THE CONTROL OF INDUSTRIAL ACCIDENTS: ECONOMIC THEORY AND EMPIRICAL EVIDENCE

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INTRODUCTION

The passage of the Occupational Safety and Health Act of 1970 represents the latest extension of a form of government regulation that began in the United States almost a century ago. Government standards concerning the physical environment of the workplace were first promulgated in America by Massachusetts, which required in 1877 that "[t]he belting, shafting, gearing and drums of all manufacturing establishments, when so located as to be, in the opinion of the inspectors hereinafter mentioned, dangerous to employees while engaged in their ordinary duties, shall be, as far as practicable, securely guarded."[1] This standard covered less than 350,000 employees. Today, under federal legislation, 62 million American workers are covered by safety rules which govern virtually every aspect of the workplace—from asbestos particles to toilet partitions.

Compared to other significant government programs, safety legislation has historically been uncontroversial. Early legislation was adopted in an era when most forms of government intervention in business and labor affairs were regarded as unconstitutional. A similar accommodating attitude has prevailed in more recent times. The debate prior to the 1970 federal Act focused on the administrative details of the proposed legislation rather than on the wisdom of a large federal safety effort. The typically noncritical nature of the debate is surely due to the moralistic nature of the safety issue. Even to question the basic premises of regulation via safety standards is often associated with an insensitivity toward workers' safety. It is just such an examination, however, which is necessary in order to understand the regulation of safety and to evaluate particular statutes such as the Occupational Safety and Health Act of 1970. It is the purpose of this paper to examine both the theoretical and empirical premises of alternative methods available for industrial accident control.[2]

The first section analyzes safety as an economic commodity, while the second reviews the alternative mechanisms for controlling behavior in a simple smoothly functioning frictionless society. The likely complications of the actual world are then considered, as is some empirical evidence on the control

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[1] Ch. 214, § 1, [1877] Mass. Acts & Resolves 599 [now MASS. GEN. LAWS ch. 149, § 127 (1932)].

[2] Throughout this essay accidents are defined as a unit of danger rather than a specific unexpected event.

of accidents. A final section examines the implications of both the theoretical analysis and empirical evidence for the Occupational Safety and Health Act of 1970 and for recently proposed changes in the workmen's compensation system.

I

SAFETY AS AN ECONOMIC COMMODITY

For all the moral anguish associated with accidents, it must be remembered that safety is an economic commodity. It can be enhanced only by the consumption of scarce resources which if not allocated to safety could serve other beneficial purposes.[3] In most instances, the resources necessary for safety have an obvious economic character. For example, machine guards, protective headgear, and safety directors all represent resources which could be devoted to other beneficial purposes if not used to increase safety. Less obvious, but not necessarily less significant, is the personal behavior resource of acting with care and caution. Individuals act as though they derive satisfaction from being less than perfectly careful. Certainly the individual who consciously does not buckle his seat belt is exchanging an increased risk of injury for the act of being careless. Therefore, to increase safety by avoiding careless behavior infringes on the likewise desirable goal of a carefree work attitude.[4] Without measures of how much satisfaction people derive from being careless it is inappropriate to label this behavior as irrational; it is rational behavior if the satisfaction of such an attitude is greater than its costs.

Since safety can only be produced by the use of scarce resources, the absence of safety, as manifested in accidents, can itself be considered as equivalent to an economic resource. As with other economic resources, a willingness to risk accidents may yield certain benefits such as the ability to undertake activities which produce wages for workers, profits for firms, and products for consumers. However, these benefits can be generated only with associated costs. The costs of accidents include costs to the worker such as anxiety over potential accidents, pain and suffering, lost wages, medical care, and rehabilitation. Other accident costs include delay and disruption of work processes, the training of replacements, and damage to capital and raw materials. Because the activity of work yields exposure to accidents, which in turn yields both costs and benefits, it becomes desirable to weigh these benefits and costs to determine the optimal quantity of accidents to be generated.

If all the costs and benefits of accidents accrued to the same decision-maker, determination of the optimal quantity would be relatively straight-

[3] For a discussion of safety as an economic commodity, see *Symposium—Safety*, 33 LAW & CONTEMP. PROB. 427 (1968); see especially Spengler, *The Economics of Safety*, *id.* at 619.

[4] It may not be carelessness per se from which people derive satisfaction. For example, in the case of seat belts it may be the utility of not wrinkling clothes or saving time which motivates some individuals. If an individual is not aware of the riskiness of an activity, additional information may cause him to consume less carelessness and more safety.

forward. A well-informed decision-maker would participate in an activity to the extent that the expected benefits at least equal the expected costs. However, the costs and benefits of an activity such as work frequently accrue to different decision-makers; for example, products go to customers while injuries go to workers. It is necessary, therefore, for society to devise mechanisms by which the balancing of these costs and benefits can be achieved. The goal of such mechanisms should be to encourage interaction so that decision-makers gaining rewards from an activity can compensate potential bearers of the costs, thereby inducing them to participate. In terms of industrial safety this goal is manifested in the desire to ensure that workers are exposed to accident risks only to the extent that the benefits of these risks are at least as great as the costs. The optimal amount of accident risk exposure is achieved when the difference between the total of accident benefits and costs to all parties is at a maximum.

II

THE AVAILABLE ALTERNATIVES

Society has several systems available to it for organizing and controlling human behavior so as to encourage mutually beneficial interaction. Decentralized control through strictly private markets and centralized control through government fiat are the extreme alternatives. Examples of intermediate systems which combine private markets and governmental actions include an *ex ante* (prior) government incentive structure such as price regulation and *ex post* (retrospective) government scrutiny of market activity as in tort actions.

Each of these alternatives is available for use in industrial safety. Use of strictly private markets in which employers have no legal responsibility for employee accident costs would yield a system of wage payments to workers which reflects the costs of accidents. The use of government fiat would involve rules about the specific safety characteristics of the work environment. An *ex ante* incentive structure would be manifested in a system in which government sets a price for each injury and the market is allowed to function within that constraint—a system comparable to workmen's compensation. *Ex post* scrutiny of private actions via the tort mechanism would be a system of review with assignments of liability for negligence based on established standards of performance.

Although these mechanisms are not mutually exclusive, an understanding of their operation is facilitated by considering each as though it were the only system in effect. Each system will initially be considered as it would work in a simple frictionless world with no costs of bargaining and enforcing contracts, full information about alternatives, and completely transferable rights and liabilities. In addition, both workers and firms are assumed to be neutral toward risk; that is, they are indifferent between obtaining one dollar or a 50 per cent chance for two dollars. After this delineation, likely sources of friction and the implications of nonneutral attitudes toward risk will be considered.

