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OSHA'S ROLE IN PROMOTING OCCUPATIONAL SAFETY AND HEALTH

By John D. Leeth

MERCATUS CENTER
George Mason University

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John D. Leeth
Bentley University
Department of Economics
175 Forest Street
Waltham, Massachusetts 02452-4705
(781) 891-2029
Fax: (781) 891-2896
JLeeth@Bentley.edu

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Abstract

When OSHA was established, proponents believed it would dramatically improve the safety and health of American workers. During the forty years of its existence, workplace fatalities and nonfatal injuries and illnesses have fallen but OSHA is not the major cause of this decline. Changes in the industrial mix of workers and improvements in safety technology have combined with expanded employer incentives unrelated to OSHA to decrease worker injuries and illnesses. The financial incentives for employers to expand expenditures on worker safety and health created by the labor market, states' workers' compensation insurance programs, and the legal system swamp the meager incentives created by OSHA.

This paper examines OSHA in light of the other forces affecting workplace safety in the United States to generate a set of policy recommendations for how it can best use its limited resources to improve worker safety and health. No evidence exists that expanding the total number of inspections or the average amount of fines for noncompliance would improve its effectiveness significantly. OSHA can best complement the other pillars of the US safety policy system by providing information to workers about possible hazards, particularly health-related hazards, and by gearing inspections toward worksites where dangers are hard to monitor and firms employing less mobile and less knowledgeable workers. It should continue to offer consultation services to small and medium-sized firms and encourage firms to establish management systems addressing worker safety and health issues.

OSHA's Role in Promoting Occupational Safety and Health[1]

I. Introduction

At the end of the 1960s, 3 percent of American workers each year were injured seriously enough on the job to require at least one day away from work to recover, resulting in the loss of over 100,000 man-years of production. Although manufacturing injury rates were fairly steady in the early 1960s, the lost-time injury rate increased from about 12 injuries per million man-hours in 1963 to 15.2 per million man-hours in 1970, a compound growth rate well exceeding 3 percent per year. Another 390,000 workers were diagnosed with industrial diseases each year, and estimates held that only 25 percent of American workers exposed to health hazards were adequately protected (Smith 1976).

The seemingly dire and deteriorating situation facing American workers led Congress to pass the Occupational Safety and Health Act of 1970 (OSH Act). The Act created two federal agencies: the Occupational Safety and Health Administration (OSHA), which establishes and enforces workplace safety and health standards, and the National Institute for Occupational Safety and Health (NIOSH), which conducts research into the causes and possible remedies of occupational injuries and illnesses.

OSHA is not the first government effort in the United States to promote occupational safety and health. Before passage of any formal program addressing workplace safety, the legal system created incentives for employers to be concerned with the safety and health of their workers. Under common law, workers injured on the job could recover damages if they could prove that their employer was negligent. The possibility of legal liability for damages raises the

[1] I would like to thank Keith Teltser for his excellent research assistance and Richard Williams, Jerry Ellig, and two anonymous reviewers for their helpful comments on an earlier draft. I am solely responsible for all remaining errors and omissions.

expected cost of workplace hazards to firms, thereby encouraging them to expand safety efforts. The safety incentives of the tort liability system were widely viewed to be inadequate because employers could avoid legal liability using three common law defenses: the worker's injury was caused by another worker (the fellow-servant doctrine), resulted from a normal hazard of the job (assumption of risk), or stemmed at least partially from the worker's own actions (contributory negligence). Additionally many felt that courts' ex post negligence determination left too many workers uncompensated for injury and created too much uncertainty regarding payment of damages (Darling-Hammond and Kniesner 1980; Fishback 1987; Fishback and Kantor 1998).

More active government involvement in the area of workplace safety began in the United States in 1877 when Massachusetts passed legislation requiring the guarding of belts, shafts, and gears; protection on elevators; and adequate fire exits in factories. Other states followed suit over the next few years, passing their own laws protecting workers against harms including, in some states, factory inspections to ensure compliance (US Department of Labor, OSHA 2009a).

States reinforced these limited safety and health regulations with workers' compensation legislation beginning in the 1910s. Workers' compensation made firms strictly liable for industrial injuries. Regardless of fault, employers must pay all of injured workers' medical bills and a portion of lost income. In return for no-fault insurance coverage, workers cannot sue employers for damages due to work-related injuries. By 1920 most states had passed workers' compensation laws and by 1948, with passage in Mississippi, all states had enacted legislation. Workers' compensation insurance should encourage employers to improve workplace safety if the price of insurance declines as the dollar value of claims for health and income replacement benefits falls. In the other direction, higher benefits reduce the economic loss from injury and

may cause workers to be less concerned with safety, particularly with respect to less serious injuries.

In the 1960s, the purchasing power of workers' compensation insurance benefits fell as inflation outpaced the increase in legislated benefits. The rise in workplace accidents and the drop in real benefits led many to believe that the workers' compensation insurance system was largely failing in its twin goals of encouraging workplace safety and compensating workers adequately for their losses. The OSH Act created not only OSHA and NIOSH, but also the National Commission on State Workmen's Compensation Laws, which evaluated the adequacy, equity, and timeliness of the state workers' compensation laws then in effect. The Commission encouraged states to modify their workers' compensation programs and raise their income replacement rates. The higher benefits raised the cost of purchasing workers' compensation insurance and may have resulted in increased filing of fraudulent claims for benefits. Cost pressures and concerns with worker safety in the 1980s and 1990s led many states to modify their programs once again.

Government safety policy has evolved over time in response to perceived deficiencies in previous efforts. Even in the absence of any legal liability for damages or formal government programs to promote occupational safety and health, employers still have incentives to be concerned with the welfare of their workers. Morally, no one wants to be responsible for the death or ill health of another. Financially, employers realize that workers will not accept employment in worksites they know are hazardous unless they are compensated for doing so. The positive relationship between wages and risk means that the market rewards employers with improving safety records with lower labor costs and punishes employers with deteriorating safety records with higher labor costs. Workplace injuries can also lower worker productivity by

disrupting production and pulling people away from the workforce temporarily. Eliminating hazards may be expensive, but the drop in wages and the rise in output may more than pay for the costs of additional safety efforts.

One may think of the US safety policy system as consisting of four pillars: the legal system, workers' compensation insurance, OSHA, and the labor market. The legal system establishes financial liability for workplace injuries and illnesses. Changes in liability standards alter worker and firm incentives regarding the appropriate level of care and the resulting overall level of safety. Workers' compensation insurance pays for the health care and a portion of lost income of workers injured on the job. A more generous workers' compensation insurance system raises the cost of injuries to firms and may encourage them to expand their safety efforts so as to lower their costs of purchasing insurance coverage. OSHA establishes safety and health standards and inspects firms for noncompliance. Depending on the level of fines and the frequency of inspections, firms will initiate new safety programs in line with OSHA requirements. Finally, all of the first three pillars alter the financial incentives facing workers and firms, and through their interplay in the labor market determine the aggregate level of safety. Even in the absence of the other three pillars, the labor market on its own creates incentives for firms to be concerned with worker safety. Workers must be compensated for doing something they dislike, such as accepting greater workplace risk, by something they like, such as more income. The positive relationship between wages and risk means firms with better safety records are rewarded in the market by being able to pay less to attract equally qualified workers than firms with worse safety records.

This paper examines the four pillars of the US safety policy system with a focus on the most recent effort, OSHA. The goal is to determine how OSHA could best use its limited

resources to improve worker safety and health in light of incentives already created through the labor market, state workers' compensation insurance programs, and the legal system. The paper is organized as follows. The next section develops the general economic model of production and the workplace when there are inevitable risks to safety and health. The third and fourth sections present the institutional details of OSHA and the nature of workplace fatalities and nonfatal injuries in the United States. The paper then moves on to examine the evolving enforcement of OSHA regulations over the forty years of its existence and the corresponding empirical estimates of its effectiveness in improving worker safety and health. The next three sections discuss the other three pillars of the US safety policy system, detailing their strengths and weaknesses in generating appropriate safety incentives. The following sections evaluate the likely impact on worker safety of expanding OSHA enforcement power and assess the cost-effectiveness of OSHA in its entirety and some of its regulations individually. The paper concludes with recommendations on how best to improve OSHA's effectiveness in promoting worker safety and health.

This paper concludes that no evidence exists that by magnifying OSHA's enforcement powers, either by increasing the frequency of inspections or by raising the level of fines for noncompliance, worker safety and health would improve dramatically. As currently designed, the compliance and enforcement costs of OSHA appear to exceed the benefits of the relatively small improvements in safety, meaning the program is not cost effective. Given our absence of knowledge of OSHA's impacts in many important areas, such as the effectiveness of its voluntary programs or its capacity to prevent work-related illnesses, eliminating or seriously reducing the scope of OSHA would also be unwise. It further finds that with its current budget, OSHA can best help workers by focusing its efforts in areas not well served by the other three

pillars of the US safety policy system. But even in these areas, OSHA need not always take a regulatory approach to improving worker safety. Firms, workers, insurance companies, and equipment manufacturers react to new information on workplace hazards, minimizing, in some cases, the need for a more heavy-handed approach.

OSHA can best complement the other pillars of the US safety policy system by providing information to workers about possible hazards, particularly health-related hazards, and by gearing inspections toward worksites with hard-to-monitor dangers and firms employing less mobile and less knowledgeable workers. Although not universal, the preponderance of the empirical evidence finds accidents within establishments inspected by OSHA falling for two to five years after the inspection. The safety impact is largest for inspections discovering violations of safety standards and for establishments inspected by OSHA for the first time. The results suggest that OSHA should target its inspection efforts broadly over many firms and not narrowly, inspecting a few firms repeatedly. Small firms face lower financial incentives to improve worker safety than large firms and generally lack the staff with the knowledge on how best to achieve a safe and healthy workplace. OSHA should continue to offer consultation services to small and medium-sized firms and encourage (but not require) all firms to establish management systems addressing worker safety and health issues.

Compensating wage differentials for workplace risk provide firms with a financial incentive to improve worker safety and health. Compensating wage differentials will not develop if workers do not know of the risks they face and, equally important, workers cannot protect themselves against harms of which they are unaware. By conducting research into the causes and the possible remedies of workplace accidents and diseases, NIOSH generates the information necessary for workers to understand the dangers they face. The Obama administration has

recommended cutting NIOSH's budget. NIOSH's budget should not be reduced and the results of its research should be widely disseminated to workers by OSHA through expanded education and outreach programs.

II. The Economic Model of Workplace Safety and Health

Before we can discuss OSHA's role in promoting occupational safety and health or any other government effort, we need to examine how workers and firms make decisions regarding risk and then show how public policy can modify these decisions. People take risks every day. They drive in small cars, they smoke, they eat too much red meat, they exercise too little, and they drink too much. The key is that for people to be willing to take risks they must get something in return. In the area of workplace safety and health, for a worker to choose employment in a more hazardous workplace the employer must offer the worker something of value, such as a higher wage, to outweigh the greater chance of an accident or illness on the job.

Programs that improve workplace safety have costs. Firms may need to purchase additional equipment or protective devices, install machine guards, slow down the pace of production or stop production entirely to service equipment, hire consultants to advise management or train workers in safe procedures, and devote valuable management time to monitor safety. For some employers these efforts may be quite expensive, but for other employers the costs may be slight. Because of the inherent dangers in production, firms in mining, logging, fishing, and construction will need to spend more than firms in manufacturing, retail trade, or financial services to achieve the same level of safety for their workers. To be willing to bear the costs of safety programs, employers must anticipate corresponding economic benefits, such as greater output, lower pay for workers, smaller insurance premiums, or lower fines for violating government standards.

Just as firms differ in their abilities to produce safety, workers differ in their attitudes regarding safety. All else equal, no worker willingly chooses a dangerous job over a safe job. At best, the worker is uninjured and earns the same as in the perfectly safe job, and at worst, the worker is injured and bears the pain of injury and a loss of income. For workers to accept the gamble of a risky job, the payoff if uninjured must be high enough to outweigh the possible welfare loss from injury. In the real world the payoff may include a higher wage, better fringe benefits, a more pleasant work environment, or even the utility gain from the thrill of risking one's life. To simplify the analysis, economists generally focus solely on wages and ignore other possible means of compensation by assuming all else is equal. Because of differences in economic circumstances, family situations, and general tastes and preferences among workers, some workers will demand very large wage premiums to be willing to accept dangerous jobs while others will demand fairly small wage premiums.

To see how differences in firms' abilities to produce a safe working environment and workers' preferences regarding safety play out in the labor market, consider the situation where there are only two types of jobs: a job with no chance of a workplace injury or illness and a job with a high chance of a workplace injury or illness. Assume for the moment that wages are the same for both types of jobs. If wages are equal, workers will prefer complete safety because they gain nothing from accepting any job risk, and firms will prefer high risk because there are no economic returns from safety programs. The supply of labor will exceed the demand for labor for perfectly safe jobs, driving down wages in these types of establishments, and the demand for labor will exceed the supply of labor for high-risk jobs, driving up wages in these establishments.

With wages rising in high-risk establishments and falling in low-risk establishments, some companies will now find it profitable to eliminate workplace hazards. The wage reduction

outweighs the expense of the programs necessary to improve safety. On the other side of the market, the gap in wages between safe jobs and dangerous jobs will entice some workers to accept employment in a dangerous workplace. The wage gain compensates the worker for the greater chance of an injury or illness. Wages will continue to adjust in the two types of workplaces until no firm can expand profits and no worker can expand their welfare by increasing or decreasing their level of safety. For firms with low costs of providing safety, the benefit of avoiding the higher wage more than pays for the added cost of the necessary safety programs and they will offer workers complete safety, but pay them less. For firms with high costs of providing safety, the cost of the necessary safety programs exceeds the wage reduction from improving safety and they will offer workers higher pay, but a more dangerous work environment. Assuming a broad spectrum of production and safety technologies, there will be some firms that are just indifferent about the two choices. This occurs when the costs of the safety programs to eliminate workplace hazards just equal the benefits of greater safety from avoiding the higher cost of high-risk wages.

In the same manner the wage gap sorts workers between the two types of jobs, with the more risk-averse workers choosing the perfectly safe job and the less risk-averse workers accepting the dangerous job. Similar to the situation with firms, there will be some workers that are just indifferent about the two types of jobs. For these workers the welfare gain from the higher wage just offsets the welfare loss from the greater chance of a drop in income, medical expense, and pain and suffering from an injury or illness. Because the wage difference between the two types of jobs reflects both sides of the market, it measures both the added cost of safety programs to the firm and the benefit to workers of improving safety (as measured by their preferences).

The distribution of firms and workers between the two levels of risk determines the average level of workplace safety in the economy. Overall safety improves as workers and firms move from the dangerous sector to the safe sector. If workers become more risk averse, perhaps in response to an increase in income from economic growth, more will desire to work in complete safety. The rise in the supply of labor in safe jobs and fall in labor in risky jobs will drive up the difference in wages between the two types of jobs, enticing more firms to expand their safety efforts to be able to hire the now relatively cheaper labor. Average workplace safety expands. Workplace safety also rises if overall shifts in the economy raise labor demand in safe industries, such as services, and lower it in dangerous industries, such as mining, or if safety technology improves so that it is now cheaper for firms to produce a safe workplace. Government actions can also increase the benefits of safety to firms, causing more of them to choose to offer a safe workplace. The additional demand for labor in safe jobs will raise wages and attract more workers to these types of jobs and away from more dangerous jobs.

