)	486 (1.6%)	486 (1.6%)
1	140 (6.8%)	1574 (5.2%)	21,996 (72.2%)
2	106 (5.1%)	1434 (4.7%)	4514 (14.8%)
3	99 (4.8%)	1328 (4.4%)	1531 (5.0%)
4	69 (3.3%)	1229 (4.0%)	680 (2.2%)
5	75 (3.6%)	1160 (3.8%)	368 (1.2%)
6–10	280 (13.6%)	4805 (15.7%)	627 (2.1%)
11–20	329 (16.0%)	6420 (21.1%)	199 (0.7%)
21–50	349 (16.9%)	7633 (25.1%)	68 (0.2%)
51–100	99 (4.8%)	3399 (11.2%)	0
100+	28 (1.4%)	1001 (3.3%)	0
Total Inspections, 1987–1993	2060 (100.0%)	30,469 (100.0%)	30,469 (100.0%)

[a] Frequency of inspections during the period of this sequence number for the contractor at *any* construction site. For example, of the total 30,469 inspections conducted during the study period, 1160 represented the fifth inspection of a given contractor; [b] Frequency of inspections during the period of this sequence number for the contractor at *a specific* construction site. For example, of the total 30,469 inspections conducted during the study period, 368 represented the fifth inspection of a given contractor at a given site.

period. This sequencing is particularly important in assessing the effect of an OSHA inspection conducted at one location controlled by a contractor on safety activities at other sites in the future. Finally, the third column of Table 3 classifies the 30,469 inspections at the contractor and site level. Specifically, it classifies an inspection as to its sequence on a specific site of a specific contractor.[11] Thus, it shows that the majority of inspections—21,996 or 72.2 percent of all inspections—represented the first site inspection for a contractor. Only 4514 of all inspections represented the second inspection received at the same site, with a smaller number of inspections representing the third, fourth, etc. inspection of the site.

OSHA invested considerable resources in monitoring the contractors in the sample between 1987 and 1993. In 1993, nationwide contractors received 4150 inspections, representing 18 percent of all inspections conducted in the industry and requiring a total of 127,348 inspection hours—about 25 percent of the total time devoted to construction inspections. These inspections led to fines of $3.1 million or 19 percent of the total penalties levied by OSHA in that year to construction contractors. This use of resources reflects long-standing OSHA policy that focuses on the construction sector because of its relatively high injury and illness rates. But does a high probability of inspection, ongoing surveillance of contractors and construction sites, and the levying of penalties for standard violations affect the compliance of contractors?

FROM ENFORCEMENT TO COMPLIANCE

Arrow B in the OSHA performance model in Figure 1 represents the effect of enforcement activity on contractor compliance with OSHA standards. OSHA achieves its intended effects on safety and health outcomes by inducing regulated businesses to comply with its standards. The contractor compliance with OSHA standards at a given site or across multiple sites reflects their perceived benefits and costs of adhering to health and safety standards. (The seminal models of this can be found in Becker [1968] and Stigler [1970]; see Polinsky and Shavell [2000] for a comprehensive review of this literature.)

The benefits of compliance include cost savings to the employer from the lower number of injuries and illnesses arising from compliance (e.g., reduced turnover, lost work time, workers' compensation costs, etc.). The costs of compliance are those associated with machinery, practices, training, or manning requirements associated with the standards. OSHA enforcement affects the relative benefits and costs in that increased probability of inspection, more strenuous scrutiny during enforcement, and higher penalties all raise the costs of not complying with promulgated standards. Other studies of OSHA enforcement have demonstrated firms' sensitivity to even a low inspection probability and modest penalty levels (Bartel and Thomas, 1985; Stanley, 2000; Weil, 1996). These studies suggest that firms may either overestimate likely OSHA penalties or believe that OSHA citations may subject them to other costs such as increased workers' compensation premiums, higher likelihood of litigation, or scrutiny from other regulatory programs. These perceptions (whether valid or not) increase the likelihood of compliance.

Measuring Compliance

Contractor compliance with OSHA standards can only be observed at the time of an OSHA inspection, when OSHA personnel survey a construction site. The inspector

[11] Inspection sequence was determined by matching zip codes, and in some cases addresses, within a 1-year time horizon for the inspections identified for a given contractor. If two projects were initiated at a common zip code and address for a single contractor, but with greater than a 1-year elapsed time between inspections, the inspections were considered to have occurred at separate sites.

issues citations for activities at the site that do not comply with OSHA standards and rates these violations according to their severity. The number and severity of health and safety standard violations cited during an inspection provide one measure of the degree to which a contractor's operations comply with OSHA standards.

The standards that apply to a contractor in the construction industry comprise almost 900 printed pages in the *Code of Federal Regulations*. Rather than looking at the totality of standards, the author examines the effect of enforcement on compliance with a subset of 100 safety and health standards that, as identified by OSHA, relate to physical hazards at the work site (OSHA, 1993).[12] This subset of standards was chosen as the basis for analyzing contractor compliance for two reasons. First, OSHA consistently enforced the standards throughout the study period.[13] Second, based on studies undertaken by OSHA, the key standards are linked to underlying physical hazards which are, in turn, associated with injuries and illnesses and therefore relevant to arrow C in the performance model depicted in Figure 1.

For each inspection, the number of times these specific standards were cited (if at all) were tallied for each inspection record. For example, if OSHA cited a contractor for four violations of the standards, three of them a single time, and the other two times, the contractor would be counted as violating the key 100 standards five times. Violations OSHA inspectors rated as "serious" were tallied separately.