A. Private Markets

If the control of industrial injuries were left only to private markets, with no remedy for employer negligence, competitive labor markets with informed workers would yield higher wages to workers in hazardous jobs. The magnitude of the extra wage payment would be equal to the value which workers placed on the hazards associated with any job. Under such a system of employee liability, two jobs, differing only in safety hazards, would be compensated at wage rates varying only by the value placed on that difference. If the wage rates differed by more than the value placed on safety risks, workers would shift to the higher paying job until the rates were equalized. Similarly, if the rates differed by less than the value placed on safety risks, workers would shift away from the more hazardous job.[5]

Under such a private market system, an employer has a choice of how to deal with the risks faced by his employees. He can allow the risks to continue unabated and pay his employees the hazardous work premium to endure them, or he can reduce the risks and pay his employees a commensurately lower wage premium. The risks can, of course, be reduced only by an expenditure of resources. In seeking to maximize profits, the employer will choose that combination of hazardous work payments and accident prevention expenditures which optimizes his labor costs. The optimal combination of wage premiums and risk reduction expenditures will be determined by their relative prices. The rational employer will expend resources on accident prevention as long as the expected marginal cost of those expenditures is less than the expected marginal return. The returns would be a decrease in some of the employer's direct accident costs such as damaged machinery as well as a decrease in the wage premium. This result can be considered economically efficient to society since, on the average, injuries will be prevented whenever the expected costs of bearing the injury are greater than or equal to the expected costs of prevention.

B. *Ex Ante* Structured Incentive

In an *ex ante* incentive system, the employer has absolute liability for all costs of employee accidents and the market will no longer yield a hazardous work premium because the workers' injury costs, including discomfort due to the risk of accidents, are now zero. An injured worker will be reimbursed for all of his costs in the form of post-injury compensation. In seeking to optimize his net cost of labor, including the cost of accident prevention, the employer will spend resources on any prevention measure that returns more than it costs. As under a system of employee liability, the employer will continue these expenditures until the expected marginal return equals the expected marginal cost.

If the assumption is made that the employer can bargain without cost for prevention of accidents which the employees can most efficiently prevent,

[5] The existence of wage differentials based on risk was noted by Adam Smith in 1776. *See* A. SMITH, THE WEALTH OF NATIONS 100 (Modern Library ed. 1937).

the result does not depend on the relative efficiency of either party in preventing accidents. For example, assume a given type of accident can be prevented either with an investment in machinery or with a less costly investment in careful behavior by the workers. Because of the lower costs, it would be efficient for the workers to prevent this type of accident. This efficient result will occur independently of which party has liability, providing there are no negotiating costs. If the workers are liable for accident costs, they will prevent this type of accident. If the firm is liable, it will induce the employees to prevent this type of accident by paying them some part of the difference between the cost of machinery and the careful behavior. Similarly, if the firm is most efficient at a particular aspect of prevention or benefit provision, the firm will provide the service. As an example, assume that protective headgear is useful for accident prevention and that it is less expensive when purchased through the firm. The firm would provide this equipment even under a system of employee liability because this is the least costly method of avoiding certain accident costs.

With either employee or employer liability for accident costs, resources will be spent on accident prevention until the expected costs of prevention equal the expected benefit. The costs and returns to prevention are quantitatively the same in each case. The only difference is that the benefits will be manifested in different forms. Under employee liability, the manifestation will be a reduction in the wage premium, while under employer liability the manifestation will be a reduction in post-injury costs. Since the pattern of employee and employer prevention is the same, the allocation of resources is identical under either arrangement.

An arrangement under which the employer must provide post-injury payments to workers which are less than 100 per cent of the employee's accident costs can be viewed as a combination of the above absolute systems. The benefits of prevention would be manifested as a combination of reduction in hazardous work premiums and reduction in post-injury costs as the market would generate wage premiums reflecting the employee's accident costs not guaranteed by the firm. In total, the benefits and costs of accidents remain the same since the components are simply varying forms of the same underlying values.

The distribution of income is also invariant with respect to each form of liability. The worker receives the costs of the risks he is bearing in the form of either regular wage premiums, after injury compensation, or a combination thereof. The firm's outlays are also the same, with only the form of payment varying.

C. The Tort Mechanism

Although the visible mechanics of tort actions take place after a particular act, the potential liabilities implicit in such a system may constitute a device for controlling behavior. Such potential incentives take the form of legal precedents which provide a set of rules by which parties must conduct themselves if they are to avoid liability for damages. With such an established body of common law, the probability of either an employee or an employer being liable for accident costs is *ex ante* determinable, although not necessarily with a high degree of reliability. The expected proportion of employee or employer negligence then becomes the mechanism by which each party determines his liability. If either party is considered negligent when he fails to engage in prevention activities where the expected cost of that prevention is less than the expected benefits, these legal rules will be economically efficient. As noted by Posner, the negligence standard formulated by Judge Learned Hand fits this standard of efficiency.[6]

To the extent an employee does not expect his full accident costs to be covered by the employer, he will require a wage premium to equalize his remuneration with other opportunities. The rules for determining negligence are the forces which yield the expectations of each party. If those rules are changed such that the probability of liability changes for each party, the wage premium will adjust to reflect this change. For example, assume that under a tort system with a fellow-servant exemption for employer liability,[7] an employee perceives the arrangement as a 50 per cent chance of receiving all accident costs. If the fellow-servant rule is voided, thereby increasing the probability of employer liability, the burden of accidents to the employee is decreased, thereby yielding a reduction in the wage premium.

The added costs of correct determination may appear burdensome in that legal fees are usually a significant percentage of the total award.[8] The benefits of legal proceedings, however, may greatly outweigh their costs. This could occur if the incentives created by such a system were more accurate and distinct than those present under alternative systems. Furthermore, under a system with relatively stable common law rules, these fees need be incurred

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[6] Posner, *A Theory of Negligence*, 1 J. LEGAL STUDIES 29, 32 (1972). The negligence standard formulated by Judge Learned Hand is a derivation from two separate opinions. In the first, Conway v. O'Brien, 111 F.2d 611, 612 (2d Cir. 1940), Judge Hand wrote: "The degree of care demanded of a person . . . is the resultant of three factors: the likelihood that his conduct will injure others, taken with the seriousness of the injury if it happens, and balanced against the interest which he must sacrifice to avoid the risk." Judge Hand supplemented his original formulation in his opinion for the court in United States v. Carroll Towing Co., 159 F.2d 169, 173 (2d Cir. 1947), when he suggested that:

> the owner's duty, as in other similar situations, to provide against resulting injuries is a function of three variables: (1) the probability that she [a barge] will break away; (2) the gravity of the resulting injury, if she does; (3) the burden of adequate precautions. Possibly it serves to bring this notion into relief to state it in algebraic terms: if the probability be called P; the injury, L; and the burden, B; liability depends upon whether B is less than L multiplied by P: i.e., whether $B < PL$.