With a wide variety of risk levels, the economic analysis becomes slightly more complex but the end result is the same.[2] Wages rise as the probability of a workplace accident or illness expands, all else equal. Figure 1 provides a graphical representation of the relationship between wages and workplace risk in the limit when the risk of an accident or illness is continuous. Workers maximize their welfare by choosing the level of safety where the added benefit of greater safety just equals the added cost. The slope of the wage function in figure 1 measures the income a worker is just willing to sacrifice to lower his or her chance of injury by a small amount, and therefore the slope provides a dollar figure of a worker's willingness to pay for workplace safety implicitly—the social benefit of safety. At the same time, firms maximize

[2] Kniesner and Leeth (1995) provide a formal derivation of the economic model of workplace safety when safety is continuous.

profit by providing the level of safety where the benefit of greater safety equals the cost of greater safety. The slope of the wage function in figure 1 measures the wage reduction just necessary to pay for the added costs of improving the work environment by a small amount, and therefore the slope provides a dollar figure of a firm's cost of eliminating hazards—the social cost of safety.

In equilibrium the wage relationship equilibrates the supply of and demand for labor along the entire risk spectrum. Workers cannot improve their welfare by moving to a safer or a more dangerous job and firms cannot raise profits by expanding or contracting safety efforts. Workers and firms are at the optimal levels of safety given their risk preferences and abilities to produce a safe work environment. Collectively, the resources society must sacrifice to improve safety by a small amount, as measured by firms' costs, just equal the benefit of improving safety by a small amount, as measured by workers' preferences. Social welfare is maximized. In such a world, there is no need for an agency to develop workplace safety standards or enforce those standards through inspections and fines.

In the real world, the labor market may be prone to certain types of failures, or impediments that may result in businesses having less than the socially optimal incentive to provide safe and healthy workplaces. Government efforts may be necessary to correct some of these failures. One of the underpinnings of the economic model of workplace safety and health is that workers have good information concerning workplace risk. Unless workers realize that they face higher hazards in some establishments than in others, they will not demand a wage premium for accepting greater job risk, and a major economic incentive for firms to improve workplace safety disappears.

Even if workers have good information about job risks, the labor market may still not create the appropriate incentives for firms to provide a safe and healthy workplace if workers cannot freely move from one job to another. When workers are mobile, firms with deteriorating workplace safety and health will see workers leave because the wage no longer compensates for the higher chance of injury. To retain workers or to attract new workers these firms will have to either expand their safety efforts or raise the wage enough to compensate for the new higher risk. If workers do not leave because they have no other employment options, then the firm will not have to improve safety or raise wages.

The labor market may also fail to provide the appropriate safety incentives if workers do not analyze risk information rationally. Psychological studies indicate that people tend to overestimate small risks and the risk from highly publicized hazards and to underestimate large risks and the risk from familiar hazards (Viscusi 1998). With these types of biases, the labor market will establish wage premiums that are too large in some cases and too small in others.

Section VI examines the empirical evidence concerning these possible labor market failures and the need for government action. One should remember that the mere possibility of a market failure does not guarantee that government involvement is appropriate. The results of a market failure must be verified empirically and quantified to determine if there is market failure that may be addressed by government action. To improve social welfare, the benefits of any proposed government action must exceed the cost of the action. In some cases, market results may be less than ideal but still not warrant government involvement. Workplace safety regulation can also come in a variety of forms, such as requirements that specify the design of equipment, limit worker exposure to hazards, or mandate the use of personal protective devices. When alternative regulatory approaches can be used to solve a market failure, the approaches

should be evaluated to determine the one generating the largest difference between benefits and costs. Finally, the government can move along a variety of avenues to improve on market outcomes. A regulatory solution is one possibility, but other possibilities exist and the effectiveness of the regulatory approach should be compared to other solutions.

III. OSHA's Approach to Improving Worker Safety and Health

Congress passed the OSH Act "to assure safe and healthful working conditions for working men and women." To achieve this goal the Act created OSHA and directed it to promulgate occupational safety and health standards, conduct worker education programs about workplace hazards, inspect worksites under its jurisdiction, investigate worker complaints about safety and health, and cite and fine employers for noncompliance with safety and health standards. If a worksite is so hazardous that workers are in "imminent danger" of death or serious physical harm, the Secretary of OSHA can petition in US district court to shut down the worksite until the danger has been removed.

The law encouraged states to develop and operate their own workplace safety and health systems. State standards must be at least as effective at promoting worker safety and health as federal standards, and most states with their own programs establish workplace standards identical to the federal standards. Currently, twenty-seven states and jurisdictions operate their own plans, but five cover only public sector workers.

OSHA safety and health standards come in a variety of forms. The most well known are specification standards that mandate specific types of safety programs. Examples of specification standards include requirements that guards be affixed to machinery to prevent injuries from moving parts, engineering and work practice controls to eliminate or minimize employee exposure to blood-borne pathogens, and requirements that machinery be shut down and

locked/tagged to prevent restart during servicing. Perhaps less well known are performance standards that set maximum levels of exposures to particular hazards such as noise or dust, but allow employers to decide how best to achieve the desired levels of exposure. Performance standards provide employers with the flexibility to reduce hazards in the most cost-efficient manner and to accommodate changing circumstances or technological breakthroughs. In some sense, the General Duty Clause of the OSH Act is the most wide-ranging performance standard. It requires an employer to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees." Besides specification and performance standards, OSHA can also require employers to post warnings specifying potential dangers from operating equipment or using a product and detailing the appropriate precautions or procedures workers need to use to avoid these dangers.

The OSH Act establishes three violation categories: (1) non-serious, (2) serious, and (3) willful and repeated. OSHA inspectors need not penalize companies for non-serious violations of safety and health standards, but must levy fines for serious (infractions substantially increasing the likelihood of a worker fatality or serious injury) and willful or repeated violations. Inspectors can fine firms up to $7,000 for each non-serious or serious violation of a safety and health standard, $70,000 for each willful or repeated violation, and $7,000 per day for each failure to comply with a previously cited standard within the specified abatement period.[3] The OSH Act also established criminal sanctions for willful violations of OSHA standards resulting in a death of a worker, unauthorized notice of upcoming inspections, and falsifying business records required by OSHA.

[3] In the original OSH Act, maximum fines were $1,000 for each serious violation, $10,000 for each willful and repeated violation, and $1,000 per day for failure to comply. The 1990 Omnibus Budget Reconciliation Act raised the maximums to the current levels.

Initial penalties are generally much lower than the statutory maximums established by the OSH Act because OSHA uses a penalty structure based on the gravity of the offense. Inspectors evaluate each violation based on both the likely severity of the injury/illness that could result from the unabated hazard and the probability that an injury could occur. Hazards with a high chance of generating a severe injury/illness receive the statutory maximum fine of $7,000, while hazards with a small chance of producing a fairly minor injury/illness receive a fine of $3,000. The penalties are further modified based on the employer's history of compliance with OSHA standards within the previous five years, the number of employees, the good faith efforts by the employer to implement an effective workplace safety and health program, and the immediate abatement of cited hazards. The modifications cannot raise penalties above the statutory maximum of $7,000 or lower them below $500. Currently the average penalty is around $1,000 (Michaels 2010). Although the average is small, proposed OSHA penalties can become substantial as the number of violations escalates. OSHA issued BP Products North America an $87.4 million penalty in 2009 for multiple failures to abate previously cited hazards (US Department of Labor, OSHA 2009b).

Employers can contest the issuance of a citation or the size of the penalty to the Occupational Safety and Health Review Commission, which is an independent federal agency created to legally review disputes between OSHA and employers. Employers have fifteen working days from the time a citation is received to file a notification with the Review Commission. If desired, they can also request an informal conference with local OSHA officials to negotiate the size of assessed penalties either before or after filing the notification with the Review Commission. Because legally employers do not have to abate a hazard until after the review process has been completed, OSHA frequently reduces initial assessments as a way to

encourage them to eliminate cited hazards promptly. Over the last two decades, the average penalty reduction from initial assessments is about 26 percent (Jung and Makowsky 2012).

An employer's case is first heard by an administrative law judge who issues a written decision affirming, modifying, or vacating the original citation. Employers can appeal the decision of the administrative law judge to the three-member panel of the Review Commission, then to the US Circuit Court of Appeals, and if need be, to the US Supreme Court. Workers cannot contest a violation, but they can contest the decision by OSHA not to issue a violation or the time given to the employer to eliminate the hazard. They may also request an informal conference with OSHA to discuss any aspect of a citation.

OSHA is responsible for monitoring the safety and health conditions of about 130 million workers employed across eight million different worksites. The federal budget for OSHA in 2011 was $573 million, about one-eighteenth the size of the Environmental Protection Agency and one-fourth the size of the Fish and Wildlife Service, but more than four times larger than the National Highway Traffic Safety Administration and the Consumer Product Safety Commission. In 2011, the federal and state programs employed about 2,200 inspectors and conducted 92,704 inspections (US Department of Labor, OSHA 2012). At this rate, if inspections are conducted randomly, a typical establishment has slightly more than a one-in-one-hundred chance of being inspected in a given year. Given the limited number of inspectors and the sizable number of worksites, OSHA attempts to direct its inspection resources to the most hazardous worksites. Specifically, in order of priority, inspectors target imminent danger situations, fatalities and catastrophes, complaints filed by employees, referrals made by government agencies and others, follow-ups to previous inspections, and planned or programmed inspections of high-hazard companies.

OSHA now has three planned programs directing inspections toward the most hazardous workplaces: (1) the Severe Violator Enforcement Program, where OSHA targets previous violators of standards for enhanced enforcement efforts; (2) the Site Specific Targeting system, where OSHA focuses inspections on worksites with an overall high frequency of injuries and illnesses regardless of the nature of production; and (3) Local and National Emphasis Programs, where OSHA inspects firms more frequently in industries with high injury, illness, or fatality rates, with a high chance of a specific type of injury such as amputation, tuberculosis, or back strain, or where workers are exposed to a specific type of hazard such as lead, combustible dust, or silica.

An inspection begins with an inspector arriving at a worksite, presenting his or her credentials, and then asking to meet with an employer representative such as a plant manager. Typically OSHA does not give advance notice of an inspection. In the opening conference, the inspector discusses the OSHA program, reviews the rights and responsibilities of employers and employees under the OSH Act, describes the procedures that will be followed during the inspection, asks for an overview of the company's business and its safety and health efforts, and examines the company's log of injuries and illnesses. As required by the OSH Act, every company must maintain an accurate record of all occupational injuries and illnesses. The inspector then tours the worksite, locating apparent violations of safety and health standards, and talks to employees about potential problems. Inspectors frequently will point out apparent violations that can be corrected immediately. The company will still be cited for these violations, but by promptly eliminating the hazards the employer indicates good faith, thereby reducing the size of the penalty. The third and final stage of the inspection, which may occur the day of the inspection or several weeks later, is the closing conference. At the closing conference the

inspector reports on his or her findings and presents courses of action the employer may take to correct the challenges or contest the findings. Citations for safety and health standard violations are presented to the employer during the closing conference or mailed to the employer several weeks later. (Lofgren 1989)

OSHA also provides consultation services to small and medium-sized companies wishing to improve worker safety and health, and has established the Voluntary Protection Program and the Safety and Health Achievement Recognition Program to encourage large and small firms to move beyond simple compliance with safety and health standards. In 2011 OSHA consultants visited about 30,000 primarily high-hazard establishments to help employers identify hazards in their workplaces and develop or maintain effective safety and health systems. Consultants suggest approaches or options for solving safety and health problems they discover during their visit and can provide safety and health training to workers if requested. Consultants do not issue citations for safety and health standard violations found during the visit or guarantee that a worksite will pass an OSHA inspection in the future. OSHA consultation services are free, confidential, and voluntary.

The Voluntary Protection Program recognizes employers who have implemented effective safety and health management systems and who maintain injury and illness rates below the average for their industry. To be accepted into the program, an employer must submit an application to OSHA and the worksite must undergo a rigorous inspection by a team of safety and health professionals. Additionally, the company must have a comprehensive safety and health plan with active involvement of managers and workers, incorporating continual worksite analysis, hazard prevention and control, and safety and health training. In the voluntary program firms are exempted from OSHA programmed inspections, although they can still be inspected

because of referrals, formal complaints, fatalities, and catastrophes. Participants in the program are reevaluated for continued inclusion every three to five years. The Recognition Program is very similar to the voluntary program but geared toward smaller employers.

IV. Safety and Health in the United States

Figure 2 displays two worker fatality rate series: the first is from the National Safety Council (1994) and runs from 1933 to 1991, and the second is from the Bureau of Labor Statistics (BLS) and runs from 1992 to 2010. The pre-1992 data are generated from a sampling of establishments and are considered to be less reliable than the newer data, which are generated from a census of workplace fatalities. The National Safety Council data end at 1991 because the Council quit independently calculating workplace fatalities, instead relying on the estimates from the annual Census of Fatal Occupational Injuries (conducted by the BLS (US Department of Labor, Bureau of Labor Statistics 2012).[4]

As shown in figure 2, the frequency of workplace deaths in the United States has declined dramatically over the past seventy-seven years. Workplace fatalities dropped from 37 per 100,000 workers in 1933 to 8 per 100,000 workers in 1992, a 78 percent reduction, and from 5 per 100,000 workers in 1993 to 3.6 per 100,000 workers in 2010, a 28 percent reduction. As points of reference, in 2010 the chance of dying in a motor vehicle accident was over three times greater (11.5 per 100,000 persons) and the chance of dying in an accident at home was almost six times greater (20.3 per 100,000 persons) than the chance of dying in an accident at work (National Safety Council 2012). Workplace fatalities were highest in agriculture, forestry,

[4] The BLS determines work relatedness for the yearly Census of Fatal Occupational Injuries (CFOI) by examining death certificates, medical examiner reports, OSHA reports, and workers' compensation records. Because workplace fatalities are relatively infrequent, the previous BLS statistics derived from a sampling of firms are subject to considerable measurement error.

fishing, and hunting (27.9 per 100,000 workers) and lowest in financial activities (0.9 per 100,000 workers).

As OSHA points out, workplace fatalities have fallen considerably since its creation in 1970, but as figure 2 indicates, OSHA is unlikely to be the sole cause of this decline. The downward trend began well before 1970. Using National Safety Council data, in the thirty-three years before OSHA the fatality rate dropped from 37 per 100,000 workers to 18 per 100,000 workers, a yearly decline of about 2.2 percent, and in the twenty-three years after OSHA the fatality rate dropped from 18 per 100,000 workers to 8 per 100,000, a yearly decline of about 3.5 percent. From 1993 to 2010 the yearly decline falls to about 1.9 percent using BLS data. OSHA may be responsible for some of the post-1970 drop, but other factors such as changes in state workers' compensation laws, tort liability, and compensating wage differentials, combined with improvements in safety technology and the evolving industrial structure of the US workforce, also played parts.

Figure 3 examines one of the potential contributors to the declining US workplace fatality rate: the changing industrial composition of the workforce. The figure shows the fraction of nonfarm workers employed in the United States from 1939 to 2010 in three relatively dangerous industries: manufacturing, construction, and mining and logging. The two areas excluded in figure 3 are service industries and the government, both relatively safe. Figure 3 shows that the fraction of employment in manufacturing and mining and logging has fallen since 1939 and the fraction of employment in construction has remained relatively constant, meaning employment in services and the government has risen. Although not shown in the graph, farm employment, another area with relatively more workplace deaths, has also declined as a share of employment in the United States. By itself, this movement of workers from sectors with relatively high

fatality rates to those with relatively low fatality rates would result in a declining overall rate of workplace deaths. As will be documented later, changes in state workers' compensation laws, product liability standards, and compensating wage differentials have also created safety incentives that have further contributed to the decline in workplace deaths in the United States.

The two leading causes of workplace deaths in recent years are unlikely to be reduced much by OSHA inspections. In 2010, 40 percent of workplace fatalities were from transportation incidents, more than half occurring on the highway, and 18 percent were from assaults and other violent acts. Less than half of the fatalities occurred from events generally addressed by OSHA standards such as falls, contact with objects and equipment, and exposure to harmful substance or environments. About 30 percent of the fatalities were in construction and agriculture, forestry, and fishing, industries with widely dispersed worksites making it more difficult to inspect for hazards.