An average contractor in the sample was cited for 1.25 violations of the key standards during an inspection, with the median inspection in the sample uncovering less than one violation. Unionized contractors were cited for fewer violations of the key standards than nonunion contracts (1.22 versus 1.33) and faced similarly lower citation rates for serious violations of these standards (0.432 per inspection for union versus 0.473 for nonunion contractors).

A contractor can also be defined as being in if there were no violations of any of the key standards at the time of inspection. Using this definition, 74.5 percent of sites complied with key standards at the time of inspection (75 percent for union contractors; 72.6 percent among nonunion contractors). As a result, whether measured in terms of the average number of core standards cited or as the percentage of sites not cited for any violation of standards, a typical construction work site was in a high state of compliance with OSHA standards.

Modeling Compliance

For OSHA to be effective, enforcement activity must elicit changes in employers' compliance behavior. Observed compliance with OSHA standards is a function of a number of factors including, but not limited to enforcement. These include the cost of bringing production and work organization practices into compliance; the expected cost arising from enforcement; and other correlated factors that raise the costs of noncompliance, such as company size and unionization. In addition, measures of compliance may be affected by the intensity of inspection activity itself, where more intensive inspections detect higher rates of violations (and therefore reduce the probability that an establishment will be found in compliance).

These problems can be addressed by modeling the determinants of compliance explicitly and then predicting construction site-level compliance given different levels

[12] A detailed list and description of the standards used for the study is available from the author.
[13] This is based on conversations with OSHA staff as well as representatives from the building trades unions and contractor associations.

of OSHA inspection activity, site- and contractor-level characteristics, inspection intensity, and OSHA administrative policies.[14] Focusing specifically on OSHA's effect, the determinants of compliance for contractor j on construction site i at time t (Cj,i,t) are:

$$C_{j,i,t} = f(S_{j,i,t}, I_{j,t}, X_j) \tag{1}$$

where S is a measure of whether the present inspection is the first, second, third, etc., for the contractor at a given site; I is a measure of contractor level enforcement activity, including the number of inspections received up to that point across all sites operated by the contractor; and X is a vector of variables capturing OSHA administrative policies and contractor characteristics relevant to compliance.

Because the vast majority of OSHA inspections are done on a surprise basis, an inspection conducted at time t measures contractor j's compliance at t–1 (that is just before inspection). The effect of the first OSHA inspection on a site, then, measures the base level of compliance promoted by OSHA absent any inspection level activity as well as the private incentives for compliance. That is, contractors will choose their individual level of compliance depending on their internal gains from compliance as well as their response to external pressures. Second and subsequent inspections directly measure the effect of OSHA since contractors have already chosen their optimal allocation of resources toward safety and health.

Accordingly, to evaluate the effect of OSHA on compliance behavior, the change in compliance between the first inspection and subsequent inspections is examined for a given contractor and for a given contractor at a specific site. If OSHA influences overall contractor behavior, the probability of compliance with key standards should increase with each additional inspection. Thus, while the initial level of measured compliance reflects optimal internal allocations of capital and labor as well as the effect of OSHA pressure, the effect of OSHA is calculated as the change in the probability of compliance elicited from either a change in site- (S) or contractor-level (I) inspection activity, holding other factors constant or:

$$\Delta p(C) = p(C_{t+1}/X) - p(C_t/X) \tag{2}$$

Given the need to estimate the change in compliance behavior in equation (2), the effect of OSHA on a contractor, *j*, at a new construction site, *i*, at time, *t*, can be found by estimating:

$$C_t = \beta_1 I_{,t} + \beta_2 S_t + \beta_3 X_j \tag{3a}$$

and

$$C_{t+1} = \beta_1 I_{,t+1} + \beta_2 S_{t+1} + \beta_3 X_j \tag{3b}$$

The change in compliance arising from site- and contractor-level OSHA activity is therefore:

$$\Delta p(C) = \beta_1 (I_{,t+1} - I_{,t}) + \beta_2 (S_{t+1} - S_t) \tag{3c}$$

[14] Related literature regarding modeling compliance includes Bartel and Thomas (1985), Jones and Gray (1991a, b), Scholz and Gray (1990), Weil (1996).

To estimate (3c), site-level effects (S) are measured using a series of dummy variables (SITE2-SITE4) to capture the effect of the second, third, and fourth inspection at a given site and a continuous variable (SITE5) to capture inspections beyond the fourth. Several different measures are employed to estimate contractor-level effects (I) on compliance. The basic model employs a series of dummy variables (INSP2-INSP6) to capture the effect of an additional inspection at any of the contractor's other construction sites prior to the present inspection, and a continuous variable (INSP7) to capture effects for contractor effects beyond the sixth inspection. More restrictive definitions of prior contractor-level inspection activity also are used to estimate these effects. The logit models include variables that influence current compliance behavior, including the past experience of the contractor with OSHA in regard to accumulated penalties, time spent on inspection, and whether the inspection was triggered by an accident investigation or employee's complaint; union status; and contractor size, measured in annual revenue. A series of year and SIC dummy variables are also included to control for, respectively, other unmeasured administrative and contractor-level correlates with compliance. Finally, the total number of inspections received by a contractor serves as a control for contractor fixed effects.[15]

Empirical Results

Table 4 presents logit estimates of compliance determinants using two definitions of compliance: where a site is found to be in compliance ($C_{j'i't} = 1$) if it did not violate any of the 100 key standards at the time of inspection (COMPLY); and where the site is considered in compliance if it did not violate any of the standards rated as serious by OSHA (SERIOUS COMPLY).[16] The estimated marginal effect of the key independent variables on compliance probability are based on these estimates. The results for the first definition of compliance, COMPLY, are the focus, although they are generally consistent with those for SERIOUS COMPLY.