[7] The fellow-servant rule is that an employer is not liable for employee injuries which are caused by fellow employees.

[8] The presence of a seemingly burdensome cost is not necessarily a reliable measure of the efficiency of a system. Benham, *The Effect of Advertising on the Price of Eyeglasses*, 15 J. LAW & ECON. 337 (1972), examined the price of comparable eyeglasses in states which prohibited advertising and in states which allowed advertising. Even though advertising was found to be a substantial percentage of price in the states which allowed advertising, the total price of eyeglasses was significantly lower in advertising states. Benham ascribes this phenomenon to the fact that advertising provides information which, in turn, yields a more competitive and efficient market. Analogously, the presence of significant court costs does not necessarily mean that a tort system is inefficient. Like advertising, the benefits of legal proceedings may greatly outweigh their costs and be a necessary part of an efficient system.

only when there are conflicting views as to the applicability of the rules of negligence.[9]

D. Government Fiat

For the purpose of safety control, government fiat involves the use of standards for the physical environment of the workplace. If such standards are individually tailored to the efficient methods of preventing accidents in each workplace and if the government's goal is to promulgate rules which return more in benefits than they cost, such intervention will yield the same result as the other control arrangements.

The expected value of the distribution of income under a perfect fiat or tort system would be the same as under the strictly private market or *ex ante* government structuring of incentives. In each case the employer bears the burdens of both prevention costs and employee accident costs. Similarly, the employee receives the expected value of his accident costs under each system. The only difference is that employee accident costs are manifested in forms which are dependent on the control system.

E. The Effect of Attitudes Toward Risk

If either party is not neutral toward risk, there may be a preference for certain forms of employee accident cost reimbursement. For example, if workers are averse to risk, they may prefer a guaranteed payment of $100 in post-injury compensation to the 50 per cent chance of a $200 tort judgment. Similarly, the firm may prefer to pay a regular wage premium rather than risk the chance of a very large court settlement. Even with these possible preferences for particular forms of compensation, the alternative institutional arrangements will be neutral, if the rights established by each arrangement are transferable. Under a tort system, if some workers preferred a guarantee of post-injury compensation to the chance of a larger court settlement, the firm could reduce its accident costs by providing the guaranteed payments. The firm would agree to do this in exchange for a disclaimer of court redress by the employee. The firm is in a preferred position because its accident costs are reduced, while the worker is better off because he now has the guaranteed payments which he desired. In this manner the exchange of rights and obligations has resulted in a situation which both parties consider more desirable than the initial arrangement. Therefore, even if the initial institutional arrangement is not optimal, the parties have both the incentives and the ability to change the situation to reflect their underlying preferences.

III

SOURCES OF FRICTION: TRANSACTIONS COSTS

The above analysis demonstrates that in a world of perfectly functioning institutions, the nature of a control arrangement is irrelevant to the alloca-

[9] Gould, *The Economics of Legal Conflicts*, 2 J. LEGAL ISSUES 279, 285-88 (1973).

tion of resources. This result, known as the Coase theorem, has generated substantial literature in the past decade on its usefulness in the analysis of public policy issues.[10] Most analysts consider this theorem on the neutrality of alternative liability arrangements valid in a simple frictionless world, but demur to its applicability in a more realistic situation. It is generally recognized that the frictions of actual situations may make the allocation of resources dependent on the form of the control mechanism.[11] These frictions are usually subsumed under the rubric of transactions costs—costs in a system which are required for its functioning but which are not necessarily desirable for their own sake.[12]

A. Information

One transactions cost of establishing a market in industrial accidents so that wage differentials provide control is the gathering of knowledge about the probability and costs of accidents at alternative jobs. If wage differentials are to develop which reflect degrees of risk, information about the riskiness of alternative jobs must be available. It is often claimed that employees consistently underestimate the probability and costs of accidents and that, consequently, they do not receive the hazardous pay premium implied by the frictionless theory of zero transactions costs.[13] For this argument to be accurate, all workers hired must underestimate the riskiness of the job. It is the marginal employee who determines the risk premium necessary to attract the equilibrium number of workers, just as in a competitive environment with no risks the last worker hired determines the wage.

The competitive process of wage determination does not, of course, guarantee that the equilibrium wage rate will be such that the last man hired will have the correct perception of the job's riskiness. It does demonstrate, however, that the presence of some workers who underestimate risk does not doom the market adjustment process to this inaccuracy. It must also be remembered that the wage determination process is not limited to the initial hiring stage, and the probability of a worker underestimating the riskiness of a job should decline substantially after he has worked at the job.

If it is correct that private markets do not optimally control accidents

[10] The basic theorem was introduced by Coase, *The Problem of Social Cost,* 3 J. LAW & ECON. 1 (1960). Two important collections of papers dealing with the Coase theorem are: *Symposium—Products Liability: Economic Analysis and the Law,* 38 U. CHI. L. REV. 1 (1970), and *Coase Theorem Symposium* (pts. 1-2), 13-14 NATURAL RESOURCES J. 557, 1 (1973-1974).

[11] In one of the few empirical tests of the Coase theorem, Thomas Crocker found that liability arrangements did influence the allocation of resources. His study analyzed changes in property values that resulted from industrial pollution. Crocker, *Externalities, Property Rights, and Transaction Costs: An Empirical Study,* 14 J. LAW & ECON. 451 (1971).

[12] George Stigler has noted, "[t]ransactions do not have a natural definition.... [T]he contrast between a transaction cost and a nontransaction cost is an empirical rather than a purely formal classification." Manne (ed.), *Edited Transcript of AALS-AEA Conference on Products Liability,* 38 U. CHI. L. REV. 117, 128-29 (1970).