The self-employed, who are exempt from OSHA jurisdiction, face a much higher chance of dying at work than wage and salary workers, which also has consequences for the effectiveness of OSHA. Although about 7 percent of the workforce is self-employed, they suffered about 22 percent of all workplace fatalities in 2010. Differences between the occupational distributions of the self-employed and wage and salary workers partially explain the higher fatality rate; compared to wage and salary workers the self-employed are more likely to work in agriculture and construction, relatively high-risk industries, and are less likely to work in manufacturing, a relatively low-risk industry. The self-employed are also more likely to be managers of food serving and lodging services and sales supervisors and proprietors, which are occupations where the risk of being a homicide victim during a robbery is high (Pegual 2004).

Figure 4 shows the frequency of all nonfatal workplace injuries and illnesses and the frequency of lost-workday nonfatal injuries and illnesses since 1973, the first year firms were required to report industrial accidents and diseases. Until 1990 the pattern of nonfatal workplace injuries and illnesses followed the business cycle closely, as might be expected. Injuries rise with worker inexperience and fatigue and as employers cut corners to maintain the pace of production. Based on empirical evidence relating changes in work injuries to changes in overtime, new hires, and plant capacity utilization, Smith (1976) credits the exceptionally tight labor markets in the late 1960s for creating the substantial rise in the workplace injury rate leading up to passage of the OSH Act. The expanding generosity of many state workers' compensation programs in the late 1960s and early 1970s may have also played a role in the rising rate of nonfatal injuries (particularly lost-workday injuries) just before and just after passage of the OSH Act. As will be detailed later, empirical evidence finds that nonfatal injury rates rise as workers' compensation insurance replaces a greater fraction of an injured worker's earnings. One should notice that the fatality rate in figure 2 shows no corresponding increase around this time, perhaps indicating that the rise in the rate of nonfatal workplace injuries was a result of a moral hazard problem created by changes in state workers' compensation insurance statutes.

As can be seen in figure 4, with the return to more normal macroeconomic conditions in the early 1970s, the rate of injuries and illnesses stabilized. The rate rose slightly during the business upturn of the late 1970s, fell during the recession of the early 1980s, rose again during the 1980s expansion, and then fell during the recession of the early 1990s. After the early 1990s the rate of nonfatal workplace injuries steadily declined although business activity accelerated in the late 1990s and the mid-2000s.

As with fatalities, OSHA may be responsible for the downward trend in nonfatal workplace injuries and illnesses seen in figure 4, but other factors may also be responsible. Skeptics of OSHA's effectiveness note that the improvement in safety began twenty years after passage of the OSH Act and the timing of the improvement appears largely unrelated to any changes in OSHA enforcement efforts. Conway and Svenson (1998) argue that nonfatal injuries and illnesses declined because employers began focusing more on safety and health in the 1990s to stem the escalating costs of purchasing workers' compensation insurance and to comply with changing state regulations. It is important to realize that one cannot simply claim that OSHA is effective at improving worker safety and health by considering intentions or by examining raw figures or trends. To determine OSHA's impact on worker safety and health, one must control for other factors that also influence worker safety and health. The next section summarizes the efforts OSHA has taken to improve worker safety and health over the last forty years and details the various approaches used by economists to control for the confounding influences on worker safety to generate more-precise estimates of OSHA's effectiveness.

V. Forty Years of OSHA Enforcement History

OSHA activities grew rapidly during the 1970s in terms of personnel, budget, and regulatory activity. Shortly after beginning operations in April 1971, OSHA issued 4,400 interim standards derived from existing federal standards required under the Walsh-Healey, Construction Safety, and Longshoring acts and the national consensus standards of the American National Standards Institute and the National Fire Protection Association. Most of these general industry standards, many which continue to apply today, address issues of safety. Later in the decade the agency went on to establish health standards regulating maximum acceptable exposure levels for arsenic, asbestos, benzene, cotton dust, lead, and noise.

OSHA's critics disparaged the early safety standards as being overly specific, incomprehensible, or largely unrelated to safety. For instance, the handrail regulation which specifies the required height (30 to 34 inches), spacing of posts (not to exceed 8 feet), thickness (at least 2 inches for hardwood and 1½ inches for metal pipe), and clearance from the wall or any other object (at least 3 inches), was viewed as overly specific (Viscusi, Vernon, and Harrington 1995). The standard specifying the slope of the grain on wooden ladders appeared incomprehensible to most:

> The general slope of grain and that in areas of local deviations of grain shall not be steeper than 1 in 15 in rungs and cleats. For all ladders cross grain not steeper than 1 in 12 are permitted in lieu of 1 in 15, provided the size is increased to afford at least 15 percent greater calculated strength for ladders built to minimum dimensions. Local deviations of grain associated with otherwise permissible irregularities are permitted. (Quoted in Smith 1976)

And, although everyone could sympathize with the need for toilet facilities, the requirement that ranchers provide portable toilets for their cowboys seemed disconnected from the very real hazards cowboys face on the job.

Critics also argued that OSHA conducted too many superficial inspections and issued too many citations for trivial violations of safety and health standards. In 1976 only 39 percent of all citations were for serious violations of standards, and in only 7 percent of the over 90,000 inspections conducted during the year did inspectors find a serious workplace hazard. The Carter administration reevaluated inspection priorities and decided to conduct more thorough inspections of worksites and issue fewer citations for non-serious violations of standards. Consequently in the next year the number of inspections dropped nearly in half and the proportion of citations for serious violations rose by over 50 percent. Still, the average penalty per violation remained quite small, never exceeding $200 (Viscusi 1983). The administration

also overhauled the safety standards, eliminating the less productive features that so incensed OSHA's early critics.

At the end of the 1970s the typical firm faced less than a 1 percent chance of an OSHA inspection. With the number of citations per inspection slightly exceeding two, the expected cost of violating OSHA's dictates was about $4 (0.01×2×$200). Based on a cost/benefit analysis the optimal strategy for an employer was to ignore the regulations until caught unless the cost of complying was very, very small.

Table 1 summarizes the major empirical studies of OSHA's impact on worker safety from its inception to 2006. Not surprisingly, the studies find OSHA having, at best, only a modest impact on worker safety during its first decade. The most straightforward way to determine the impact of OSHA is to compare injury rates before and after passage of the OSH Act in 1970, controlling for contributing factors such as the unemployment rate and the gender composition of the labor force. Unfortunately, the BLS changed its method of monitoring worker safety at the same time that OSHA was established, making this direct comparison using national injury-rate data problematic. Mendeloff tries to overcome this difficulty by regressing year-to-year changes in the manufacturing injury rate against changes in several explanatory variables (such as the new hire rate and percentage of young men employed) using pre-OSHA data. He then multiples the coefficient estimates from the regression by the actual changes in the explanatory variables post-OSHA to form injury-rate change predictions absent OSHA. He finds no statistical differences between the predicted changes and the actual changes in injury rates from 1970 to 1975, leading him to assert, "We cannot reject the conclusion that OSHA has had no effect on the overall injury rate" (1979, 105).

Another way to circumvent the absence of a consistent national injury-rate series spanning OSHA's creation is to use data not subject to the methodological changes instituted by the BLS in 1970. Butler (1994) examines the National Safety Council data on worker fatalities to see if the downward trend shown in figure 2 accelerated post-OSHA. He finds an absence of an OSHA effect both in the overall decline and in the decline after controlling for other factors. In fact, in the four empirical specifications he uses, the estimated impact of OSHA is generally positive (although statistically insignificant), meaning the fatality rate decline slowed post-OSHA.

Two studies examine state workers' compensation data, and both find that the creation of OSHA caused some types of injuries to fall but other types of injuries to rise (Mendeloff 1979; Curington 1986). In reconciling the differences across injury types, Mendeloff argues that early OSHA standards were largely directed at preventing workers from being caught in or between equipment or being struck by equipment. The standards did not address strains and overexertion injuries and could only marginally prevent falls and slips. Further, the rise in workers' compensation indemnity benefits in the early 1970s enticed some workers to file fraudulent claims for benefits, which resulted in an increase in difficult-to-diagnose injuries such as strains. He finds that OSHA reduced caught-in-or-between injuries by 19 percent in 1974 and 27 percent in 1975, but had no impact on struck-by injuries. With caught-in-or-between injuries representing about 10 percent of all worker injuries, Mendeloff contends that OSHA reduced worker injuries overall by about 2 percent, an impact that was masked by the rise in strains and the general randomness of injuries unaddressed by OSHA standards.

Another approach to determine if OSHA is effective in improving worker safety is to examine the relationship between enforcement activities and injuries. Firms in industries targeted

by OSHA for more frequent inspections and/or higher fines for violations should be more likely to comply with the standards and have fewer injuries. Viscusi (1979a) uses industry data from 1972 to 1975 and finds OSHA had no significant impact on worker safety. Bartel and Thomas (1985) conclude based on an analysis of industry data from 1974 to 1978 that OSHA enforcement activities had a sizable impact on firm compliance with safety and health standards, but compliance had only a small, and statistically fragile, impact on worker safety.

The final method for estimating OSHA's effectiveness is to examine the impact of inspections on the change in worker safety within a plant or a firm. The approach will underestimate OSHA's impact if firms largely comply with safety and health standards before they are inspected and will overestimate OSHA's impact if inspections are geared toward more dangerous worksites or worksites with deteriorating safety records. To control for the latter possibility, two studies examine the impact of inspections by comparing lost-workday injuries in plants inspected early in the year to lost-workday injuries in plants inspected late in the year. The factors causing OSHA to inspect these firms should be the same regardless of the time of year they were inspected, but firms inspected first have more time to eliminate workplace hazards and, therefore, should have fewer injuries if inspectors correctly identify those hazards. Smith (1979) discovers that inspections in 1973 reduced injuries but inspections in 1974 did not. McCaffrey (1983) finds no impact of inspections on lost-workday injuries from 1976 to 1978.

Cooke and Gautschi (1981) examine the impact of OSHA inspections by relating injury-rate changes to the number of citations issued during an inspection. Using a sample of Maine manufacturing plants from 1970 to 1976, they estimate that OSHA citations lowered the number of days lost from injury by 23 percent in plants with more than 200 workers and by 37 percent in plants with more than 300 workers. Citations had no statistical impact on the number of days lost

from injury in plants with fewer than 200 workers. The sizable impact Cooke and Gautschi find may reflect their somewhat limited sample or a type of regression to the mean. Ruser (1995) shows that unexplained high injury rates decline over time even in the absence of OSHA inspections. In Cooke's and Guatschi's sample of Maine manufacturing plants, average days lost were considerably higher for plants visited by OSHA than plants not visited, meaning the drop in injuries after inspection may simply reflect a decline unrelated to OSHA.

During the Reagan administration, OSHA's real annual budget and staff fell. OSHA issued fewer new major standards than during the Carter years and the standards, such as the rules geared toward eliminating grain handling accidents, gave firms some flexibility on how best to satisfy the requirements. The Reagan OSHA paid increased attention to enforcing health standards, as opposed to safety standards, and redirected safety inspections away from manufacturing toward construction, the most dangerous industry as measured by industrial accident rates. The total dollar amount of penalties for violations dropped dramatically from the Carter years but the proportion of penalties for serious violations rose. The agency became less confrontational and more cooperative with firms concerning safety matters, and consequently firms contested far fewer OSHA fines.

In 1981, as an attempt to get more injury deterrence for its money, OSHA began to use firms' safety records to target inspections at worksites with comparatively poor safety records. Under the new procedure an inspector would arrive at a worksite and first calculate the injury rate at the site using the firm's log of accidents and illnesses. The inspection would only continue if the site's lost-workday accident rate for the past two or three years was above the most recent overall manufacturing accident rate. The records-check procedure was discontinued in 1988 partly over concern that government injury data were becoming less accurate over time as firms

underreported injuries to avoid inspections. Ruser and Smith (1988) provide evidence that the record-check program caused firms potentially subject to an inspection to underreport injuries by 5 to 14 percent.

The Bush administration continued to redirect inspections and new regulations away from stereotypical manufacturing workplaces and toward more hazardous settings, including logging, construction, agriculture, maritime, and petrochemicals. Legislation in 1990 increased by a factor of seven the maximum penalties a firm could receive for noncompliance with safety and health regulations, causing total assessed penalties to skyrocket. On the safety front, OSHA issued the lockout/tagout standard in 1989, requiring workers doing machine maintenance to either lock down the machine or tag it with a notice not to use so that other workers either cannot or will not attempt to use it. Before OSHA issued the standard, as many as 120 deaths and 50,000 injuries happened annually because workers accidently switched on machines other workers were servicing (US Department of Labor, OSHA 2011).

The empirical evidence shown in table 1 on OSHA's impact on worker safety and health in the 1980s is mixed. In an update to his earlier study, Viscusi (1986) examines manufacturing industry data from 1973 to 1983 to see if greater OSHA enforcement activities within an industry reduced injuries within the industry. The first study from 1972 to 1975 finds no impact, but the new study that extends the data into the early 1980s finds that OSHA inspections reduced lost-workday injuries by 1.5 to 3.6 percent. Inspections and assessed penalties continued to have no effect on the severity of injuries, and assessed penalties had no impact on the frequency of injury. Because the results show no evidence of increasing OSHA effectiveness over time, Viscusi credits the varying level of statistical significance of the impact of inspections on lost-workday injuries to the differing sample sizes. With more years to examine, the later Viscusi study is able

to detect a statistically significant but fairly small impact on worker safety from OSHA enforcement activities.

Scholz and Gray (1990) examine plant-level data from 1979 to 1985 and find that a 10 percent increase in the frequency of OSHA inspections decreased lost-workday injuries in manufacturing by 1.61 percent, and a 10 percent increase in the average OSHA penalty lowered lost-workday injuries in manufacturing by 0.93 percent. Based on these estimates (and ignoring the econometric issue of forecasting out of the range of the underlying data), overall OSHA enforcement efforts reduced injuries by 10 to 16 percent. Over 90 percent of the improvement in safety uncovered by Scholz and Gray is from the threat of inspection and fines deterring firms not yet inspected by OSHA from violating safety standards in the first place (the deterrence effect). Less than 10 percent of the improvement in safety is from firms eliminating safety hazards after they have been inspected by OSHA (the abatement effect). The authors suggest that their results may not be representative across all firms. The sample they investigate is composed of larger, more hazardous, and more frequently inspected plants than typically found in manufacturing, and managers in these types of plants may be more responsive to OSHA enforcement efforts. Ruser and Smith (1991) examine another cross section of plants from 1979 to 1985 and find no evidence that more frequent inspections within an industry reduced worker injuries.

The two studies that investigate the impact of inspections on injuries within inspected plants also come to quite different conclusions. Gray and Scholz (1993) find, using a large national cross section of establishments from 1979 to 1985, that an OSHA inspection with penalty on average lowers injuries in the plant the year of the inspection and in each of the following three years. Cumulated over the entire four years, OSHA inspections with penalties

reduce injuries by 22 percent. Only 9.3 percent of the plants in their sample were penalized, meaning that OSHA's enforcement efforts reduced workplace injuries by about 2 percent (0.093×22) overall, a result very close to Viscusi's (1986) estimate using industry data. In the other direction, Ruser and Smith (1991) compare a cross section of plants from 1979 to 1985 that were inspected early in the year with ones that were inspected later in the year and discover no impact of inspections on lost-workday injuries.

Considering the conflicting econometric results, it is difficult to come to a firm conclusion regarding OSHA's effectiveness during the 1980s. Of the three studies examining OSHA's overall impact on all firms, only Scholz and Gray (1990) find OSHA enforcement efforts reducing injuries dramatically. Smith (1992) argues that their results are not credible because a 16 percent reduction in the aggregate injury rate would be readily observable in the aggregate data. Moreover, he believes that the very low overall frequency of inspection and level of penalties existing in the 1980s make it unlikely that the pre-inspection deterrence effect of OSHA would be so large, more than 90 percent of the total improvement in safety. More likely, their results are driven by the unique nature of their sample or the estimating technique they use.