Table 4 provides evidence of a site-level OSHA enforcement effect on compliance. The probability of compliance increases by 0.063 between the first and second inspection received by a contractor at a site (see the marginal effect of SITE2). Subsequent site inspections beyond the second have more modest effects on predicted compliance (see the variables SITE3-SITE5), with the predicted probability of compliance leveling out at 0.8 after the fourth inspection. Because work on a construction work site is relatively short-lived, these estimates provide an accurate picture of contractor responsiveness to OSHA pressure on a given construction project.[17]

The positive and significant coefficients for INSP2-INSP7 imply the existence of "spill-over" effects from prior inspections on a contractor's other sites to its behavior at a current site. The estimated spill-over effect of OSHA enforcement on one site onto other sites is larger and persists over more inspections than the estimated site-level effects. The predicted level of compliance on a given site increases by about 0.05 between the first and second inspection received by a contractor on any site during the study period. Predicted compliance rises by 0.06 given additional inspections at other sites until it levels out at 0.76 at the sixth inspection received by a contractor. Beyond that, the marginal effect of subsequent inspections at any site is very small.[18]

[15] The names and definitions of all variables are provided in Table 6.
[16] More relaxed definitions of compliance (e.g., a site is considered to be in compliance if it violated one or fewer standards) yield similar parameter estimates.
[17] There is the possibility that for a subset of cases where there are multiple site inspections, initial inspections occurred before the study period, causing a small downward bias of the SITE estimates.
[18] The absence of a spill-over effect beyond the sixth inspection persists even if one uses alternative dummy variable structures (e.g., separate dummies for individual inspections beyond the sixth).

Table 4. Determinants of compliance, key construction health and safety standards, 1987–1993.

Variable	Means	COMPLY = < 1 violation of standards		SERIOUS COMPLY = < 1 *serious* violation of standards	
		Parameter Estimate	Marginal Impact[a,b]	Parameter Estimate	Marginal Impact[a,b]
Dependent Variable Means		0.745 (0.436)	—	0.852 (0.355)	—
INTERCPT		0.2926 (0.2433)	—	1.7658** (0.3018)	—
COMPLNT	0.071 (0.257)	0.2805** (0.0912)	0.05[a]	0.118 (0.1087)	0.013[a]
UNION	0.554 (0.497)	0.1452** (0.0295)	0.029[a]	0.062* (0.0365)	0.007[a]
UNIONCOM	0.0414 (0.199)	0.0355 (0.1193)	0.0[a]	–0.0793 (0.1395)	–0.009[a]
LNACPEN	6.732 (3.42)	–0.0951** (0.00755)	–0.066[b]	–0.1387** (0.01)	–0.066[b]
LNACHRS	5.464 (1.95)	–0.0662** (0.0218)	–0.025[b]	–0.0121 (0.0267)	–0.003[b]
LNSIZE	17.87 (1.40)	0.0285* (0.0125)	0.008[b]	0.00192 (0.0155)	0.0[b]
INSPTOT	50.77 (46.60)	0.00442** (0.000639)	0.038[b]	0.00528** (0.000869)	0.026[b]
INSP2	0.933 (0.249)	0.2384** (0.1035)	0.055[a]	0.2868** (0.1293)	0.052[a]
INSP3	0.887 (0.317)	0.1119 (0.0921)	0.025[a]	0.182 (0.1156)	0.028[a]
INSP4	0.844 (0.363)	0.2544** (0.0962)	0.052[a]	0.1421 (0.1184)	0.02[a]
INSP5	0.804 (0.397)	–0.13 (0.0989)	–0.026[a]	–0.1145 (0.1185)	–0.016[a]
INSP6	0.767 (0.423)	0.2255** (0.0762)	0.044[a]	0.3786** (0.0906)	0.048[a]
INSP7	20.654 (30.07)	0.00155 (0.00111)	0.006[c]	0.00222 (0.00148)	0.005[c]
SITE2	0.271 (0.445)	0.3534** (0.0417)	0.063[a]	0.3411** (0.052)	0.039[a]
SITE3	0.120 (0.326)	–0.0878 (0.0742)	–0.015[a]	0.0185 (0.0953)	0.001[a]
SITE4	0.069 (0.253)	0.067 (0.0936)	0.011[a]	0.285** (0.1293)	0.026[a]
SITE5	0.229 (1.70)	0.0218* (0.0127)	0.001[c]	0.0301** (0.0197)	0.001[c]
ACCID	0.026 (0.160)	0.3757** (0.0968)	0.066[a]	0.0374 (0.1075)	0.002[a]
Year Dummies		Yes		Yes	
SIC Dummies		Yes		Yes	
Log likelihood		30,786		22,361	
Number of observations		27,693		27,693	

See Table 6 for definition of the variables. Standard errors are in parentheses. * Statistically significant at the 5 percent level. ** Statistically significant at the 1percent level. [a]Change in probability evaluated by changing dummy variable from 0 to 1; [b]Calculated as change in probability from one standard deviation increase in independent variable.; [c]Calculated as change in probability from prior inspection to mean value of this variable.