[13] J.R. HICKS, THE THEORY OF WAGES 110-11 (2d ed. 1963), describes lack of knowledge about risks as one reason market determination of the quantity of safety is not likely to be optimal. A study of natural disasters also suggests that individuals underestimate risks. H. KUNREUTHER, RECOVERY FROM NATURAL DISASTERS 27 (American Enterprise Institute for Public Policy Research Evaluative Studies No. 12, 1973).

because of inadequate information about risk, the government might require disclosure of each firm's injury record.[14] Alternatively, liability for employees' accident costs could be placed on the firm. The latter system, rather than increasing labor market information, would reduce the need for information since the difference in effective risk among firms would be eliminated. Unfortunately, this alternative is not without its own associated transactions costs since eliminating the costs of accidents to employees may reduce their incentive to avoid accidents.

B. Bargaining

Bargaining among parties[15] to achieve an efficient situation involves transactions costs such as searching for the least costly preventer, trading obligations, and enforcing contracts. If one party is the least costly preventer of most accidents, assignment of liability to this party would minimize these costs and thereby achieve the best available situation. For example, if there are significant economies of scale in accident prevention, then the employer is likely to be the least costly preventer of most accidents. On the other hand, if employee carelessness is a major factor in producing accidents, the assignment of liability to the employer is likely to generate more accidents than under other arrangements.[16]

Under either employer or employee liability, there is a danger of insurance protection reducing incentives for self-protective behavior. If employees use the hazardous work premiums to save against future losses, the equilibrium amount of carelessness would not appear to be influenced because the full cost of carelessness would be borne by the employee. However, if employees are risk averse and choose market insurance, a potential inducement to carelessness, known as moral hazard[17] could develop. This occurs because each insured individual may not incur the full costs of careless behavior. The costs of this induced carelessness would be reflected in the insurance loading factor. This induced carelessness would be reduced or eliminated to the extent that insurability or premium levels can be made a function of careless behavior.

If employers are more careless under employer liability, it would be reflected in the firm's riskiness and, in turn, the wage premium. Therefore, because the firm bears the full costs of its careless behavior, there would be no induced incentive to be careless. As noted above, under employer liability,

[14] Prior to the enactment of workmen's compensation, the employer had a common law duty to provide the employee with information about certain risks. This duty was limited to a "warning of dangers of which the employee might reasonably be expected to remain in ignorance." W. PROSSER, HANDBOOK OF THE LAW OF TORTS 526 (4th ed. 1971).

[15] These negotiating costs are not limited to the employee-employer relationship. Since safe behavior by one employee has implications for other employees' safety, bargaining may occur among employees.

[16] This could happen for two reasons. First, the employer is essentially providing insurance for accident costs, thereby reducing the employees' reward for avoiding accidents. Second, the employer is unable to obtain efficient employee carefulness because of the associated transactions costs.

[17] For a discussion of insurance and moral hazards, see Ehrlich & Becker, *Market Insurance, Self-Insurance, and Self-Protection*, 80 J. POL. ECON. 623 (1972).

the employee is essentially forced to buy insurance against accident costs, thereby creating a potential moral hazard. A firm which is self-insured would have no related incentive to be careless. However, a firm which insures its liability through market insurance would be subject to a moral hazard to the extent its careless behavior is not taken into account in the premium.[18]

Carelessness could best be prevented by a system of tort liability under which carelessness is the basis for a finding of negligence. Transactions costs might be large, however, if the law requires a determination as to negligence in each case. As previously noted, a formal legal proceeding is not usually required for each case under a stable common law system. Whatever the legal costs, however, their amount is not an accurate measure of efficiency. It is the net value of all costs and benefits rather than the value of one particular cost which must be considered.[19] Even when substantial costs are needed to determine fault, tort liability is sometimes viewed as the system likely to be most efficient. For example, in a situation where the costs of making ancillary bargains with the efficient preventer are high, the economies associated with elimination of the need for such bargains may minimize total costs. If the common law standards for determining fault are based on the relative efficiencies of each party in the various phases of prevention, the need for ancillary bargains would be reduced. Where both parties cause an accident, a system of comparative negligence may be most efficient.[20] The causes of industrial accidents, however, are extremely difficult to determine. Analysts are unable even to make consistent assignments of cause based on the broad categories of environmental and behavioral causes.[21] There is not even a consensus as to the appropriate framework for analysis of causes.

C. Transferable Rights

Barriers against the transfer of rights and liabilities are another cause of friction which may be detrimental to the accident optimization process. For example, an employer under a tort system may find that his costs which include legal fees, are much higher than they would be under a system where he guaranteed all accident costs for his employees. Accident costs themselves may be higher under a tort system because of the uncertain outcomes which such a system implies. Because his employees may not like such additional risks, they may be willing to exchange their rights to a risky court hearing with a potentially large payoff for a guaranteed smaller amount of accident compensation. Thus, the parties may be able to ex-

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[18] The presence of a moral hazard cost does not imply that insurance is undesirable any more than legal costs make the tort system undesirable. *See generally* Demsetz, *Information and Efficiency: Another Viewpoint,* 12 J. LAW & ECON. 1 (1969).

[19] Benham, *supra* note 8.

[20] Comparative negligence is a system in which damages are formulated based on the degree of fault of each party. *See generally* Posner, *supra* note 6, at 44-46. Posner concluded that the rules of negligence create incentives for efficiency both in the mix of prevention activities and the number of accidents.

[21] NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, COMPENDIUM ON WORKMEN'S COMPENSATION 287-88 (1973).

change rights and obligations to their mutual benefit, yet such transfers are often prohibited. For example, individuals are not allowed to exchange their workmen's compensation benefits for a tort recovery; and pre-injury exculpatory clauses are frequently not legally enforceable.

D. Bureaucratic Goals

One final friction which likely affects the mechanisms of accident control is bureaucratic goals. In describing the workings of an ideal system of control by fiat, it was assumed that the goal of the bureaucracy is to require safety prevention efforts up to the point where the returns to prevention equal the costs of prevention. Since these costs and returns are likely to vary with each firm it is unlikely that rules which are the same for all firms will be optimal for each firm. In addition, it is unlikely that government workers enforcing the fiat enforcement mechanism will be familiar with the least-cost method of achieving a goal in a specific firm.

IV

SOME EMPIRICAL EVIDENCE ON THE CONTROL OF SAFETY

Although the quantity of accidents may be influenced by institutional arrangements when transactions costs are taken into account, there is no theoretical basis for concluding whether a specific set of transactions costs is significant enough to influence a particular control system's outcome. Therefore, if one is to understand the impact of various control mechanisms, empirical analysis is necessary. The hypothesis to be empirically tested here is that variations in the mechanisms used to control safety have no impact on the allocation of resources to safety. This hypothesis is based on the assumption that transactions costs and other deviations from the frictionless Coasian model are negligible.