Of the two studies examining the actual impact of OSHA inspections, the Gray and Scholz (1993) results might be the most reliable. Unlike Ruser and Smith (1991) they examine those inspections most likely to result in safety improvements, inspections uncovering actual safety and health hazards, and they examine the impact of these inspections over several years, not merely eight to eleven months after the inspection. Relying on the results of Viscusi (1986) and Gray and Scholz (1993), OSHA enforcement efforts in the 1980s reduced workplace injuries by 2 to 4 percent.

During the 1990s OSHA issued new safety standards regulating work in confined spaces and the handling of chemicals, strengthened requirements for employers to provide fall protection to workers involved in construction, established safety standards for logging operations and working with blood and other potentially infectious materials, established permissible exposure limits to methylene chloride, and reduced permissible exposure limits to asbestos. Yearly inspections rose from about 60,000 in the last year of the Bush administration to over 80,000 in the first year of the Clinton administration. Inspections remained high for another year, dropped by 10 to 20 percent each of the next two years, and then steadily rose until 2000. The real dollar value of initial penalties followed a pattern similar to that of to inspections (Jung and Makowsky 2012).

As part of the Clinton effort to reinvent government, OSHA began a Cooperative Compliance Program targeted to high hazard employers, where employers would set up a partnership with OSHA to develop a comprehensive plan to improve safety. To encourage participation, OSHA made the firms an offer they could not refuse: develop a workplace safety and health program meeting certain conditions, and reduce your chance of inspection from 100 percent to 30 percent. By February 1998, when the DC Court of Appeals ruled that OSHA had not followed proper rule-making procedures and struck down the approach, 87 percent of the 12,250 employers marked for inclusion had accepted. OSHA replaced the Cooperative Compliance Program with the Site-Specific Targeting Plan. Previously, OSHA had targeted firms in the most dangerous industries for programmed inspections, regardless of the firm's own safety record. The new program focuses OSHA inspections toward those worksites with the highest frequency of injuries and illnesses, regardless of the industry's safety record.

Given the expansion of inspections and fines, one might anticipate that OSHA had a larger impact on worker safety in the 1990s than in the 1980s. The one study in table 1 examining data over the entire 20 years, however, discovers the opposite. Using a national cross section of manufacturing plants from 1979 to 1998, Gray and Mendeloff (2005) find that OSHA inspections with penalties reduced lost-workday injuries by 19.2 percent in 1979–85, but by only 11.6 percent in 1987–91, and by a statistically insignificant 1 percent in 1992–98. The authors cannot explain the overall decline in OSHA's effectiveness.

In another study the same authors narrow the focus to small manufacturing plants from 1992 to 1998 and investigate the impact of OSHA inspections with penalties on specific categories of injuries (Mendeloff and Gray 2005). They argue that OSHA standards attempt to control hazards that are likely to result in certain types of injuries such as "struck by objects and equipment" and "caught in or compressed by objects or equipment," but not other types of injuries such as "bodily reaction and exertion" and "falls on same level." For companies employing fewer than 250 workers, Mendeloff and Gray find statistically significant declines from an inspection with penalty in two of the five injury categories controllable by safety standards and in two of the three injury categories not controllable by safety standards. Aggregating over the two broad classes of injuries, an OSHA inspection with penalty reduced controllable injuries by 7.2 percent and uncontrollable injuries by 11.2 percent through the three years following the inspection. They also find that citations for violating standards on personal protective equipment reduced not only caught-in injuries and eye abrasions, as might be expected, but also exertion injuries, which seem unrelated to the use of personal protective equipment. Surprisingly, citations for machine guarding had no impact on caught-in injuries, but did reduce injuries from high falls. Mendeloff and Gray argue that OSHA citations force

managers to pay more attention to worker safety and this general attention spills over into areas not directly related to OSHA standards.

Although the two studies by Mendeloff and Gray paint far different pictures of OSHA's effectiveness in the 1990s, neither finds OSHA having a major impact on worker safety in total. About 20 percent of the manufacturing establishments in the two samples had an inspection with penalty and about 44 percent employed fewer than 250 workers.[5] Using 11 percent as the impact of an inspection with penalty on small firms and 1 percent as the impact on establishments of all sizes, the two studies suggest that OSHA inspections reduced manufacturing injuries in the 1990s from 0.2 to 0.97 percent.

Throughout the 1990s OSHA attempted to establish an ergonomics program standard to reduce repetitive motion disorders such as carpal tunnel syndrome. OSHA issued a first draft of a formal standard in 1995. Intense business pressure and the threat of congressional intervention forced OSHA to withdraw the draft proposal shortly thereafter. For three years congressional action prevented OSHA from spending funds on an ergonomics program proposal, but once the legal restrictions expired OSHA began work on a new standard. OSHA presented the new proposal to the general public in July 1999 and the final rule was published in November 2000, to become effective January 2001. In March 2001 Congress passed and President Bush signed a bill repealing the standard.

The ergonomics program standard was not unique. During the Bush administration, many of the pending safety and health standards developed during the Clinton years were eliminated and relatively few new standards were developed. The Needlestick Safety and Prevention Act passed at the end of President Clinton's second term directed OSHA to revise its Bloodborne

[5] The summary statistics are from table 1 in Gray and Mendeloff (2005). Gray and Mendeloff consider any firm that was inspected and penalized in a given year or any of the previous three years to have been inspected and penalized, which explains the quite high fraction of penalized firms in their sample.

Pathogens standard, which it did in January 2001. It also issued new standards limiting worker exposure to hexavalent chromium, a chemical associated with lung cancer, and protecting shipyard workers against fire hazards. OSHA inspected firms at about the same rate in the eight years of the Bush administration as it did during the last half of the Clinton administration and issued roughly the same level of fines in real terms (Jung and Makowsky 2012).

Three studies in table 1 track OSHA effectiveness during the 2000s. The first, Haviland et al. (2010), updates Mendeloff and Gray (2005) using data drawn from Pennsylvania single-establishment firms employing from 20 to 250 workers from 1998 to 2005. Similarly to the earlier study, they find that OSHA inspections with citations reduced injuries with the impact largest for injuries seemingly unrelated to OSHA standards and smallest for injuries related to OSHA standards, 14.4 percent versus 8.2 percent cumulated over two years. As expected, citations for violating the personal protective equipment standard reduced caught-in and eye-abrasion injuries, but in addition they unexpectedly reduced exertion injuries that have little to do with using personal protective equipment. Also unexpectedly, electrical wiring citations reduced high-fall injuries, fire extinguisher citations raised eye-abrasion injuries, and struck-against injuries and forklift truck citations raised high-fall injuries. The authors argue that citations signal to managers that they need to be more concerned with safety and their renewed efforts spill over into areas unrelated to specific standards. The authors do not explain the positive impact of citations on some categories of injuries.

The second study, Haviland et al. (forthcoming), reanalyzes the Pennsylvania single-establishment firm data used in the first study using the approach of Gray and Mendeloff (2005). Both of the Haviland et al. studies find no impact of OSHA inspections on firms with fewer than 20 workers or with more than 250 workers and so exclude them from the analysis. For firms with

20 to 250 workers, the second study finds that an OSHA inspection with penalty on average reduced injuries by a cumulative 19.3 percent over two years. Based on this result, they argue that the decline in the effectiveness of OSHA penalty inspections from the late 1970s to the late 1990s documented by Gray and Mendeloff (2005) reversed in the early 2000s. One may disagree with their analysis. The results from a single state may not represent national trends, and differences between the two studies make a direct comparison problematic. Most notably, the Haviland et al. estimates are for inspections with penalties in the current or previous year, whereas the Gray and Mendeloff estimates are for inspections with penalties in the current or any of the previous three years. With a four-year window, Haviland et al. find that the impact of an inspection with penalty from 1998 to 2005 fell to a cumulative 3.9 percent.

The third study, Levine, Toffel, and Johnson (2012), compares injury rates from a sample of 409 single-establishment firms in California that were randomly chosen by OSHA for a programmed inspection from 1996 to 2006 with a matched sample of 409 firms eligible for inspection but not chosen. They find that an OSHA inspection in the current year or any of the previous four years reduced annual injuries by 9.4 percent and workers' compensation outlays by 26 percent. Based on their estimates, an OSHA inspection reduces injuries by a whopping 47 percent over the five years after an inspection and creates a $355,000 (2011 dollars) savings in workers' compensation expenses, roughly 14 percent of average annual payroll of the sample of firms included in the study. The authors find no evidence that the improvement in safety came at the expense of employment, payroll, sales, credit ratings, or firm survival.

The Levine, Toffel, and Johnson study is the only one finding OSHA inspections in general having a large impact on worker safety. Their results are difficult to reconcile with previous studies finding much smaller safety improvements from inspections with penalties. The

results may also not pertain across all worksites. During the time of the study, programmed inspections in California were restricted to firms in high-hazard industries. Inspections may be less effective in improving worker safety in less hazardous environments or other states. Even using 9.4 percent as the impact of inspections across all types of firms and all states, with only 1 percent of establishments inspected each year the overall impact on worker safety is less than half a percent over five years.

OSHA during the Obama administration has issued relatively few new standards. In 2009 the agency updated a previous standard geared to making chemical labels easier to understand and bringing them into conformity with international guidelines. The agency also proposed in 2010 to require firms to implement management systems to find and eliminate hazards in the workplace, similar to systems required under the Cooperative Compliance Program started and ended in the Clinton administration, but a final standard has not yet been issued.

OSHA has taken a more confrontational approach to enforcing workplace safety and health standards in the first few years of the Obama administration than it did during the eight years of the Bush administration. The agency has hired more safety and health inspectors, transferred personnel from voluntary compliance to inspection, and raised average penalties by toughening internal guidelines. In 2010 OSHA refocused the Enhanced Enforcement Program started in 2003 toward larger employers, renaming it the Severe Violator Enforcement Program. The program concentrates inspections on employers who have demonstrated a reluctance to abide by their obligations under the OSH Act by committing willful, repeated, or failure-to-abate violations in situations that: (1) resulted in a fatality or a catastrophe; (2) exposed workers to a highly hazardous chemical; (3) arose from a highly dangerous production process; or (4) revealed a flagrant disregard of safety and health standards. If OSHA identifies a broad pattern of

noncompliance across worksites of the same employer, then through a nationwide referral system it will target all of the employer's worksites for inspection.

VI. Market Incentives

The empirical evidence on OSHA's effectiveness in improving worker safety and health is mixed. The most optimistic guess based on existing estimates is that OSHA has modestly lowered the frequency of occupational injuries and illnesses. Yet despite OSHA's fairly small impact, the rates of occupational fatalities and nonfatal injuries continue to trend downward. The overall decline partially reflects changes in the industrial structure of the American workforce and general improvements in safety technology over time, but the decline also reflects the changing financial incentives facing firms, causing them to be more concerned with worker safety.

Even in the absence of OSHA, firms would be concerned with worker safety as a way to reduce labor costs. As discussed previously, the interplay between workers and firms generates an upward sloping wage function in risk. All else equal, workers must be compensated for accepting something they dislike (risk) by something they like (higher wages). By eliminating hazards and improving worker safety and health, firms are able to pay lower wages and still attract workers. The reduction in wage may more than offset the expense of the safety programs, resulting in higher profits for the firm. In the other direction, firms with deteriorating workplace safety and health will have to pay higher wages to attract workers, and the expansion of labor costs may more than offset any savings from scrimping on safety programs, resulting in lower profits for the firm.

Critics contend that market forces are insufficient to protect workers adequately because workers lack the information necessary to evaluate hazards properly, and even when they

become aware of hazards, moving from one job to another job is difficult. In other words, the assumptions of perfect information and complete labor market mobility, which underlie the theory of compensating wage differentials, are unrealistic, making the conclusions of the model false. In the absence of information about hazards and the ability of workers to move from high-risk to low-risk jobs labor markets will not establish compensating wage differentials for risk and firms will lack incentives to improve safety. Even if workers realize that hazards exist but they underestimate the risks they face, then compensating wage differentials will be too small and safety incentives will be too weak.

Evidence indicates that workers do consider risk when accepting employment. Many labor market studies show wages rising as the chance of a fatal or nonfatal injury or disease at work expands. All else equal, the typical US worker in a job with a likelihood of injury at about the labor market average earns 1 to 2 percent more than a person working in a totally safe job (Viscusi and Aldy 2003). The positive relationship between wages and risk has been found in the United States and other industrial countries and also in less developed countries. Wages rise not only for accident risks but also for the risk of a long-term illness such as cancer (Lott and Manning 2000; Sandy and Elliott 2005; Wei 2007). Although the onset of cancer can occur years after exposure to a harmful substance and the end result is not always fatal, the impact of cancer risk on wages is of about the same magnitude as the impact of fatal-injury risk on wages.

Even when workers initially do not understand the risks they face, they reevaluate their beliefs relatively quickly. Evidence indicates that workers quit hazardous jobs more frequently than relatively safe jobs (Viscusi 1992). Increases in the probability of an accident also raise quit intentions and job searching, and reduce job tenure. Learning about job risks after accepting employment may be the cause of about one-third of all worker quits (Viscusi 1979b).

In short, workers do have information about job risks and when they discover that a job is more hazardous than they originally thought, they react by searching for another job. The added compensation firms must pay to entice workers to accept employment in hazardous worksites gives them the incentive to expand their investments in safety programs. To put the size of these compensating differentials in some context, at 1 to 2 percent of labor earnings the total market compensation paid by private firms in the United States for workplace risk in 2010 was $50 billion–$100 billion. Total initial penalties issued by OSHA for safety and health standard violations during the same year fell below $150 million (Jung and Makowsky 2012).

Because risk compensation varies across groups of workers and over time, firm financial incentives will also vary. In the United States, union members receive higher fatal-injury risk compensation than nonunion workers (Viscusi and Aldy 2003); whites receive higher compensation than blacks (Viscusi 2003); and women receive higher, but less statistically robust, compensation than men (Leeth and Ruser 2003). Fatal risk compensation for native workers is roughly the same as for immigrant workers, except for non-English-speaking immigrants from Mexico who appear to earn little compensation for bearing very high levels of workplace risk (Hersch and Viscusi 2010). Fatal-injury risk compensation varies by age with values rising until the mid-40s and then very gradually falling (Kniesner, Viscusi, and Ziliak 2006; Aldy and Viscusi 2008). Finally, a substantial body of research discovers a very strong positive relationship between income and fatal-injury risk compensation (Mrozek and Taylor 2002; Viscusi and Aldy 2003; Bellavance, Dionne, and Lebeau 2009; Kniesner, Viscusi, and Ziliak 2010).

The diversity of risk estimates across populations reflects both the heterogeneity of risk preferences across workers and the possibility that the market, in some cases, may fail to

compensate some workers adequately for the risk they face. Regardless of the reason for the diversity, the need for safety regulation is much lower for populations of workers who already receive substantial wage compensation for bearing a higher chance of injury or death on the job than for populations of workers who receive small or no wage compensation. The benefit to the firm of being able to reduce labor expenses by eliminating hazards and the cost to the firm of introducing new hazards are high if workers receive a great deal of additional pay for risk and low if workers do not receive a great deal of additional pay for risk.

Returning to the issue of improving safety over time, Costa and Kahn (2004) estimate the impact of occupational fatality risk on wage compensation in the United States from 1940 to 1980 to see if risk compensation has expanded with the general growth in the economy. They find a strong upward trend from 1940 to 1980. The positive trend should not be a surprise. Almost all economists believe safety is a normal good, meaning that people desire more safety as their income rises. As noted above, US wage studies find a strong positive relationship between fatal-injury risk compensation and income. Similar wage studies across a multitude of countries find fatal-injury risk compensation to be larger in high-income, developed countries and lower in low-income, less developed countries (Viscusi and Aldy 2003). As the US economy has grown, average worker income has risen resulting in greater demands for a safe work environment and higher compensation for bearing workplace risk. With the implicit cost to firms of workplace accidents and diseases rising over time, the economic incentive to expand safety efforts has risen, which correlates quite well with the decline in fatal-injury risk seen in figure 2.