The findings, however, must be interpreted with some caution. First, the above estimates do not measure OSHA's general deterrence effect embodied in contractors' overall investments in safety- and health-related activities, but only the specific deterrence effects engendered by changing policies at the site and contractor level (Scholz and Gray, 1990). Second, even in regard to specific deterrence, the high level of initial compliance and the relatively small change in compliance behavior reflects contractor behavior for the period 1987–1993. Though the study period begins in 1987, OSHA has been actively involved in enforcing safety and health standards since 1972. As a result, this evidence does not imply contractor responsiveness the very first time they were cited by OSHA. In fact, the high rates of compliance observed at the beginning of the study period reflect in part responses to OSHA enforcement activity in the prior 15 years.[19] Estimates of the marginal impact of OSHA on compliance therefore must be interpreted as conditional on this past history of enforcement activity as well as the general deterrence effects discussed above.

Nevertheless, the effect of recent inspections can be estimated for a contractor's compliance behavior at a given site. That is, during the study period, do inspections have a larger effect on compliance if they are spaced more closely together in time? To address this issue, additional logit models were estimated using several different forms of the contractor inspection sequence variable. The first variable, RECINSP, measures the number of inspections received by the contractor at any site other than the current site inspected in the past 2 years; VERYREC is defined in a similar manner, except that it is limited to contractor inspections conducted only within the past year.[20]

Given the national scope of contractors in the data set, a second method to more accurately estimate contractor-level effects is to include only those inspections done in a nearby region, assuming that spill-over effects are largest for inspections conducted at sites that are relatively nearby. CLOSEINS captures this by counting only the number of prior contractor inspections conducted in a nearby region within the past 2 years; VERCLOS follows the same definition, but for proximate inspections conducted within the past year.[21]

Table 5 provides predicted compliance estimates for a site given these four variants of contractor-level effects of prior inspections, holding other variables constant at their means. The predicted spill-over effects in part A of Table 5 are smaller than those found in Table 4 once the timing of inspections is limited to the prior 1 or 2 years. For contractor inspections conducted in the last 2 years, the probability of compliance changes by about 0.05 between the first and second inspection at the contractor-level (from a predicted level of 0.66 to 0.71). Predicted compliance increases an additional 0.03 following an additional inspection and levels off at 0.75 after four inspections have been conducted at other sites controlled by the contractor in the 2 previous years. The changes in probability are quite similar using a 1-year cut-off for prior inspections. More proximate timing of inspections across the sites of a contractor do not seem to raise the overall spill-over effect results found in Table 4.

[19] This also helps to explain the large difference in these results and those reported in Weil (1996). That study examined the effect of enforcement activity from the inception of OSHA. Thus, the first inspection in that study represented the first time that establishments were inspected by the newly created regulatory agency.

[20] A combination dummy and continuous variable structure is used, similar to that used for the INSP variable in Table 4. Alternative variable structures yield similar predicted results.

[21] The 10 U.S. Department of Labor regions were used to define "proximate" areas. For example, if a given site inspection is undertaken in Massachusetts, the variable CLOSEINS will count only the number of inspections carried out in the past 2 years (other than at that site) in Region I which consists of Massachusetts, Maine, New Hampshire, Vermont, Connecticut, and Rhode Island.

Table 5. Impact of contractor-level inspections on predicted compliance with key construction health and safety standards, 1987–1993.

A. Impacts of inspections conducted within the last 2 years/1 year on compliance.

Predicted Effects of Sequential Inspections

	Compliance		Serious Compliance	
Sequence	Contractor Inspections in 2 Years Prior to Current Inspection	Contractor Inspections in 1 Year Prior to Current Inspection	Contractor Inspections in 2 Years Prior to Current Inspection	Contractor Inspections in 1 Year Prior to Current Inspection
1	0.662	0.677	0.769	0.797
2	0.709	0.722	0.823	0.834
3	0.735	0.739	0.843	0.848
4	0.751	0.755	0.860	0.872
5	0.752	0.756	0.863	0.875
6	0.753	0.758	0.866	0.878
7	0.754	0.759	0.870	0.880
8	0.755	0.760	0.873	0.883
9	0.756	0.761	0.879	0.885
10	0.757	0.763	0.882	0.888

Predicted compliance based on logit estimates, all other variables held constant at their means. Detailed results available from the author.

B. Impact of inspections conducted in adjoining region on compliance

Predicted Effects of Sequential Inspections

	Compliance		Serious Compliance	
Sequence	Inspections in adjoining region within last 2 years	Inspections in adjoining region within last 1 year	Inspections in adjoining region within last 2 years	Inspections in adjoining region within last 1 year
1	0.735	0.733	0.850	0.848
2	0.747	0.739	0.854	0.854
3	0.747	0.753	0.864	0.868
4	0.739	0.740	0.860	0.869
5	0.741	0.745	0.863	0.873
6	0.743	0.750	0.867	0.877
7	0.746	0.755	0.870	0.881
8	0.748	0.760	0.874	0.885
9	0.750	0.765	0.877	0.889
10	0.753	0.770	0.880	0.893

Predicted compliance based on logit estimates, all other variables held constant at their means. Detailed results available from the author.

Estimated spill-over effects virtually disappear given recent inspections conducted in proximate areas (part B of Table 5). Predicted levels of compliance change little even between those contractors receiving one and two prior inspections in the last 2 years in an adjacent region to the current site. It seems that the spill-over effects reported in Table 4 are a national- rather than regional level phenomena. The RECENT and CLOSE variables therefore suggest that OSHA's contractor-level effects are not very dependent on the proximity of inspections in time and especially space.