The alternative mechanisms examined are workmen's compensation, government safety standards, and private markets.[22] Workmen's compensation is a form of liability whereby the employer is liable, without consideration of negligence, for a portion of each employee's job-related accident costs. Each state government determines the portion of these costs for which the employer is liable. It is clearly a form of *ex ante* structuring of incentives. Government safety standards are, on the other hand, rules concerning the physical environment of the workplace—a form of government fiat. Prior to the Occupational Safety and Health Act of 1970, these rules were determined by each state government.

If private markets control accidents, a wage premium will develop which is positively associated with the degree of risk in each firm. That is, after correcting for all of the other factors that influence wages, the level of wages will be higher in those situations where risks are greater.

[22] No empirical test of the tort system's influence on safety is possible within the scope of this analysis, since workmen's compensation has supplanted the tort system in all but a few industries. The Federal Employers' Liability Act, which covers railroad workers engaged in inter-

A. General Description of the Empirical Model[23]

To test the impact of each alternative, it is necessary to develop a model which relates variations in these factors to the level of safety. Because all three systems may be simultaneously influencing the level of safety, it is also necessary to use a statistical technique which isolates the influence of each mechanism. The level of safety will be measured in negative time unit equivalents, specifically the number of injuries per million man-hours of exposure.[24] Variations in the injury rate represent variations in the level of safety. If workmen's compensation, safety standards, and wages influence the level of safety, their impact will be manifested in the injury rate. The injury data used are for the year 1967 from 2,627 manufacturing establishments (each with more than 100 employees) in 13 states.[25]

State variations in workmen's compensation reflect variations in the portion of employee's accident costs for which the employer is liable. An actuarial procedure is used to calculate these differences in the magnitude of the employers' liability. The procedure evaluates the benefits associated with a standardized set of industrial injuries. Since benefits depend on the state statutes governing workmen's compensation and in most cases on the wage level, the benefits were evaluated for the laws in effect in 1967 at several wage levels.

Prior to the enactment of the Occupational Safety and Health Act of 1970, each state also had its own system of safety standards. It is this variation in state systems that will be used to gain insight into the effectiveness of this method of control. Although there are substantial differences between the OSHA system of safety standards now in effect and the state systems used prior to 1970, they are differences of degree rather than kind. Therefore, an understanding of the influence of the state systems can provide insight into the likely influence of the new system. Four dimensions of each state's system are considered: the extensiveness of the standards, the strictness of the standards, the amount of resources devoted to enforcement, and the extent to which inspectors are used.[26]

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state commerce, and the Jones Act, which covers seamen, mandate a tort system based on a comparative negligence standard. W. PROSSER, *supra* note 14, at 435-36.

[23] A detailed description is found in the Appendix to this article.

[24] Three versions of the injury rate are used. They are the frequency rate, which is the number of disabling injuries per million man-hours of exposure; the severity rate, which is the number of days lost per million man-hours; and the serious injury frequency rate, which is the number of disabling injuries which require four or more lost work days per million man-hours. Although the severity rates most closely correspond to the economic loss of an injury, many analysts consider frequency rates better measures of the controllable aspect of injuries. For example, frequency rates are more heavily weighted than severity rates in the determination of workmen's compensation insurance premiums.

[25] Specific information about all data, calculation procedures, and statistical methods is contained in the Appendix.

[26] Extensiveness and strictness are measured by considering the standards used to control three major areas of safety concern. These areas are woodworking machinery, mechanical power-transmission apparatus, and abrasive wheels. Although only a subset of the total number of potential areas for standards, it is felt that they represent the character of the state's standards. For these three areas of safety concern, the American National Standards Institute (ANSI), a non-profit organization, recommended 301 specific standards as necessary for

If the private market exerts an influence over the level of safety, it will be manifested in an extra wage payment to workers which reflects the level of risk. Greater degrees of risk as manifested in higher injury rates will yield an extra wage payment to workers. Unfortunately, this payment cannot be directly measured; therefore, the overall level of wages must be used to measure the impact of the market on safety. This requires that wage levels be corrected for other influences which they reflect. These influences include unions, discrimination, and regional differences in the cost of living.

In addition, many factors which are embodied in the wage level can also be expected to influence the accident rate. For example, higher levels of education imply a higher wage level. However, higher levels of education may also enhance the worker's ability to prevent accidents and, therefore lead to a lower accident rate. Moreover, higher wage levels reflect a greater cost of lost work time from injury. Therefore, independent of any other factors, we would expect more effort to avoid injuries to higher wage workers because of the higher cost of lost work time. If the wage payment for risk is to be isolated, it is necessary for the empirical model to adjust the wage level for those factors which are extraneous to the relationship between wage and injury rates.

Just as there are several factors which simultaneously influence wages and injury rates, there are other factors which simultaneously influence other elements in the system. Whether safety standards influence injury rates is one of the key relationships to be tested. Before the extent of this influence can be observed, it is necessary to adjust for any influence which injury rates may have on safety standards. Finally, injury rates must be corrected for other extraneous influences, such as the age of the labor force and the unemployment rate.

The result of these complex interlocking factors is a system of simultaneous relationships that is schematically represented by Figure 1. The arrows represent the direction of hypothesized causality. An arrow pointing in both directions is a relationship where the factors are hypothesized to be simultaneously influencing each other. For purposes of determining the effect of safety standards, workmen's compensation, and private markets on the injury rate, the other factors serve only to isolate the primary factors