The existence of compensating wage differentials does not mean that OSHA has no role to play in improving worker safety and health. Workers will not receive any added compensation for bearing risk if they are ignorant of the hazards they face. OSHA can best help workers by

developing and enforcing standards addressing ill-understood injury or health risks. In particular, industrial illnesses generally develop after prolonged exposure to a hazardous substance, and the ultimate cause may not be knowable to the worker or the physician. Even when the hazard causes immediate harm, such as overexposure to carbon monoxide, the hazard may not be observable to a worker until it is too late. Workers can more readily observe accident risks, and so compensating wage differentials are likely to develop, making the development and enforcement of safety standards less crucial.

OSHA's Microwave Popcorn Processing Plants National Emphasis Program serves as an example of an effective use of OSHA resources. Public health officials contacted NIOSH about a cluster of former employees of a microwave popcorn manufacturing plant in Missouri who had been exposed to butter flavoring chemicals and who had developed bronchiolitis obliterans, a rare lung disease. In 2000 NIOSH conducted an investigation of the workers at the plant and discovered high rates of both respiratory symptoms and abnormal lung function. Investigations at other workplaces using butter flavoring and other flavoring chemicals have found that workers have developed similar health problems. OSHA has not yet developed a formal standard on these flavorings but is targeting firms using these flavorings for more frequent inspection and when necessary penalizing them for violating the General Duty Clause of the OSH Act.

Even here, however, market forces probably exert an equally, if not more, powerful incentive for firms to limit worker exposure to chemical flavorings. The news media widely reported the association between working in a microwave popcorn manufacturing plant and developing lung disease. If workers did not already know, the new information would have alerted them to the danger, increasing the likelihood that they would have demanded a compensating wage differential for the newly perceived risk or simply quit. Firms faced the

choice of either expanding efforts to limit worker exposure to chemical flavorings or bearing the costs of recruiting and training new workers and paying higher wages to all workers.

A benefit of providing information over developing a formal standard regulating use or exposure is that information allows workers to make the cost/benefit calculations or decide on the appropriate precautions to take based on their own circumstances and preferences. Accidents generally do not happen in a vacuum, but instead are the result of the interaction of the user and the technological characteristics of the product. Simply specifying workplace characteristics may not address all of the contributors to deteriorating safety and health. A formal standard may also be less effective in reducing workplace hazards than information provision, because it focuses industry efforts on compliance rather than results. Finally, in many situations, usage of a product is so decentralized that government monitoring of regulations dictating appropriate precautions is difficult, if not impossible. In these situations, providing information through hazard warnings or training programs on appropriate usage may be the only way to encourage workers to take suitable precautions (Viscusi 1991b).

Workers do react to information concerning safety and health risks, but because of the public goods aspect of basic research, the private market will underprovide safety and health information. A public good is one where the use of the good by one party does not diminish its use by others and where it is difficult for the party providing the good to one person to exclude its use by others. Because the results of basic research generally become widely known without all of the benefiting parties having to pay for the information, the private market will provide too little information. The social benefits of research are much higher than the revenue firms can collect by selling the information to private parties. The government can counteract this market failure by subsidizing the research of others or by engaging in basic research itself.

The public goods nature of basic research means the government has a role to play in trying to uncover and disseminate information on the causes and consequences of safety and health hazards. NIOSH was explicitly created to gather information and conduct scientific research about workplace injuries and illnesses. Research by NIOSH can be conveyed to workers through news releases, outreach programs, and hazard warning requirements; can be used by OSHA to develop better workplace safety and health standards; and can be used by equipment manufacturers to develop new production technologies.

The empirical estimates of compensating wage differentials should guide OSHA's inspection efforts. The larger the risk premium, the greater the financial incentive for employers to be concerned with safety, and the lower the need for extra OSHA prodding. An earlier study found that, although as a percentage of total earnings the typical US worker earns a 1 to 2 percent risk premium for bearing the average level of workplace risk, workers in chemicals and allied products earn 3 to 5 percent more for bearing the risk they face, workers in paper and allied products earn 6 to 9 percent more, and workers in lumber and wood products earn 12 to 15 percent more (Viscusi 1985b). Union workers, high income workers, and middle-aged workers receive higher risk compensation, and blacks and non-English-speaking Mexican immigrants receive lower risk compensation than others. OSHA's outreach assistance to the Hispanic community that includes providing Spanish language training to employers and employees and free on-site consultation programs seems sensible, given the rising workplace fatality rate for Hispanic workers and the seeming absence of a compensating wage differential for a sizable subset of the community.

VII. Workers' Compensation Insurance

Workers' compensation is primarily a state-operated disability insurance program covering workers against losses caused by industrial accidents and some diseases. Regardless of who is at fault, employers must fully compensate employees for medical expenses and partially compensate them for lost wages caused by work-related injuries. Standards for replacing lost wages from injury vary across states. Most states require employers to replace two-thirds of weekly wages up to a maximum benefit of two-thirds of the state's average weekly wage for more serious injuries. In return, employees forgo their rights to sue employers when injuries occur. Most states allow employers to provide workers' compensation coverage either by purchasing insurance with a private provider or by self-insuring after proof of financial ability to pay. In return for receiving no-fault insurance coverage, workers give up their right to sue their employer for damages even for injuries caused by employer negligence.

The price of workers' compensation insurance coverage consists of a manual rate and an experience rating modification factor. Insurance providers combine the injury experience of a group of workers within an industrial class to determine the manual rate for that class. The manual premium is higher for industrial classes with more accidents and lower for industrial classes with fewer accidents. For small employers, insurance companies take the product of each worker's wage rate and the manual rate for his or her industrial class and then sum over all workers to determine the total workers' compensation insurance premium for the firm. As employer size rises, insurance companies modify the manual rate to reflect the firm's injury experience. Firms with worse safety records pay more than the manual rate and firms with better safety records pay less. Excluding firms that self-insure, only the very largest firms have workers' compensation premiums that are completely experience rated. The process is very

similar to the pricing of car insurance. The "manual" rate is higher for people living in urban areas than in rural areas, and within each area the rate will rise for people with worse driving records and fall for people with better driving records.

Assuming everything else is the same, passage of workers' compensation insurance or the expansion of income benefits should improve worker safety by encouraging firms to eliminate hazards to lower their insurance premiums. As one builder put it, safety regulation is important, but "the occasional tripping, loss of balance, touches of carelessness" that cause the high loss of life in construction are probably inevitable. Based on his experience, workers' compensation insurance has a bigger impact on safety because once builders start worrying about insurance premiums, they find ways to make the worksite safer (as reported in Lowenstein 2012, p. A11).

Unfortunately, workers' compensation insurance may have some side effects that may counteract the direct incentives it creates for employers. Wages adjust not only for undesirable job characteristics, such as a high likelihood of injury, but also for desirable ones, such as generous insurance coverage. Employers pass along some of the costs of higher insurance benefits through lower wages (Fishback and Kantor 1998; Moore and Viscusi 1989; Viscusi 2004). Additionally, workers' compensation benefits alter the relationship between wages and risk. By reducing income losses from injury, more generous workers' compensation benefits reduce the wage demanded by workers for accepting a more dangerous job. Greater ex post compensation for an injury lowers the ex ante compensation required for accepting higher job risk, flattens the market wage function, and may reduce firms' incentives to provide a safe work environment.

More generous workers' compensation insurance may also entice workers to report more accidents and diseases (either legitimate or illegitimate) and file more claims for disability benefits. Even if workers' compensation insurance has no influence on workers' acceptance of risk, the stronger incentives to file workers' compensation insurance claims as benefits expand would likely cause a positive relationship between benefits and reported injuries. Most empirical studies find that larger benefits raise the number of reported nonfatal workplace injuries, suggesting a tradeoff between compensating workers adequately for their losses and reducing injuries (Ruser and Butler 2009).

Kniesner and Leeth (1989) separate reported injuries from actual injuries and show that the greater incentives to file claims for workers' compensation insurance can easily mask the measured impact of employers' actions that improve workplace safety. Reported injuries rise even when actual injuries fall. This so-called reporting effect may explain why the number of claims jumps on Mondays, particularly claims for hard-to-diagnose muscular and skeletal injuries, such as sprains and lower back impairments (Smith 1990; Ruser 1998). By contrast, studies focusing on either fatal or extremely severe injuries, injuries unlikely to suffer from a reporting effect, discover that higher benefits improve safety. Moore and Viscusi (1989) find that a 10 percent increase in workers' compensation benefits reduces occupational fatalities by 2 percent. Based on their estimates, workplace fatalities are 22 percent lower now than they would be in the absence of workers' compensation insurance.

The evidence on workplace fatalities suggests that there is no tradeoff between adequately compensating workers for losses from injury and improving worker safety. A more generous workers' compensation program may cause reported injuries to rise, but the larger financial incentives for firms to control workplace accidents to limit the escalation of their

workers' compensation insurance premiums end up reducing actual injuries, as measured by the injury category least prone to a reporting effect: workplace fatalities. In comparison to OSHA, the impact of workers' compensation benefits on workplace safety when properly measured is massive. The vast majority of the empirical estimates summarized earlier (see table 1) find OSHA reducing workplace injuries by a fairly modest 2 to 4 percent. The Moore and Viscusi (1989) estimate places the total impact of the workers' compensation system at between five and ten times greater than the total impact of OSHA. The relative effectiveness of the two programs should not be too surprising given the relative magnitudes of the financial incentives generated by the two programs. Employer costs for providing workers' compensation insurance coverage in 2010 totaled nearly $72 billion, versus OSHA penalties of less than $150 million (Sengupta et al. 2012).

Shortly after passage of the OSH Act, the National Commission on State Workmen's Compensation Laws encouraged states to raise income replacement rates for injured workers. Based on the Commission's recommendation, the generosity of most state workers' compensation insurance programs expanded in the mid- to late 1970s. As can be seen in figures 2 and 4, the rate of lost-workday injuries rose but the rate of workplace fatalities fell during the period, as would be expected from the empirical evidence. The higher benefits and the expanding claims for nonfatal injuries caused firms' costs of providing workers' compensation insurance coverage to skyrocket, leading them to introduce new safety and health initiatives. The cost pressures also caused many states to modify their programs in the 1980s and 1990s once again. Conway and Svenson (1998) examine injuries and illnesses from 1992 to 1996 by state and industry and conclude that firms' new efforts to control workers' compensation expenses by

improving worker safety and changes in state workers' compensation insurance programs explain most of the injury reduction during the period.

Although workers' compensation insurance can provide firms substantial financial incentives to improve worker safety and health, the actual pricing of policies and gaps in coverage suggest that OSHA should target its inspection efforts toward smaller firms and toward health-related hazards. To create the optimal incentives for providing a safe workplace, the price of workers' compensation insurance must reflect firms' safety efforts. The larger the premium reduction for a given improvement in safety, the more likely firms will expand safety as workers' compensation insurance benefits rise. Very small firms are not experience rated at all, which means that their individual safety records have no impact on the prices they pay for workers' compensation insurance. This muted impact on small firms' insurance premiums implies that the incentives of smaller firms to invest in workplace safety are limited. Studies find that small, imperfectly experience-rated firms have the largest increase in total worker injuries and the smallest reduction in fatalities when workers' compensation benefits rise (Ruser 1985, 1991).

The absence of experience rating does not mean small firms have no financial incentive through the workers' compensation system to be concerned with worker safety. Private insurance firms will refuse to provide coverage to firms with excessive claims, and these companies will be forced to purchase their workers' compensation insurance from the more expensive state-assigned risk pool. Insurance companies also have the financial incentive to offer discounts to firms engaging in certain safety practices if the expected outcomes of these activities are sufficiently large reductions in claims.

The workers' compensation system awards benefits to accident victims at low administrative costs and, as suggested by research on workplace fatalities, provides powerful

incentives for firms to improve workplace safety. The system is far less effective in the area of occupational diseases, particularly diseases with a long latency period. Firms can contest a claim for benefits if there is too long of a delay in filing the claim, the worker was injured while employed elsewhere, or the injury was not work related. For occupational diseases the point of injury or even the cause of injury is frequently unclear, making it difficult for workers to collect benefits.

The failure to experience-rate small firms' workers' compensation insurance premiums and the difficulty of workers collecting claims for work-related health hazards limit the financial incentives for small firms to minimize safety hazards and for all firms to minimize health hazards. To counteract these failings, OSHA should target its enforcement efforts toward smaller firms and toward health hazards. Workers' compensation insurance already provides strong incentives for large firms to control industrial accidents, making OSHA efforts less necessary.

VIII. The Legal System

State workers' compensation laws prevent employees injured on the job from suing their employers for damages even if the employer is negligent. Workers have been able to overcome this limitation in some cases by suing other parties for damages under product liability laws. Instead of suing the employer for an injury from operating a backhoe, the worker sues the manufacturer of the backhoe. Litigation for illnesses arising from asbestos exposure is perhaps the most famous example of workers bypassing employers and suing product manufacturers for work-related damages.

Potential damage awards through tort liability can produce powerful incentives for firms to produce safe products. Litigation costs can be substantial. Firms can be forced to pay for economic losses, pain and suffering, and punitive damages if found liable for an injury or an

illness. Originally, companies were liable for product-related injuries only if they failed to exercise the care of a reasonable person. Starting in the 1960s, strict liability increasingly became the norm, and producers were found liable for product-related injuries regardless of negligence. The courts believed that manufacturers could assume product risks and spread these risks across all consumers through higher prices (Viscusi 1991a). Under strict liability, manufacturers are liable for damages to users if the products are unreasonably dangerous or users are inadequately warned of the hazards.

The ability of workers to sue manufacturers for product liability raises their incentives to produce safe equipment and provide suitable warnings of job hazards. In some areas, changes in equipment design occur well before changes in applicable OSHA standards. Because manufacturers who meet international guidelines are less likely to lose product liability suits, changes in these guidelines, which often lead OSHA requirements, get incorporated into equipment design quite quickly. In 2009 OSHA updated its standard on personal protective equipment to incorporate changes in the national consensus standards of the American National Standards Institute and the ASTM International, but manufacturers had already altered their products and were advertising compliance with the consensus standards well in advance of the 2009 update.

Potential criminal penalties for accidents and illnesses also serve to supplement the various financial incentives encouraging managers to minimize work hazards. An employer convicted of a willful violation of an OSHA standard resulting in the death of an employee faces up to six months in prison. The effectiveness of criminal punishment as a deterrent is unclear. The punishment is small and the probability of conviction tiny. OSHA refers few cases to the Justice Department for criminal prosecution, and federal prosecutors seldom decide to pursue

these cases or win convictions. Nothing, however, in the OSH Act precludes enforcement of state criminal laws to address workplace safety, and state prosecutors have pursued criminal charges against employers for safety-standard violations that have resulted in worker deaths.

Legal incentives to invest in workplace safety and health could be expanded by allowing employees to sue their employers for negligence in cases of gross misconduct. The current limited liability system established by state workers' compensation laws prevents employees from suing employers for full economic damages, which include the costs of pain and suffering. Allowing worker suits for pain and suffering would produce a more appropriate level of safety by forcing employers to internalize the complete cost of injuries. The fairness of the work-related disability insurance system would also be improved by shifting an important cost of injury to the party responsible. To avoid unduly increasing administrative and court expenses, the right to sue should be strictly limited to instances of gross employer misconduct.