Table 4 also presents the marginal impacts of other enforcement characteristics on the probability of compliance. Accumulated penalties for a contractor have the anomalous effect of reducing the probability of compliance, with a one standard deviation increase in accumulated penalties above the mean for the sample decreasing the predicted probability of compliance by 0.06. On the other hand, accumulated inspection hours have no significant association with current compliance behavior. It seems the presence of a previous inspection, rather than its duration, plays a larger role in determining compliance. Inspections instigated by an accident or fatality are associated with higher probabilities of compliance, while those instigated by workers raise probabilities by 0.05, other factors held constant at their mean. This in part arises from the more narrow scope of investigations instigated by those types of inspections, which lowers the expected number of violations detected.

Finally, despite their relatively large effects on inspection probability and other aspects of enforcement, unions raise compliance by about 0.03, holding constant their effects via inspections and penalties. The magnitude of the union effect is a somewhat surprising result given the significant impact of unionization on enforcement. This muted effect might arise in part from the higher prevalence of employee participation in OSHA inspections on union sites and therefore higher levels of detection of violations (and correspondingly lower measured levels of compliance).

The estimated effects of inspections on compliance at both the site- and contractor-level as well as those for other enforcement-related variables are much smaller from those found in studies of OSHA in traditional manufacturing settings. Most directly, in a study of small, custom woodworking manufacturers, Weil (1996) finds large effects from moving from a first to second inspection, with predicted compliance going from 0.19 at the time of the first inspection up to 0.67 at the second inspection. In addition, subsequent inspections continue to raise compliance probabilities, albeit at a decreasing rate, through the seventh or eighth inspection in contrast to the fleeting effects of inspections beyond the second inspection found here.

Contractors' lack of responsiveness to OSHA suggests the difficulty of changing behavior using traditional regulatory instruments once they reach a certain level of compliance. High levels of compliance in the study period arise in part from vigorous enforcement activity in the years prior to the study period and OSHA's general deterrence effects. Nonetheless, the fact that inspections conducted during the study have limited spill-over effects suggests the difficulty of further changing privately chosen health and safety policies of these highly scrutinized large contractors. The policy implications of this insight are taken up in the conclusion.

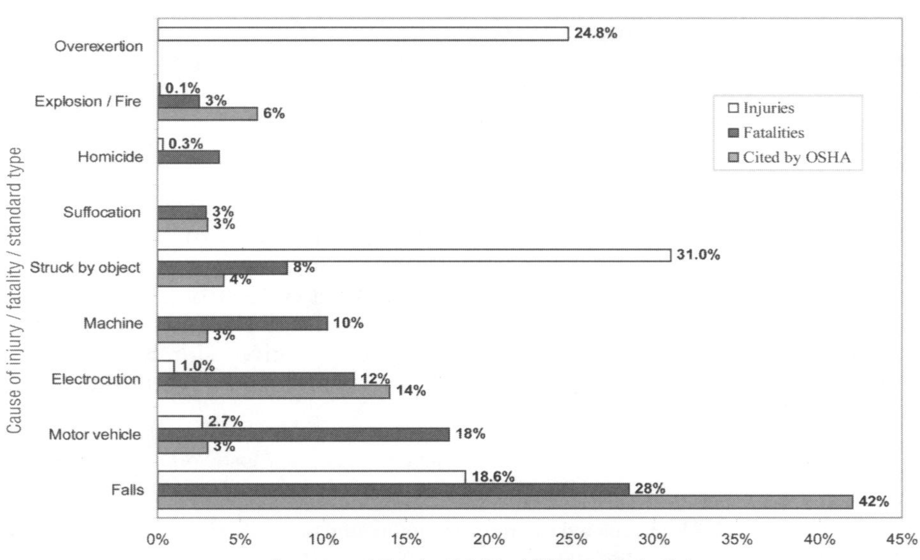
RELATING STANDARDS AND HEALTH AND SAFETY OUTCOMES

Figure 1 has as its final link in the model of regulatory performance the relationship between regulatory standards and health and safety outcomes. How closely do the standards that OSHA enforces correspond to the causes of workplace injuries and fatalities?

Few studies have linked violations of OSHA standards to safety and health outcomes. Mendeloff's (1984) is one of the few studies that directly examines the relation of violation of standards with workplace deaths reported in California in 1976. He concludes that violation of standards accounted only for 13–19 percent of the 645 fatalities reported to workers' compensation, and that only one-half of these violations could have been detected in advance of the accident. A recent NIOSH study (1998) examines the connection between fatalities caused by electrocution and a number of different factors including standard compliance. The study concludes "...most of the 224 occupational electrocution incidents investigated...could have been prevented through compliance with existing OSHA, National Electrical Code (NEC), and National Electrical Safety Code (NESC) regulations" (p. 20). On the other hand, a major literature review commissioned by NIOSH regarding the impact of safety and health training on injury and illnesses finds little evidence of a connection between compliance with mandated OSHA training standards and safety outcomes (Cohen and Colligan, 1998).

Figure 2 provides one way to begin to address this question. The figure compares the percentage of fatalities and the percentage of injuries arising from different causes with the standards that OSHA cited in the construction industry in 1994. Looking first at fatalities, the figure indicates discrepancies between the major causes of construction fatalities and the most frequently cited OSHA standards in construction. For example, while 28 percent of all fatalities arose from falls on the workplace, 42 percent of all OSHA standards cited in that year pertained to falls or fall protection. In contrast, although 18 percent of deaths at the work site arose from motor vehicle-related causes, less than 5 percent of OSHA standards cited in that year relate to motor vehicles.

Workplace fatalities, however, are low-probability events, not necessarily representative of the profile of physical hazards workers face at the construction site. Injury rates, in contrast, better measure the profile of physical hazards at the



Source: Bureau of Labor Statistics 1997 (Injuries); Chen and Fosbroke 1998 (Fatalities); IMIS Data (Cited by OSHA).