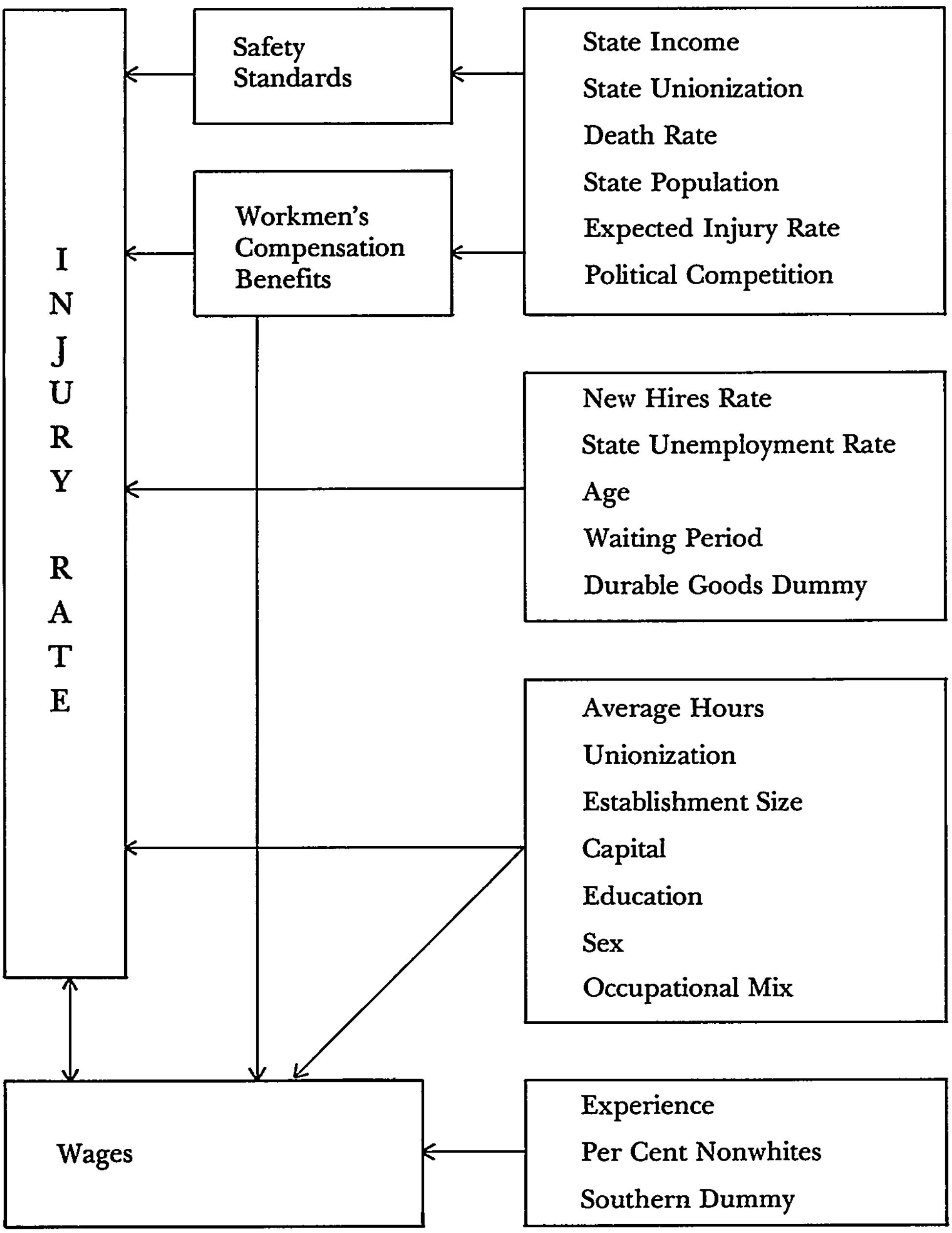
complete control. As a measure of extensiveness, the number of specific standards used by each state to control the three types of machinery were counted. It is assumed that a greater number of standards represents a more extensive set of standards. As a measure of strictness, each of the state standards were graded as either (1) the same or similar to the ANSI recommendation; (2) more restrictive than the recommendation; or (3) less restrictive than the recommendation. An overall index of strictness is developed by giving a state no points for each less restrictive standard, one point for each equal standard, and two points for each more restrictive standard. The total of strictness points is then averaged over all standards.

The amount of resources devoted to enforcing these standards is measured by each state's industrial safety budget per nonagricultural member of the labor force. The safety inspectors dimension is formulated as the number of inspectors per nonagricultural establishment. An overall index of each state's safety standards system was constructed by combining each of the four dimensions into one variable. The index was devised by calculating the first principle component of the variables representing each of the four dimensions. This principle component is then used to weight the standardized values of the four separate variables.

under consideration. The resultant system of simultaneous equations was estimated using the specified data base as indicated in the Appendix.

FIGURE 1

DIAGRAM OF THE RELATIONSHIPS



B. Results of the Study

The results indicate that for most sample establishments the state safety standards systems in effect in 1967 had no impact on injury rates. Estimates based on a subsample of the largest 10 per cent of establishments in which the data were weighted so as to equalize the number of observations in each state indicate that the standards reduced the injury rate.[27] The limitation of the impact of standards to larger establishments is intuitively plausible in that these large establishments are more visible and hence probably subject to closer scrutiny by the regulatory agencies. Increases in the proportion of employee accident costs covered by the firm had the effect of increasing injury rates. There is no evidence that higher levels of risk are reflected in the wages paid to workers.[28]

The findings that there are no observable extra wages resulting from increased injury risks and that higher workmen's compensation benefits are associated with higher rates of injury are inconsistent with the implications of the theoretical framework based on zero transactions costs. At least three circumstances could account for the result that higher workmen's compensation benefits are associated with higher injury rates.[29] First, the uncertain money flow associated with a given accident risk may be less distasteful to the employer than to the employee. This difference in taste for risk would result in the same accident risk being perceived as a lower cost by the employer than by the employee. As more of the accident risk liability is placed on the employer, the cost avoidance reward for reducing accidents is thereby decreased. Second, if insurance rates for equal risks are less for employers than employees, a transfer of liability to employers could yield more injuries. This would occur because the cost of insuring a particular risk is now less and, therefore, the benefits of avoiding it are now less. If differences in accident costs resulting from different risk valuation or different insurance rates are to influence injury rates, it is necessary that the established rights not be legally transferable or that the costs of transference be substantial. If this were not the case, the parties would privately adapt to these differences so as to neutralize any inefficiences in the established rights. Third, the results could also be explained by the presence of substantial costs of contracting with employees for an efficient amount of careful behavior. As the costs of accidents to employees decrease with increased benefits, the employees' incentive to avoid accidents would be decreased. Unless the firm can make arrangements with employees for careful behavior, higher benefits would induce less careful behavior and, hence, greater injuries.

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[27] The largest 10 per cent subsample included establishments with 779 or more employees.

[28] Another study has found evidence that higher risks are associated with wage premiums. *See* R. Thaler & S. Rosen, The Value of Saving a Life: Evidence From the Labor Market (paper presented at the National Bureau of Economic Research Conference, Washington, D.C., Nov. 30, 1973).

[29] None was verified by the empirical study for in testing a theory it is important to specify its implications prior to the empirical test so as to insure that the theory is truly tested, rather than matched to the data. Such an *ex post* matching of theory and data cannot be said to constitute a valid test.