OSHA partially compensates for the inability of workers to sue for full economic damages by investigating workplace fatalities and serious injuries, and fining negligent companies for breaches of safety and health standards. The fines can sometimes be sizable. After an explosion killed fifteen workers and injured 170 others at a refinery in Texas City, Texas, OSHA inspected the worksite and fined the owner, BP Products North America, $21 million (US Department of Labor 2005). These ex post investigations by OSHA serve as a type of injury tax on employers that should expand their financial incentives to reduce worksite hazards in the first place. Still, notwithstanding the seemingly high penalty imposed on BP Products, the normal penalty is quite small, about $5,900 in cases involving a worker death (Michaels 2010).

IX. Why Has OSHA Had Only a Small Impact on Worker Safety?

OSHA's efforts to inspect firms for violations of safety and health standards and to fine them for noncompliance can improve worker safety in two ways: the threat of fines may deter firms from violating safety and health standards in the first place, and an actual inspection may cause inspected firms to abate existing hazards. Based on existing evidence, OSHA's deterrence effect is fairly small, a 1.5 to 3.6 percent reduction in worker injuries at best (Viscusi 1986). The current abatement effect appears much larger, but given the small fraction of firms inspected by OSHA the overall impact is quite small. One recent study finds inspections with penalties reducing worker injuries in small establishments by about 20 percent over two years (Haviland et al. forthcoming), and another finds inspections reducing injuries by about 50 percent over five years (Levine, Toffel, and Johnson 2012). With only about one in one hundred worksites inspected by OSHA each year, the abatement effect on worker safety using the 50 percent reduction is less than half a percent over all firms. Giving OSHA the benefit of the doubt, its inspection efforts in total have reduced worker injuries by a modest 4 percent. By way of comparison, Moore and Viscusi (1989) estimate that workers' compensation insurance has reduced workplace fatalities by 22 percent.

No estimates exist on the safety impacts of the market incentives created by compensating wage differentials for workplace risk or of the legal incentives created by the court system. Still, the financial incentives of the other three pillars of the US safety policy system dwarf the financial incentives created by OSHA. In 2010, initial proposed OSHA penalties for safety and health violations totaled less than $150 million. Employers' costs for providing workers' compensation insurance coverage totaled nearly $72 billion and compensating wage differentials for workplace risk totaled around $100 billion. Estimating legal liability for worker

accidents and illnesses in a given year is difficult but the amount is likely to be high, particularly for producers of products used by workers. Estimates place the eventual cost of asbestos litigation in the $200–$265 billion range (as reported in White 2004).

In passing the OSH Act, Congress believed American worker safety and health would improve through the creation of agency that would generate workplace safety and health standards, inspect employers for violations, and then fine them for noncompliance. Why has the approach not created the vast improvements in worker safety that proponents of the agency had predicted? Unfortunately, the regulatory approach can fail at each stage of the process. Worker safety and health will not improve if standards do not address the underlying causes of workplace injuries and diseases, if inspectors fail to uncover violations related to worker safety and health, or if the frequency of inspections and level of assessed fines are too low to get firms to comply with the standards. OSHA's record in all three areas is far from stellar.

Mendeloff (1984) directly examines the question of the effectiveness of OSHA standards in reducing workplace fatalities. He finds that only 13–19 percent of the 645 workplace fatalities reported to workers' compensation in California in 1976 resulted from violations of standards, and only half of these violations could have been detected before the accident. Another study finds little evidence linking firm compliance with mandated worker training in safety and health and tangible improvements in worker safety (Cohen and Colligan 1998). In a more indirect route, Bartel and Thomas (1985) examine industry data and find OSHA enforcement activities having a sizable impact on compliance with OSHA standards but compliance having only a small, and statistically fragile, impact on worker safety. They argue that their results support the view "that the Act itself is flawed because it emphasizes standards for capital equipment when most

accidents in fact are caused by complex epidemiological interactions of labor, equipment, and the workplace environment." (pp. 24-25)

Workplace accidents are rare events. Using the rates for 2010, a workplace fatality occurs less than once every 50 million work hours and a lost-workday injury occurs about once every 100,000 work hours. Standardizing across all hours of the day, a workplace fatality occurs once every 139 minutes and a workplace injury once every 6 seconds (National Safety Council 2012). Although these rates may seem high, by way of comparison, a motor vehicle death and a motor vehicle injury occur once every 15 minutes and once every 9 seconds, while an accidental death and an accidental injury in the home occur once every 8 minutes and once every 2 seconds (National Safety Council 2012). Based on the National Health Interview Survey, 52.6 percent of the recorded medically consulted injury and poisoning episodes in 2009 were inside or outside the home; only 3.1 percent of the episodes occurred in areas of industry, construction, or farming (National Safety Council 2012). Workplace fatalities and workplace injuries are generally a combination of unusual events. In a probability framework, they represent the simultaneous occurrence of multiple events, with each event residing in the tail of its respective probability distribution, making the likelihood of the joint event extremely rare. It is debatable whether a regulatory approach can effectively identify and control the largely random and momentary hazards that result in workplace fatalities and injuries.

Studies finding no impact of OSHA inspections on worker safety in the inspected establishments suggest that inspectors may not uncover the true causes of worker accidents. A study by Weil (2001) examines the relationship between the distribution of cited violations and the distributions of the causes of fatalities and nonfatal injuries within the construction industry from 1987 to 1993. Construction is one of the most hazardous industries for American workers

and one targeted by OSHA for expanded inspection efforts. He finds that OSHA violations were not closely related to the causes of either fatalities or nonfatal injuries. For instance, 4 percent of the violations cited during the time were for standards addressing accidents that are categorized as "struck by hazards" and yet 31 percent of the injuries and 9 percent of the fatalities were caused by "struck by hazards." The single largest category of citations by number was for falls, which accounted for 42 percent of all violations, and yet falls resulted in only about 19 percent of the nonfatal injuries and 28 percent of the fatalities. OSHA has no standards addressing overexertion injuries, but cumulative trauma and musculoskeletal injuries accounted for about 25 percent of the reported nonfatal injuries in construction. And, although 10 percent of all fatalities were from machine injuries, only 3 percent of all violations were for machine hazards.

Most experienced OSHA inspectors are well acquainted with the dangers that confront workers in construction and the safety and health standards that apply. They may be less familiar with the dangers facing workers in other less frequently inspected industries, and the relationship between compliance and worker safety and health may be even lower. Given the variety of different worksites and production technologies OSHA inspectors are asked to investigate, the lack of specific knowledge of the risks confronting workers in a given situation is certainly understandable. Even so, the lack of knowledge certainly reduces an inspector's effectiveness in uncovering potential dangers.

Proponents of the regulatory approach to improving worker safety argue that OSHA's enforcement budget and small statutory penalties for noncompliance limit its effectiveness. Armed with many more inspectors and the ability to issue large fines for violating safety and health standards, OSHA would become a potent weapon against employers who unnecessarily put their workers at risk.

Determining the likely impact of dramatically raising OSHA's enforcement powers is difficult. No empirical study finds a significant relationship between dollar penalties and worker safety, but some do find OSHA inspections reducing injuries, particularly ones citing employers for serious violations of safety and health standards. Simply magnifying this inspection effect upward to generate a prediction of the impact of a more powerful OSHA would be inappropriate. OSHA focuses its inspections toward more dangerous worksites and firms in more dangerous industries. As inspections expand into less dangerous situations the safety improvements uncovered during an inspection are likely to fall, reducing the net gain in safety. Working in the other direction, more frequent inspections may also deter firms from violating safety standards in the first place, an impact not captured by the abatement effect of an inspection.

One way to determine the likely impact of beefing up OSHA's enforcement powers is to examine the effectiveness of other agencies charged with protecting worker safety and health. Mine safety is regulated not by OSHA but instead by a separate government agency, the Mine Safety and Health Administration (MSHA). The law governing miner safety is more powerful than the OSH Act in that inspections are much more frequent and penalties for noncompliance with safety regulations more substantial. Still, despite purposely employing an econometric approach likely to overstate the efficacy of MSHA activities, Kniesner and Leeth (2004) find only small impacts on miner safety.

The Canadian regulatory system of worker protection has many of the attributes desired by the proponents of a regulatory approach to worker safety in the United States and offers another comparison to determine the likely impact of strengthening OSHA's enforcement powers. In Quebec province workers can refuse hazardous tasks, firms must establish joint labor-management workplace safety committees, and firms are required to initiate accident prevention

programs. The Commission de la Santé et de la Sécurité du Travail, Quebec's equivalent of OSHA, also spends over four times more per worker in prevention activities than OSHA. Even with more innovative safety measures and a much greater level of enforcement, the Quebec system of workplace regulation has been no more successful than OSHA in improving worker safety and health. Similar to the results in Viscusi (1986) for the United States, an expansion of the rate of safety inspections in Canada reduced the frequency of accidents in an industry by only a modest amount. Other safety-enhancing measures such as the percentage of firms adopting prevention programs or the number of interventions for refusal to work either had no impact on the frequency of accidents or appeared to cause them to rise (Lanoie 1992).

X. Is OSHA Cost Effective?

Although OSHA may have only reduced worker injuries and deaths by a small amount, the benefit of this small improvement may more than outweigh the compliance and enforcement costs of OSHA, resulting in a net gain in social welfare. Does OSHA, as currently designed, pass this cost/benefit test? As one might anticipate, evaluating the benefits of safety improvements from any program can be quite controversial. Some believe that life has infinite value and so the benefits of improving safety always exceed the costs. But people do not live as if their lives had infinite value. No one lives a risk-free life and everyone makes tradeoffs between safety and other things they like such as the lower expense of driving a small car, the joy of skiing, the time saved from jaywalking, or the pleasure of smoking.

Economists argue that the best way to evaluate the benefits of safety improvements is to use the monetary value that people place on small improvements in their own safety. According to the economic model of workplace safety discussed earlier, workers maximize their expected welfare by choosing the level of safety where the benefit of slightly greater safety just equals the

cost of slightly greater safety. The slope of the wage curve in figure 1 measures the drop in wage workers must sacrifice to get additional safety, and through the equality of benefits and costs it also equals the value workers place on a small reduction in the chance of a fatal workplace injury.

Suppose that based on an estimated wage equation, wages fall by $80 when the chance of a workplace fatality drops from 5 in 100,000 to 4 in 100,000, all else equal. If a typical person would pay $60 to reduce his or her chance of death by 1 in 100,000, then collectively 100,000 people would pay $6 million and, on average, one life would be saved. The saved life is not known beforehand, but in a sense is drawn randomly from the 100,000, so the $6 million represents the value of a statistical life. An implicit value of injury can be found in a similar manner by dividing an estimated wage change for a small reduction in the probability of a workplace nonfatal injury or illness by the change in the probability. The resulting calculation is known as the value of a statistical injury.

The value of a statistical life or the value of statistical injury does not represent the amount people would pay to avoid their own certain death or injury or society would pay to rescue individuals from certain death or injury. Instead, the values allow policymakers to determine the benefits of actions that reduce risk by small amounts.

Viscusi and Aldy (2003) review the empirical evidence and find across US labor market studies that estimates of the value of a statistical life range from $6.3 million to $15.2 million, with a median value of $8.9 million, and the estimates of the value of a statistical injury range from $25,000 to $89,000. (All values have been converted to 2010 dollars using the CPI). There were 4,690 fatalities and 933,200 lost-workday accidents and illnesses in 2010, so if OSHA improved safety on average by 4 percent, it prevented 38,883 lost-workday injuries and 195

fatalities (US Department of Labor, Bureau of Labor Statistics 2011a and 2011b). Using the median estimate for the value of a statistical life and the midpoint of the estimated range for the value of a statistical injury, the monetary benefit of OSHA is about $4 billion.

Only a few studies attempt to estimate the total yearly cost of all OSHA regulations on business. Using changes in input productivity and expenditures on OSHA mandated capital equipment, Hahn and Hird (1991) place the cost of OSHA's safety and health standards that existed in 1988 at $15.7 billion (2010 dollars). They argue that their estimate probably overstates OSHA's true cost because firms would have instituted some of the safety features in response to labor market pressures in the absence of OSHA. James (1998) examines the regulatory impact analyses commissioned by OSHA on twenty-five major rules, rules expected to generate compliance costs in excess of $100 million per year, issued from 1980 to 1993, to generate a yearly compliance estimate for all affected firms of $9.1 billion (2010 dollars). Using data from the National Association of Manufacturers on the compliance costs of regulations issued in the 1970s, James argues that it is reasonable to assume that total compliance costs are least 5.55 times higher per firm than the costs of the twenty-five rules he examines, for a total compliance cost of $50.5 billion. Using a similar methodology, Johnson (2001) estimates that the yearly compliance costs of the major rules issued by OSHA from 1980 to 2000 were $9.4 billion (2010 dollars) and the total cost of complying with all regulations was $51.9 billion. Crain and Crain (2010) update Johnson's work to incorporate the major rules issued by OSHA from 2001 to 2008. They find that the new rules added another $447 million in annual compliance costs to generate a total cost of complying with all OSHA regulations of $65.6 billion.

Eisenbrey and Shapiro (2011) take issue with the approach of estimating OSHA's total compliance costs by multiplying the yearly compliance costs of major regulations by a factor of

5.55, a number generated by an unpublished and now dated study by the National Association of Manufacturers. They further contend that the cost estimates from the regulatory impact analyses are themselves outdated. The cost figures reflect production practices and technologies that existed prior to the adoption of the standards. With the passage of time and the adoption of new work practices and technologies, the costs of complying with OSHA standards likely have fallen. For at least two of the more costly standards issued by OSHA, actual compliance costs were lower than the costs predicted in the regulatory impact analyses, consistent with the belief that costs fall over time.

If one ignores the 5.55 adjustment factor, the yearly cost of complying with the major standards issued by OSHA since 1980 based on the regulatory impact analyses is $9.9 billion. On top of the $9.9 billion one must also include the yearly federal expenditure on OSHA, which in 2010 was $560 million, for a total cost of $10.5 billion (US Department of Labor 2010). Based on the most optimistic empirical studies of OSHA's impact on worker safety, the monetary benefit of OSHA is $4.0 billion, meaning the agency fails the cost/benefit test for improving social welfare. For OSHA to pass the test, the regulatory impact analyses would have to have overestimated compliance costs on average by more than 250 percent, which seems unlikely. And the yearly cost figure of $10.5 billion excludes the cost of complying with pre-1980 regulations, all regulations expected to generate compliance costs under $100 million per year, and state expenditures on state-operated OSHA programs, which means the total compliance and enforcement cost of OSHA may far exceed $10.5 billion.

In the other direction, however, there is much about OSHA's impact on safety and health that we still do not know. Most empirical studies examining OSHA's effectiveness at reducing worker injuries have focused on the manufacturing sector. Our knowledge of the safety impacts

of OSHA outside of manufacturing is limited. The long latency period for many industrial diseases makes estimating the impact of regulatory efforts on reducing their incidence difficult. No empirical studies have examined the impact of OSHA's consultation programs or individual standards such as the Hazard Communication standard, the Process Safety Management standard, or the Respiratory Protection standard.

Given our gaps in knowledge of the overall impact of OSHA and its overall costs, a more fruitful way to evaluate OSHA's effectiveness may be to examine specific safety and health regulations to see if these regulations themselves individually pass a cost/benefit test. To maximize social welfare, OSHA should establish a new safety and health standard only if the standard generates more benefits in terms of injuries, illnesses, and deaths avoided than it imposes costs on firms, workers, and others.

Morrall (2003) examines the cost-effectiveness of seventy-six final regulatory actions aimed at improving safety and health that were imposed by the Federal government from 1967 to 2001, including twenty-five regulatory actions by OSHA. To be able to compare across the various regulations, he divides the total yearly compliance cost of the regulation by the expected number of lives saved per year to generate "the opportunity costs per statistical life saved" (OCSLS). An effective OSHA regulation would be one where the life-saving benefits of the regulation, as measured by workers' willingness to pay for reductions in mortality risk, exceed the opportunity costs per statistical life saved. The work of Viscusi and Aldy (2003) suggests that $8.9 million is a reasonable dollar figure to use to value a statistical life saved and so serves as a dividing line between cost-effective regulations and cost-ineffective regulations.