Figure 2. Causes of injuries and fatalities versus standards cited, 1994.

workplace.[22] Figure 2 shows that considerable discrepancies between the primary causes of lost-workday injuries and the standards commonly cited by OSHA in the same year. For example, the percentage of standards cited relating to falls (42 percent) is disproportionate to the percentage of injuries arising from falls (19 percent) in 1994. In contrast, a far higher proportion of injuries arise from workers being struck by or against an object (31 percent) than the percentage of standards relating to this problem (4 percent). Even more striking are causes of injuries not directly regulated by safety and health standards, such as overexertion, which constitute one-quarter of all lost workdays. In fact, OSHA standards in construction do not cover a range of health and cumulative trauma and musculoskeletal injuries that affect construction workers, although this is an area of active OSHA attention in recent years.

This simple analysis suggests divergence between the standards OSHA enforces and the "bottom-line" safety and health outcomes of concern during the period under study. The comparisons illustrated in Figure 2 are far from conclusive and may reflect other aspects of OSHA's enforcement policy. For example, standards cited by OSHA may reflect relative benefits and costs of detecting violations given inspectors' time constraints. Alternatively, enforcement of one set of standards may in itself spill over into compliance with other standards the inspector does not cite (e.g., enforcement of one standard may induce compliance with another, not cited standard), or may affect safety-related practices not covered explicitly by standards (e.g., improved vigilance on overexertion). The apparent lack of overlap between the causes of construction injuries and the standards cited by OSHA may therefore understate their true relationship.

Nonetheless, Figure 2 illustrates the importance of connecting the standards OSHA enforces to the injury, illness, and fatality outcomes of ultimate policy concern.[23] Estimating the relationship between specific standard compliance and fatality or injury outcomes requires careful experimental design and data collection that are surprisingly uncommon in the area of safety research.[24] Yet developing better evidence concerning link C in the OSHA performance model will allow policymakers to better gauge how a firm's improved compliance with standards ultimately translates into safer workplaces, as well as how enforcement might be more effectively focused on those standards that matter most.

CONCLUSIONS

OSHA devotes a substantial percentage of its resources to ongoing enforcement of a subset of very large contractors. This enforcement activity has some effect on the compliance behavior of contractors at both the site and company level. These models of enforcement effects indicate that OSHA has some effect on compliance behavior of contractors at both the site and contractor level. Site-level effects, however, are relatively modest beyond OSHA's initial inspection impact on a given site. Enforcement activity has more substantial effects at the contractor level, where inspection effects

[22] Because of data availability for injury rates by cause of injury, the causes of lost-workday injuries presented in Figure 2 are for construction laborers only and not the sector as a whole (Bureau of Labor Statistics, 1997, Table E-4).

[23] Of course, a finding that standards are related to injury or fatality outcomes of consequence is a necessary but not sufficient condition to conclude that the standard meets a benefit/cost criterion.

[24] Although a vast research literature links a wide variety of worker exposure to toxins, carcinogens, etc. to health outcomes, the literature linking physical hazards in construction (and other industries) to injuries and fatalities is surprisingly thin (Martonik, Grossman, and Gordon, 1998). For example, Rivara and Thompson (2000) document the absence of studies incorporating rigorous experimental design in evaluating measures to protect construction workers from falls.

appear to ripple across the sites controlled by a given contractor. However, the positive marginal impact of repeat inspections arise on a base of fairly high initial compliance among these large firms (arising in part from OSHA activity in the 15 years prior to the study period). OSHA's ability to improve compliance beyond the high initial levels is therefore somewhat limited using traditional enforcement devices among very large construction employers.

OSHA's targeting protocols identify contractors for programmed inspections based in part on the volume of construction activity in a region, thereby focusing substantial enforcement resources toward the very large contractors that make up the sample (Construction Resource Analysis, 1997; OSHA, 1998).[25] Given that method of targeting inspection resources, it is little wonder that the group received 18 percent of all construction inspections and accounted for 25 percent of time spent on inspections in construction in 1993.[26]

Inspection targeting based on the universe of current projects made sense in OSHA's first decade, where it was reasonable to try to move as many contractors (and workers) toward compliance in a noncompliant world. As noted above, studies of the effects of OSHA inspections in the early period of regulation show a high level of responsiveness to enforcement (Bartel and Thomas, 1985; Jones and Gray, 1991a; Scholz and Gray, 1990; Weil, 1996). The high states of initial compliance and relatively modest enforcement effects among large contractors suggest that this historic targeting philosophy makes much less sense as OSHA enters its fourth decade of operation.

A comparison between the contractors in the sample with all other construction contractors inspected by OSHA during the study period underscores this problem. Figure 3 compares the large contractors in the sample with all other construction contractors inspected by OSHA, excluding those in the sample. We use the percentage of all inspections where any violation was cited as a broad measure of compliance in these comparisons.[27]