V

IMPLICATIONS FOR PUBLIC POLICY

The results of this analysis raise doubts as to the efficiency and effectiveness of the systems controlling industrial safety in 1967. Although certainly not conclusive enough to serve as the basis for radical change, it is important to consider the implications of these results for the formulation of public policy.

The finding that higher workmen's compensation benefit levels are associated with higher injury rates is not conclusive evidence that higher benefits are undesirable. If higher benefits reduce the real cost of injuries by eliminating a portion of the disutility from the uncertain income stream associated with injuries, then the resultant increase in injuries is not dysfunctional. Alternatively, if the increase in injuries is due to increased incentives for employees to engage in careless work practices, then higher benefit levels are not desirable. Unfortunately, it is impossible within the scope of this study to distinguish between such potential causes for the observed positive association between benefits levels and injury rates. It is also possible that higher benefits encourage workers to report more injuries with no change in real injury rates, but the injury rate data collection system, which is independent of the workmen's compensation claim system, makes this unlikely.

In view of this evidence, it is necessary to be quite tentative in making prescriptions for public policy. If one is willing to assume that the observed increase in accidents is undesirable, however, then the appropriate public policy is to decrease rather than increase the level of workmen's compensation benefits. Such a policy could, however, lead to problems in the attainment of other social goals such as income maintenance. Determination of the nature of the injuries which increase in response to higher benefits would help in the formulation of public policy toward workmen's compensation. For example, if minor injuries were found to be the cause of increased accidents, it might then be appropriate to lower benefits for minor accidents while maintaining or increasing benefits for more serious accidents.

The evidence on private markets is also subject to alternative interpretations. The observed lack of market control over accidents could be optimal if the costs of market operation are higher than the gains from controlling accidents. On the other hand, lack of control would be inefficient if it could not be justified as due to the costs of operating a market. The lack of wage premiums for risk indicates that some transactions costs are likely to be interfering with the attainment of market control over accidents. One such transactions cost, often cited as significant, is information about risk. A seemingly low cost remedial device for such a problem would be the collection and dissemination of information about the injury rates in each establishment. Such a program was mandated by the Occupational Safety and Health Act of 1970 and is now in progress.

The evidence on controls is also difficult to interpret because even if they are effective in reducing accidents, there is no guarantee that such efficacy is desirable. For example, it would not be efficient to spend more money controlling accidents than the cost of accidents prevented by such controls. The empirical analysis tested the more limited question of the effectiveness of controls rather than their economic efficiency. The general lack of a negative relationship between the level of controls and injury rates indicates that standards were generally not effective in reducing injuries.

Based on this evidence, it is difficult to predict the impact of the 1970 federal legislation which initiates an elaborate control system using safety standards. However, if the operation of past safety standard systems is a valid indicator of the operation of current and future controls, the outlook for regulatory effectiveness is not bright.[30] The finding that the standards influenced the injury rates in the largest establishments, however, may indicate that the more rigorous OSHA system will extend this impact to smaller establishments.

The National Commission on State Workmen's Compensation Laws has recently recommended increases in the portion of employee accident costs to be covered by employers.[31] As with the new safety standard system introduced by the Occupational Safety and Health Act of 1970, it is difficult to predict the impact of these recommended changes because the proposals are outside the range of the estimates made from the 1967 observations. However, it would seem unlikely that the relationship between bene-

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[30] The OSHA standards are roughly equivalent to the ANSI recommendations used as a basis for calculating the extensiveness and strictness dimensions of the state systems. The mean number of standards used by each state to regulate the three sample areas of concern was 116 (range = 0 to 279). The OSHA standards are approximately equivalent to the full 301 recommended standards. Whereas the mean index of strictness for the sampled states was .54 (range = 0 to .94), the OSHA standards are approximately equivalent to 1. No data appear to be available on the number of OSHA inspectors. The budget per nonagricultural employee is probably the most descriptive basis for comparing the state standard systems and OSHA. After adjusting for changes in the labor force and inflation, the proposed fiscal year 1974 expenditure for combined federal and state industrial safety standard regulation is $1.15 per nonagricultural employee. THE BUDGET OF THE UNITED STATES GOVERNMENT, FISCAL YEAR 1974—APPENDIX 386-87, 644-45 (1973). The amount per nonagricultural employee was derived as follows:

Occupational Safety and Health Administration	$ 69,836,000
State Expenditures	30,080,000
National Institute for Occupational Safety and Health	25,600,000
Total safety expenditure	$125,516,000

The total safety expenditure was converted to 1967 dollars:

$$\text{(1967-June 1973): } \frac{\$125{,}516{,}000}{132.4} = \$94{,}800{,}604.$$

The 1967 equivalent expenditures was adjusted to reflect the amount per nonagricultural employee (July 1973):

$$\frac{\$94{,}800{,}604}{82{,}201{,}000} = \$1.15 \text{ per nonagricultural employee.}$$

Hence, the legislation is close to, but outside, the range of prediction allowed by the existing data.

[31] NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, THE REPORT OF THE NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS (1972).

fits and accidents would significantly change at the recommended levels. It is, therefore, probable that further increases in workmen's compensation will result in increased injuries.

CONCLUSION

For all the difficulties and uncertainties associated with empirical analysis, it is the only method which can provide a basis for determining the appropriate system of industrial accident control. We are at a point in our understanding of industrial safety where further anecdotes and even theoretical development are of limited value. What is needed is empirical work to test existing theoretical frameworks. Useful work would include investigations of the nongovernmental determinants of injuries, such as workers' perceptions of risk, market reactions to variations in risk, and the impact of tort systems on behavior. In addition, it would be valuable to have time-series analyses of the effects of government programs and of different methods of administering them (including the influence of inspectors, penalties, and educational programs). Only by such analyses can we hope to develop programs which are based on more than just good intentions.

Appendix

The purpose of this Appendix is to provide a more specific and detailed description of the empirical model used to test the impact of the alternative control devices. As noted previously, many factors other than the control mechanisms and injury rates had to be considered in order to isolate the relationships which are of primary concern. Additionally, the simultaneous influence of the injury rate on the control mechanisms had to be accounted for in order to observe the impact of the control mechanisms on the injury rate. The system of market and governmental forces which are related to the injury rate is represented by four relationships. The estimation of these relationships is based on a simultaneous equation system with four endogenous variables. The first relationship in the system is a model of injury determinants including governmental and nongovernmental factors. The second relationship is a model of total wage determination; a model of *total* wage determination is necessary because the risk premium component of wages is not directly observable. The third and fourth relationships are the determinants of the nature and extent of safety standards and workmen's compensation benefit levels. The system was estimated using two-stage least squares. The four relationships are summarized below with the relevant hypothesis and the sources of the data listed with each variable.