Table 2 reproduces Morrall's table 2 for the twenty-five OSHA regulatory actions with the dollar amounts adjusted to reflect the impact of inflation to 2010. Of the twenty-five

regulatory actions, thirteen have costs per statistical life saved below $8.9 million and are cost effective. Of the twelve regulatory actions failing the cost-effectiveness standard, the range of cost per life saved is enormous. The Grain Dust standard saves a statistical life at a cost of about $13.3 million, just moderately above the value of a statistical life as indicated by US labor market studies, while the Formaldehyde standard saves a statistical life at a cost exceeding $9.4 billion. The extremely large costs per life saved shown in table 2 suggest that at least some of OSHA's regulatory actions are misguided and enforcement resources could be better allocated in other directions.

The difficulty with table 2 is that it ignores any benefits from reducing the frequency or severity of nonfatal workplace accidents and diseases. Viscusi (1985a) considers both aspects in his investigation of OSHA's 1978 health standard limiting worker exposure to cotton dust. Based on Viscusi's estimates, with full compliance the standard would reduce over 9,000 cases of byssinosis per year, but most of the cases prevented would be quite minor, resulting in occasional chest tightness or breathing difficulties on the first day of the work week. The symptoms from these minor forms of byssinosis can be reversed by simply transferring the worker to a non-cotton-dust area. The standard would only prevent 1,210 illnesses resulting in partial disability and 487 illnesses resulting in total disability. By severity, the standard imposed costs on firms of $33,400 (2010 dollars) per year per case of the least serious forms of the illness, $1.26 million per year per case resulting in partial disability, and over $3.3 million per year per case resulting in total disability. With labor market studies suggesting that workers are only willing to forgo $25,000 to $89,000 to avoid the possibility of a serious accident, Viscusi concludes that "the costs seem somewhat disproportionate to the benefits." (p. 338)

In his analysis, Viscusi raises another very important issue: regulations should be designed to achieve the desired results at the least cost. OSHA's Cotton Dust Standard required firms to install engineering controls to limit worker exposure to cotton dust, monitor workers' health for signs of byssinosis, and mandate that their workers wear respirators in conditions of high cotton dust exposure. Similar reductions in the rate of byssinosis could have been achieved by requiring workers to wear cotton dust masks for a few hours a day in high-exposure situations and by rotating workers around the plant to limit their cumulative exposure to cotton dust, but at a much cheaper cost than the engineering controls chosen by OSHA.

On the positive side for OSHA, an early estimate placed the capital cost of fully complying with the Cotton Dust Standard at $599 million, consisting of $171 million for ventilation equipment and $428 million for new production equipment. Viscusi finds that firms would have purchased most of the new production equipment, even if the standard had not been imposed, to improve productivity. When these purchases are excluded, the capital costs of complying with the standard drops by more than half to $246 million. Nevertheless, even with these much lower capital costs, the total costs of complying with the Cotton Dust Standard far exceed "any value that can be reasonably placed upon its achievements" (Viscusi 1985a, p. 339).

XI. Recommendations

OSHA may fail an overall test of cost-effectiveness, but certainly the cost per statistical life saved estimates presented in table 2 suggest that at least some of its regulatory actions generate more benefits than costs. Much is still not known about OSHA's impacts, particularly in the area of health, and a fuller accounting of these benefits and more accurate estimates of costs might nudge the very rough cost/benefit numbers presented earlier in OSHA's favor. A more

thorough investigation of the regulatory actions in table 2 may also find more passing a cost-benefit test.

Given what is known, it seems unwise to recommend eliminating OSHA entirely or even reducing its scope dramatically. In the other direction, expanding OSHA's enforcement powers by raising the statutory maximum penalties for noncompliance or increasing the frequency of inspection also seems ill advised. Such actions are unlikely to improve worker safety greatly, given the effectiveness of MSHA and the Canadian system of worker protection, but they will raise compliance and enforcement costs and magnify business animosity.

OSHA does not operate in a vacuum. The labor market, state workers' compensation laws, and the legal system generate incentives for employers and equipment manufacturers to control workplace hazards. Given its existing budget, OSHA can best help improve worker safety and health by targeting its efforts in areas not well addressed by these other three pillars of the US safety policy system.

Expand Educational Outreach to Workers. In the labor market, worker desires for safety generate compensating wage differentials for risk. All else equal, the typical US worker in a job with a likelihood of injury at about the labor market averages earns 1–2 percent more than a person working in a totally safe job. The added compensation firms must pay to entice workers to accept employment in hazardous worksites gives them the incentive to expand efforts to improve safety. Because workers will not receive wage premiums for hazards they do not know exist, OSHA can help workers through educational efforts alerting them to possible dangers and through employer requirements to provide hazard warnings. The chemical labeling requirement first issued during the Reagan administration and amended during the Obama administration is a good example of OSHA's regulatory efforts reinforcing market incentives. Instead of

establishing direct regulatory controls on the myriad of chemicals used by workers throughout the United States, OSHA required that labels be placed on chemicals warning of possible dangers and providing information on safe handling.

Target Disadvantaged Groups. The 1–2 percent average compensating wage differential masks a considerable variation across industries and across demographic groups. Employer incentives to eliminate workplace hazards are already high when workers receive a significant wage premium for accepting those hazards. Compensating wage differentials appear to be smaller for disadvantaged groups such as non-English-speaking Mexican immigrants, making these groups prime candidates for expanded attention by OSHA.

Target Health Hazards and Small Firms. State workers' compensation laws require firms to compensate their workers for medical expenses and a portion of lost income from an occupational accident or disease. Firms, particularly large firms, can lower their costs of purchasing workers' compensation insurance by reducing the frequency and severity of claims for benefits, which creates an incentive for them to control workplace hazards. The long latency period and the possible non-work-related causes of many industrial diseases make it difficult to determine who is responsible for the payment of workers' compensation benefits, if anyone. Workers' compensation insurance provides workers some protection against the income loss from industrial accidents but very limited protection against the income loss from industrial diseases. Consequently, the incentive for firms to control industrial diseases in an effort to control the expense of purchasing workers' compensation insurance is far smaller than the incentive to control industrial accidents. Likewise, small firms who do not have their workers' compensation insurance premiums experience-rated do not see their premiums falling with fewer accidents, and, therefore, have a smaller financial motivation to improve worker safety than large

firms who do have their workers' compensation premiums experience-rated. To counter the failings of workers' compensation insurance, OSHA should direct its resources toward protecting workers in firms of all sizes from health hazards and workers in small firms from safety hazards.

Level Fund NIOSH. The public goods nature of basic research on occupational safety and health argues for strong government involvement to fund scientific studies into the causes and possible cures of workplace injuries and illnesses. NIOSH, which was also created by the OSH Act in 1970, is tasked with providing leadership in this area. The Obama administration has proposed reducing NIOSH's budget by about 14 percent to $249.4 million for FY2013 by eliminating funding for graduate programs and research training in occupational safety and health and for research into hazards affecting workers in agriculture, forestry, and fishing. Funding to NIOSH should not be cut. Resources should be redirected from other areas of the federal budget, including OSHA's enforcement budget, to NIOSH, which can use the funds to improve worker safety and health by researching the causes of industrial hazards and disease and by providing information and guidelines to firms and workers concerning threshold levels of exposure to dangerous substances and workplace practices.

Target Firms for Initial Inspection. In some situations a regulatory approach may be required to protect workers against possible harm. Workers face information overload and they cannot always monitor hard-to-observe hazards. In these situations, OSHA can best focus its limited enforcement budget where noncompliance is likely to be high. Many studies find that firm compliance with OSHA standards rises considerably after the first inspection and then quickly levels off, meaning OSHA can get more overall compliance by inspecting extensively rather than intensively. (Gray and Jones 1991a, 1991b; Weil 1996; Ko, Mendeloff, and Gray

2010). In other words, OSHA should inspect more worksites for the first time and inspect fewer worksites for the second and third times.

Level Fund Consultation Services. OSHA can also help improve worker safety by providing consultation services to firms, particularly small and medium-sized firms, wishing to identify and eliminate possible hazards in their workplaces. In 2011, the Obama administration shifted resources away from consultation services to compliance and reduced funding to the Voluntary Protection Programs. Because of the pricing of workers' compensation insurance, small firms have fewer financial incentives to eliminate hazards in their workplaces than large firms. They also lack the specialized staff devoted to safety and health issues that many large firms employ. Reducing consulting services to employers wanting to better control hazards seems inconsistent with OSHA's goal of assuring "safe and healthful working conditions for working men and women."

Reducing funding to voluntary programs also appears to be inconsistent with OSHA's recent initiative to require firms to establish strategic management systems to find and eliminate hazards in their workplaces. Injury and illness prevention programs have been found to be quite successful in some contexts in reducing injuries and illnesses and lowering workers' compensation expenses (Shannon et al. 1996; Bunn et al. 2001; Smitha et al 2001; Whiting and Bennett 2003). Some states already mandate that some or all of their employers establish such plans, and other states encourage their employers to establish such plans by discounting the price of workers' compensation insurance for those who do. From anecdotal evidence and some empirical studies, the key element for a successful injury and illness prevention program is strong engagement by both managers and workers. Whether or not a federal mandate can generate the necessary level of engagement is uncertain. Equally uncertain is the ability of

OSHA inspectors to evaluate such plans to ensure compliance, given the widely varying production processes they must inspect.

The Voluntary Protection Program accomplishes on a voluntary basis what the Injury and Illness Prevention Program Standard would require. For a firm to gain admission into the voluntary program, it must have a comprehensive safety and health management system with strong management and worker involvement, thorough worksite analysis, clear procedures for preventing and controlling hazards, and adequate safety and health training. Firms admitted into the program are exempted from programmed inspections. The voluntary program has grown considerably since its inception in 1982, particularly over the last decade, and OSHA's internal controls have not kept pace with the growth (US Government Accountability Office 2009). Firms with fatalities, serious injuries, and citations for serious violations of standards have remained in the program although program requirements specify their exclusion. OSHA acknowledges the difficulties, but instead of addressing them they have decided to move resources away from the program and into enforcement.

XII. Conclusions

OSHA is unlikely to ever be the powerful force proponents had hoped for when Congress passed the OSH Act more than forty years ago. Workplace fatalities and nonfatal injuries have fallen since 1970, but the downward trend in fatalities began in the 1930s and the drop in nonfatal injuries started in the 1990s, unrelated to any change in OSHA activities. The decline has been driven less by OSHA and more by changes in the industrial structure of the American workforce, technological improvements, and expanded financial incentives facing firms to eliminate hazards. The most important financial incentive for firms to improve workplace safety and health is implicit, operating through the matching of workers and workplaces. Firms with

poor or deteriorating records on safety and health will find it difficult to hire new workers or replace the many workers who leave. A firm with too little safety will discover that spending to make a safer and healthier workplace will lower wage costs. OSHA can complement this process by providing information to workers about possible hazards, particularly health-related hazards, and by gearing inspections toward worksites with hard-to-monitor dangers and firms employing less mobile and less knowledgeable workers.

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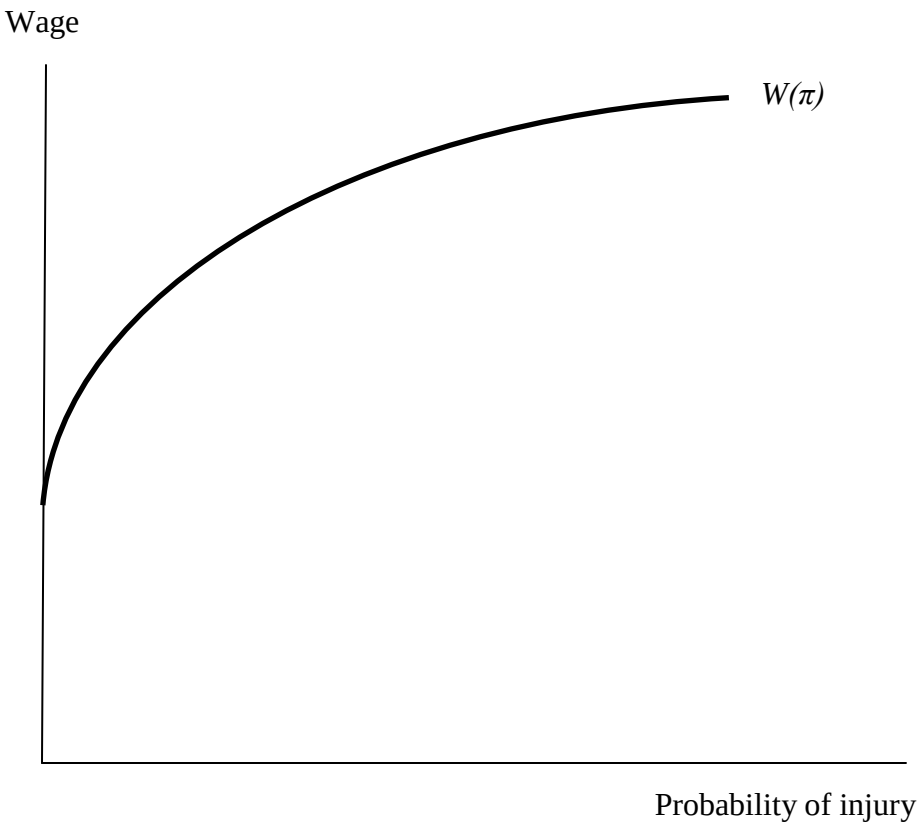

Figure 1. Labor Market Equilibrium

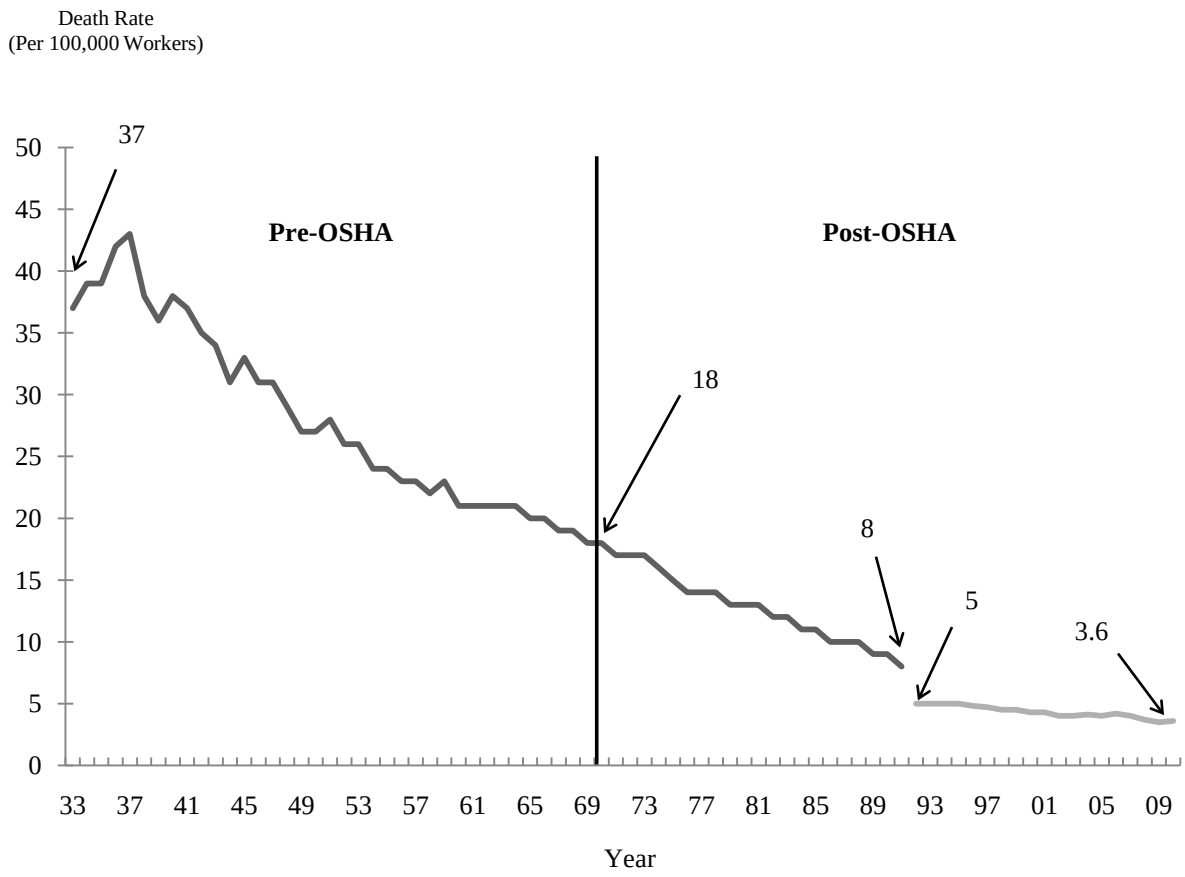

Figure 2. Workplace Fatalities, 1933-2010

Sources: National Safety Council (1994) and
U.S. Department of Labor, Bureau of Labor Statistics (2012)