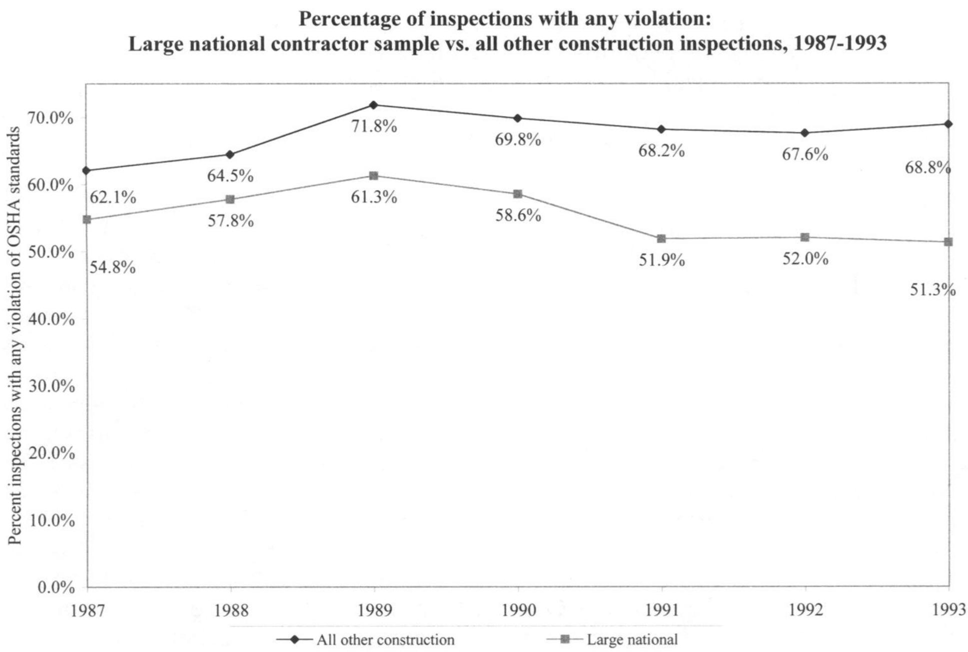
The upper panel of Figure 3 shows that the large national contractors had a lower percentage of inspections with any violations compared to inspections conducted at all other construction establishments. In 1993 for example, while 51 percent of the inspections of large national contractors found at least one violation, almost 69 percent of the inspections of all other construction establishments found violations. The percentage of inspections with serious violations presented in the lower panel of Figure 3 shows a similar gap between the two groups that grew from 5.6 percent in 1987 to 16 percent in 1993.[28]

[25] The current targeting system used by OSHA arose from the ruling in *Barlow's Inc. v. F. Ray Marshall* in 1986. The ruling required the creation of a "neutral system" for programmed inspection in OSHA's national office and states with federally administered programs.

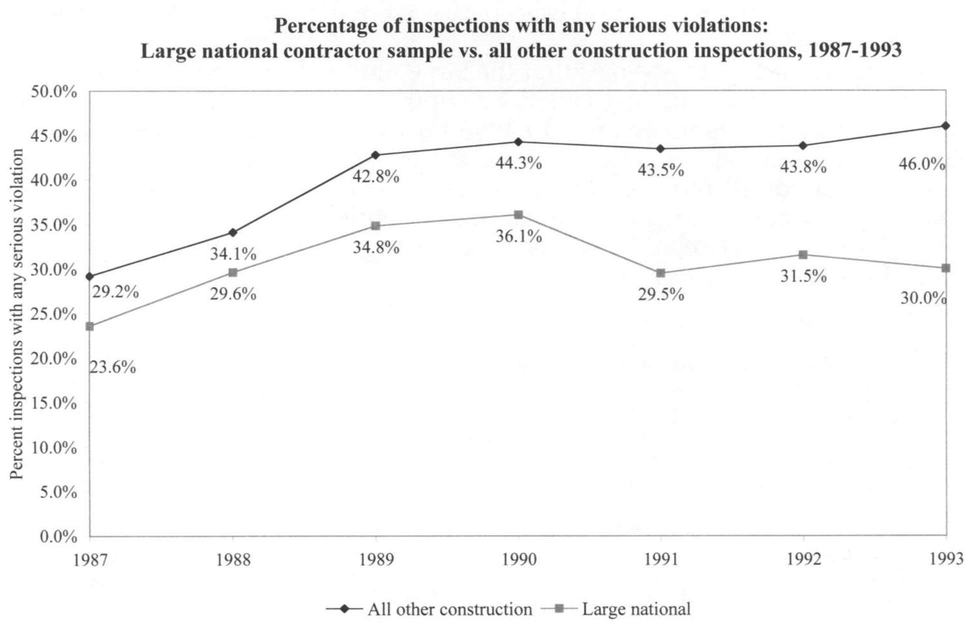
26 Larger projects with longer duration tend to account for a high percentage of the construction workforce in a geographic area. For example, in 1993, establishments with more than 50 workers constituted 2 percent of all construction establishments, but accounted for 33 percent of all construction workers (U.S. Bureau of the Census, 1993).

[27] Figure 3 includes violations of any OSHA standard for both groups, including but not limited to the subset of standards used in the rest of the paper for examining compliance. Serious violations of standards includes those inspectors classified as "serious," "willful," or "repeat." For comparability between the national contractor sample and all other construction inspections, the construction inspections in the comparison group include inspections conducted by federal OSHA as well as state-administered (so-called 18[b]) OSHA programs .

[28] Comparing the sample contractors with inspections conducted at manufacturing establishments reveals even wider divergences between these inspections and those conducted at the large contractors. For example, in 1993, 79 percent of manufacturing inspections conducted by OSHA found one or more violations (vs. 51 percent for the large contractors) and 62 percent of manufacturing inspections found serious violations (vs. 30 percent for the national contractors). These results are available from the author.



Note: Figure compares all OSHA inspections less national sample with the national sample



Note: Figure compares all OSHA inspections less national sample with the national sample

Figure 3. Percentage of inspections with violations of OSHA standards.