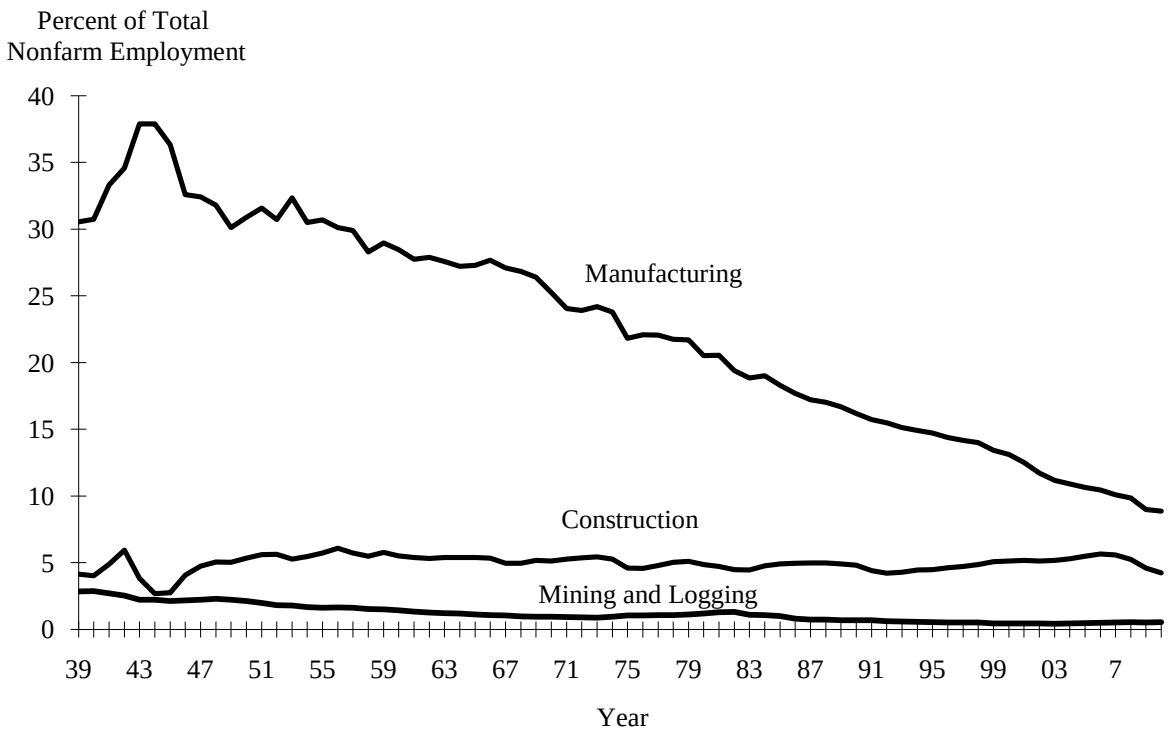

Figure 3. Industrial Composition of the US Labor Force, 1939-2010

Source: http://data.bls.gov/cgi-bin/surveymost?ce

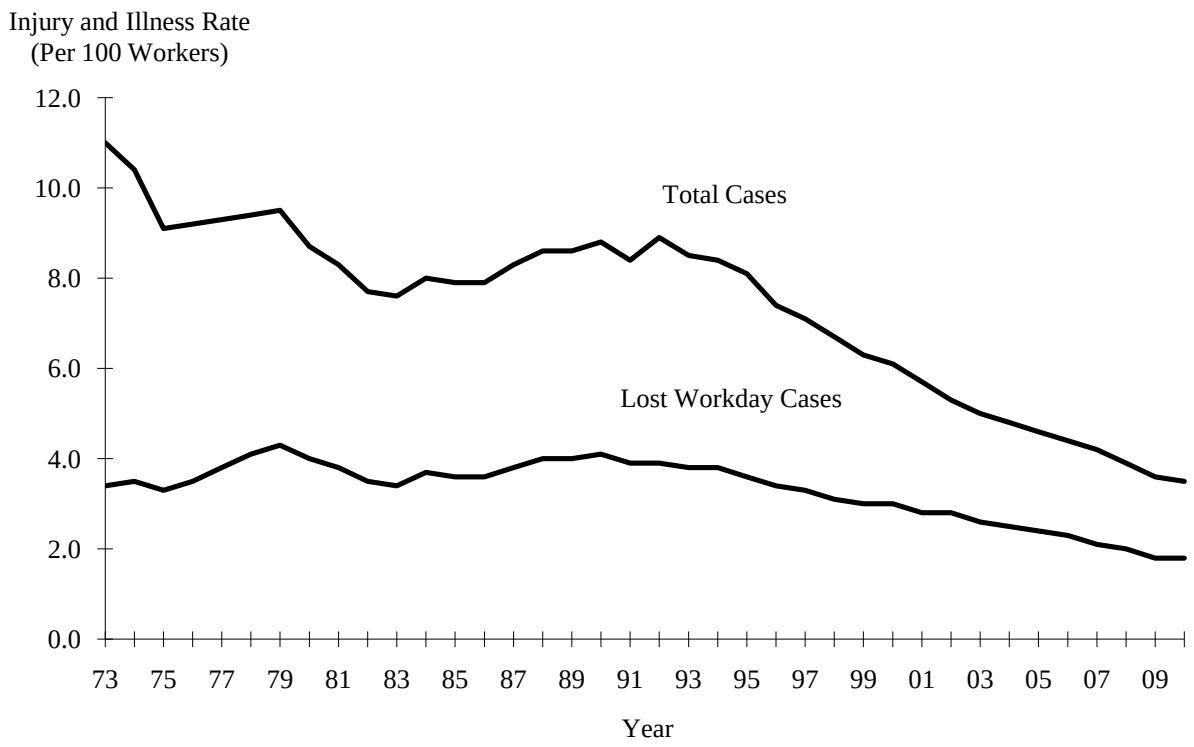

Figure 4. Workplace Injuries and Illnesses, 1973-2010

Source: http://www.bls.gov/iif/oshsum.htm

Table 1

Empirical Estimates of OSHA's Impact on Safety and Health

Study	*Time Period*	*Sample*	*Risk Measurement*	*OSHA Enforcement Measurement*	*Impact*
Mendeloff (1979)	1971–1975	US manufacturing, 1948–1975	Bureau of Labor Statistics (BLS) Lost-workday injury rate	A comparison of the actual year-to-year change in the injury rate and the predicted year-to-year change	No impact
		California manufacturing, 1948–1975	California Department of Industrial Relations Frequency of: (1) Caught in or between injuries (2) Struck by injuries (3) Strains (4) Falls and slips	A comparison of actual and predicted injury rates Predicted injury rates and injury rate changes are derived from regression estimates using pre-OSHA data	(1) 19%–27% decrease 1974–1975 (2) No impact (3) 8%–14% increase 1972–1975 (4) 31%–34% decrease 1974–1975
Butler (1994)	1970–1990	US employment, 1947–1990	National Safety Council Aggregate worker fatality rate	Passage of OSH Act (1 = post-OSH Act, 0 = pre-OSH Act)	No impact

Curington (1986)	1971–1976	Time series/cross section of 18 New York manufacturing industries, 1964–1976	New York Workmen's Compensation Board Frequency of workers' compensation claims and days of impairment for all injuries, caught in machine injuries, and struck by machine injuries	Passage of OSH Act (1 = post-OSH Act, 0 = pre-OSH Act)	Pooled sample: OSHA reduced struck by machine injuries 13.1%. By industry: OSHA decreased the severity of injury in 5 industries, the frequency of struck by machine injuries in 9 industries, and the severity of caught in machine injuries in 6 industries. It increased the frequency of injury in 5 industries, the severity of injury in 3 industries, and the frequency of caught in machine injuries in 1 industry.
Viscusi (1979)	1972–1975	Time series/cross section of 2-digit manufacturing industries	BLS Injuries and illnesses per full-time worker	Inspections per 100,000 workers in years t, t-1, t-2, and t-3 Proposed penalties per 1,000 workers in years t, t-1, t-2, and t-3	Individually and jointly insignificant Individually and jointly insignificant
Bartel and Thomas (1985)	1974–1978	Time series/cross section of 3-digit industries in 22 states	BLS Log of lost workdays per 100 workers	Inspections per worker	A doubling of inspections would increase compliance by 25.8% but lower injuries by only 2.5%. The impact of compliance on injuries is significant at only the 10% level, 1-tail test.
Smith (1979)	1972–1974	Cross section of plants	BLS Frequency of lost-workday injuries	Inspections (1 = inspected early in the year, 0 = inspected late in the year)	Plants inspected in 1973: Injuries fell 7% in 1973 and 11.6% in 1974 Plants inspected in 1974: No impact

McCaffrey (1983)	1976–1978	Cross section of plants	BLS Frequency of lost-workday injuries	Inspections (1 = inspected early in the year, 0 = inspected late in the year)	No impact 1976, 1977, and 1978
Cooke and Gautschi (1981)	1970–1976	Time series/cross section of Maine manufacturing plants	Maine Industrial Accident Commission Change in average days lost from injury	Citations per plant	Citations reduced average days lost by 23% in plants with 200 or more workers and 37% in plants with more than 300 workers. Citations had no impact on average days lost in plants with fewer than 200 workers.
Viscusi (1986)	1973–1983	Time series/cross section of 2- and 3-digit manufacturing industries	BLS (1) Frequency of injuries and illnesses (2) Frequency of lost-workday injuries and illnesses (3) Rate of lost workdays	Inspections per production worker in year t and t-1 Assessed penalties per production worker in year t and t-1	(1) no impact (combined) 2.6% reduction (year t-1) (2) 1.5% reduction (combined) 3.6% reduction (year t-1) (3) 4.7% reduction (combined) 6.1% reduction (year t-1) Insignificant across all three risk measures

Scholz and Gray (1990)	1979–1985	Time series/cross section of manufacturing plants	BLS (1) Percentage change in lost-workday injuries (2) Percentage change in lost workdays	Expected probability of an inspection with penalty in years t, t-1, and t-2 Expected penalty given an inspection with penalty in years t, t-1, and t-2 Inspection with penalty in years t, t-1,t-2, and, t-3	A 10% increase in inspections reduces lost-workday injuries by 1.61% and lost workdays by 0.88%. A 10% increase in average penalties reduces injuries by 0.93% and lost workdays by 0.50%.
Gray and Scholz (1993)	1979–1985	Time series/cross section of manufacturing plants	BLS (1) Percentage change in lost-workday injuries (2) Percentage change in lost workdays	Inspection with penalty in year t, t-1, t-2, or t-3	An inspection with penalty reduces injuries by 22% and lost workdays by 20% over four years.
Ruser and Smith (1991)	1979–1985	Time series/cross section of manufacturing plants	BLS Frequency of lost-workday injuries	Inspections (1 = inspected early in the year, 0 = inspected late in the year) Frequency of inspections per establishment by state, 2-digit industry, and 9 establishment size classes in year t and t-1	No impact No impact individually or jointly

Gray and Mendeloff (2005)	1979–1998	Time series/cross section of manufacturing plants	BLS Frequency of lost-workday injuries	Inspection in year t, t-1, t-2, or t-3 Inspection with penalty in year t, t-1, t-2 or t-3	1979–1985: 10.4% reduction 1987–1991: 4.4% reduction 1992–1998: No impact 1979–1985: 19.2% reduction 1987–1991: 11.6% reduction 1992–1998: No impact
Mendeloff and Gray (2005)	1992–1998	Time series/cross section of manufacturing plants with fewer than 250 workers	BLS (1) Injuries with days away from work related to OSHA standards (2) Injuries with days away from work unrelated to OSHA standards	Inspection with penalty in year t, t-1, t-2, or t-3	(1) 7.2% reduction (2) 11.2% reduction
Haviland et al. (2010)	1998–2005	Time series/cross section of single-establishment manufacturing firms in Pennsylvania with 20 to 250 workers	Pennsylvania Workers' Compensation (1) Log of number of injuries with days away from work related to OSHA standards (2) Log of number of injuries with days away from work unrelated to OSHA standards	Inspection with penalty in year t or t-1	(1) 8.2% reduction over 2 years (2) 14.4% reduction over 2 years

Haviland et al. (forthcoming)	1998–2005	Time series/cross section of single-establishment manufacturing firms in Pennsylvania with more than 10 workers	Pennsylvania Workers' Compensation Change in the log number of injuries with days away from work	Inspection with penalty in year t or t-1 Inspection with penalty in year t, t-1, t-2, t-3	19.3% cumulative reduction in injuries over 2 years for firms with 21–250 workers. No impact for firms with 11–20 workers or more than 250 workers. Firms with 21–250 workers: t no impact t-1 reduction t-2 no impact t-3 no impact
Levine, Toffel, and Johnson (2012)	1996–2006	Time series/cross section of 409 randomly selected inspected establishments with 409 eligible, but not inspected match-control establishments. All firms were single-establishment firms with 10 or more workers.	California Workers' Compensation Number of injuries	Inspection in year t, t-1, t-2, t-3, or t-4 Inspection in year t, t-1, t-2, t-3, t-4	9.4% annual reduction in injuries t reduction t-1 no impact t-2 no impact t-3 reduction t-4 reduction

Table 2

Opportunity Costs Per Statistical Life Saved (OCSLS)

Regulation	Year Issued	Type of Standard	OCSLS (millions of 2010 $)
Respiratory Protection	1998	Health	0.12
Logging Operations	1994	Safety	0.12
Electrical Safety	1990	Safety	0.12
Safety Standards for Scaffolds	1996	Safety	0.24
Electrical Power Generation	1994	Safety	0.48
Underground Construction	1983	Safety	0.61
Servicing Wheel Rims	1984	Safety	1.09
Crane Suspended Personnel Platform	1984	Safety	1.82
Trenching and Excavation	1989	Safety	2.55
Concrete & Masonry Construction	1985	Safety	2.91
Confined Spaces	1993	Safety	3.03
Hazard Communication	1983	Safety	3.76
Asbestos	1972	Health	6.67
Grain Dust	1988	Safety	13.33
Methylene Chloride	1997	Health	15.76
Benzene	1987	Health	26.67
Acrylonitrile	1978	Health	37.57
4.4 methylenedianiline	1992	Health	43.64
Coke Ovens	1976	Health	61.82
Asbestos	1986	Health	80.00
Asbestos/Construction	1994		86.06
Arsenic	1978	Health	93.33
Ethylene Oxide	1984	Health	96.97
Lockout/Tagout	1989	Safety	118.79
Formaldehyde	1987	Health	94,543.46

Source: Morrall (2003)