These results all suggest that OSHA could improve its performance by redirecting scarce inspection resources, such as by using prospective safety and health risk rather than construction scale as the basis for inspection targeting and by focusing inspections on those standards most closely related to major hazards and amenable to change via enforcement activity. This would lead OSHA to move inspection resources now focused on large companies toward more hazardous sectors often characterized by smaller contractors and work sites and a different profile of health and safety problems (e.g., residential construction). This does not imply that OSHA should cease its efforts to improve safety and health conditions in large companies, but that it apply other mechanisms to do so while reserving traditional tools of regulation for sectors and companies where they will prove more fruitful in changing behavior.[29]

The tendency to focus regulatory energy towards the largest and most high-profile firms in an industry is certainly not limited to OSHA enforcement in construction. Like the parable of a person searching for his lost keys under a street lamp because of the better light there, regulators often concentrate enforcement resources on the larger and more established end of a given industry. Yet large firms, like the national contractors in this study, are often the firms that have already achieved relatively high levels of compliance with long established regulatory standards, while firms at the other end of the size spectrum may operate with relatively little scrutiny. Just as OSHA might be better able to improve its overall performance by redirecting its efforts towards smaller, more risky sectors of construction, other regulatory programs might similarly improve their performance by looking for lost keys not directly under the street lamp, but instead where the problems lay hidden.

This research was funded by the Center to Protect Workers Rights under a grant from the National Institute of Occupational Safety and Health. I am grateful to Bill Londrigan and Joe Wise of the Greater Louisville Building and Construction Trades Council for their painstaking work in assembling the comprehensive list of contractors drawn on for this study. I am also grateful to Knut Ringen, Pete Stafford, Heather Grob, and Earl Pollack of the Center to Protect Workers Rights and to Rick Rinehart and Bruce Beveridge of OSHA for their assistance. Colleagues and seminar participants at Boston University, MIT, Harvard University, Cornell University, University of Massachusetts at Lowell, and the Economic Research Network of the Center to Protect Workers Rights, as well as two anonymous referees provided many helpful suggestions on this manuscript. Finally, I thank Igor Choodnovskiy and Helen Mogun for their assistance in matching the contractor database with OSHA IMIS data and subsequent data analysis.

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[29] Examples of alternative mechanisms for construction are numerous. OSHA has experimented since the late 1980s with allowing construction companies to conduct self-inspections and create internal health and safety programs guided by joint union–management steering committees (OSHA, 1998; Rees, 1988). Contractors, project managers, building trades unions, and government agencies involved in the "Big Dig" project in Boston have developed innovative programs aimed at reducing exposure to safety and health risks and accident rates, and controlling workers' compensation costs and disputes (Moir and Buchholz, 1996).

Table 6. Variable definitions.

Variable name	**Definition**
COMPLY (Dependent)	Dichotomous variable = 1 if no violations of standards (compliance) and 0 if one or more violations of key standards cited
SERIOUS COMPLY (Dependent)	Dichotomous variable = 1 if no *serious* violations of standards (compliance) and 0 if one or more *serious* violations of key standards cited
COMPLNT	Dummy variable for inspection initiated by employee complaint (= 1 if employee complaint)
UNION	Dummy variable for union status of contractor (= 1 if union)
UNIONCOM	Union / complaint interaction term (= 1 if both union and employee complaint)
LNACPEN	Natural logarithm of accumulated penalties received by contractor at all sites up to but not including present inspection (1987 $s)
LNACHRS	Natural logarithm of accumulated inspection hours up to but not including the present inspection
LNSIZE	Natural logarithm of contractor size (measured in revenues, 1995 $s)
INSPTOT	Total number of inspections received by the contractor over the study period
SIC variables	3- and 4-digit industry dummy variables to capture the segment of the construction industry in which the contractor operates
INSP2, INSP3, INSP4, INSP5, INSP6	Dummy variables for second (third, fourth, etc.) inspection received by a contractor at any site (INSP2 = 1 for second and subsequent inspections, 0 otherwise; INSP3 = 1 for third and subsequent; etc.)
INSP7	Continuous variable for seventh, eighth and subsequent inspection for contractor at any site (0 for first through sixth inspection, 1 if seventh, 2 if eighth, etc.)
SITE2,SITE3, SITE4	Dummy variable for second, third, and fourth inspection received by a contractor at a specific site (SITE2 = 1 for second and subsequent inspections; SITE3 = 1 for third and subsequent inspections, etc.)
SITE5	Continuous variable for fifth, sixth, and subsequent inspection for the contractor at a specific site (0 for first through fourth inspection, 1 if fifth, 2 if sixth, etc.)
ACCID	Dummy variable for inspection initiated by serious accident or fatality (= 1 if accident / fatality investigation)
RECINSP1 – RECINSP3	Dummy variables for inspection conducted prior to current inspection within past 2 years (RECINSP1 = 1 if 1 or more; RECINSP2 = 1 if 2 or more, etc.)
RECINSP4	Continuous variable counting the number of previous inspections within last 2 years (= 0 for 1 to 3 previous inspections in last 2 years; = 1 if 4 or more; 2 if 5 or more, etc.)
VERYREC1 – VERYREC3; VERYREC4	Same structure as RECINSP variables except for inspections conducted within last year only
CLOSEINS1 – CLOSEINS3	Dummy variables for inspections conducted in an adjoining region prior to current inspection within past 2 years (CLOSEINS1 = 1 if 1 or more in proximate area; CLOSEINS2 = 1 if 2 or more, etc.)
CLOSEINS4	Continuous variable counting the number of previous inspections in adjoining region within last 2 years (= 0 if 1 to 3; = 1 if 4 or more; 2 if 5 or more, etc.)
VERCLOS1 – VERCLOS3; VERCLOS4	Same structure as CLOSEINS variables except for inspections conducted within last year only

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