(1) The determinants of the injury rate:

$$\text{INJRATE} = \alpha_{1.0} + \alpha_{1.1}\,(\text{NEWHIRES}) + \alpha_{1.2}\,(\text{UNE}) + \alpha_{1.3}\,(\text{HOURS}) + \alpha_{1.4}\,(\text{AGE}) + \alpha_{1.5}\,(\text{UNION}) + \alpha_{1.6}\,(\text{SIZE}) + \alpha_{1.7}\,(\text{CAPITAL}) + \alpha_{1.8}\,(\text{EDUC}) + \alpha_{1.9}\,(\text{SEX}) + \alpha_{1.10}\,(\text{OCC}) + \alpha_{1.11}\,(\text{WAIT}) + \alpha_{1.12}\,(\text{WAGE}) + \alpha_{1.13}\,(\text{STANDARDS}) + \alpha_{1.14}\,(\text{WC}) + \mu_1.$$

Where:

INJRATE = the number of disabling injuries per million man-hours of exposure. Alternatively, the number of days lost and the number of injuries of more than three days duration, both per million man-hours, were also used. These alternative measures were used to insure that any observed phenomena were not limited to a particular measure of the injury rate. The injury rate is assumed to measure the level of safety in the firm. The source of the data was from the Work Injury Survey conducted by the Bureau of Labor Statistics.[32] The sample was based on yearly averages and included 2,627 firms from 13 states in 1967.[33]

NEWHIRES = "[t]emporary or permanent additions to the employment roll of persons who have never before been employed in the establishment (except employees transferring from another establishment of the same company) or of former employees not recalled by the employer."[34] The new hires rate is defined as the number of such additions per 100 employees. Although not documented by existing studies, it would appear likely that new workers would be involved in a disproportionate share of accidents thus resulting in a positive coefficient. This could result from the new worker's unfamiliarity with work equipment and procedures. The data are from *Employment and Earnings*[35] at the United States 3-digit Standard Industrial Classification (SIC)[36] level of detail for 1967.

UNE = the unemployment rate. This variable is intended as a measure of the impact of the business cycle on the injury rate. During an upswing, the price of foregone output will increase and, therefore, the cost of devoting inputs to prevention rather than output will increase. For the same reason, however, the cost of an injury in terms of interrupted production will increase. Also, to the extent the hours of work variable does not completely reflect the pace of work, it is expected that an increase in unemployment will lower the effectiveness of prevention measures by making workers susceptible to injuries. Finally, the lower unemployment rates associated with an upswing make it more difficult to replace an injured worker, therefore tending to increase the price of injuries. This combination of conflicting attributes leads to uncertain expectations about the net impact of the unemployment rate on injury rates. The state's unemployment rates at any one point in time reflect long run differences in their labor markets as well as stages of the business cycle. Therefore, the variable was formulated as the 1967 state unemployment rate relative to the state's average unemployment for the previous 5 years. The data are from the *Manpower Report of the President*.[37]

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[32] See U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1458, HANDBOOK OF METHODS FOR SURVEYS AND STUDIES 197-207 (1966), for a description of the Work Injury Survey.

[33] Unpublished files, U.S. Bureau of Labor Statistics, Dep't of Labor.

[34] U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1312-8, EMPLOYMENT AND EARNINGS: UNITED STATES, 1909-71, at 671 (1972).

[35] *Id.* at 36.

[36] *See* EXECUTIVE OFFICE OF THE PRESIDENT, OFFICE OF MANAGEMENT AND BUDGET, STANDARD INDUSTRIAL CLASSIFICATION MANUAL, 1967 (1967). This manual has since been superseded by the 1972 edition.

[37] U.S. DEP'T OF LABOR, MANPOWER REPORT OF THE PRESIDENT 232 (1972).

HOURS = average hours worked per week. This variable is intended as a proxy for the influences of work pace and fatigue. Hence, increases in hours are expected to be associated with increases in injury rates. Average hours of overtime and average hours of overtime squared were used as alternative measures of this influence. The data are from *Employment and Earnings*[38] and are for the United States at the 3-digit SIC level of detail.

AGE = the average age of the industry's work force. Researchers have found a higher rate of injuries for younger workers. The relationship between age and injury rate is complicated by the possibility that older workers, rather than being less susceptible to injuries, merely avoid jobs where there is a high risk of injuries. The observed result would be the same in either case—younger workers would be associated with higher injury rates. The age variable was derived from the files of the Social Security Administration's Continuous Work History Sample.[39] The data represent the average age for each 2-digit SIC industry in each state.[40] Because of the smallness of some of the sample cells, an average of 1967 and 1968 was used.

UNION = the percentage of workers in establishments where more than half of the production workers are covered by collective bargaining agreements. It is hypothesized that the presence of unions results in greater safety. The potential impact of unions on safety could be due to factors such as more vocal employee representation with management, formalized grievance procedures, labor-management safety committees, or direct union efforts with equipment manufacturers. Information generated by a union could also serve to eliminate the possibility of a wage rate based on an underestimation of risk. The data used for this variable were obtained from an unpublished appendix to Weiss' article *Concentration and Labor Earnings.*[41] The data were estimated for each 3-digit SIC industry in 1965.

SIZE = the number of employees in the establishment. This variable is intended to reflect economies of scale in accident prevention. Such economies might include factors such as efficiencies in safety training, the ability to hire full-time safety personnel, the use of production techniques which are amenable to accident preventions, and stability in the time pattern of accidents which in turn allows insurance companies to offer premiums which are more sensitive to individual establishment experience. The data are for each firm in the sample.[42] It is hypothesized that larger firms have fewer accidents.

CAPITAL = the gross book value of depreciable assets per employee. This variable is intended to measure the influence of exposure to capital

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[38] U.S. BUREAU OF LABOR STATISTICS, *supra* note 34, at 35.

[39] This is a one per cent sample of those workers with Social Security numbers. Sampling procedures are described in U.S. DEP'T OF HEALTH, EDUCATION, AND WELFARE, WORKERS UNDER SOCIAL SECURITY, 1960: ANNUAL AND WORK HISTORY STATISTICS (1968).

[40] Unpublished files, Office of Research and Statistics, Social Security Administration, U.S. Dep't of Health, Education, and Welfare.

[41] Weiss, *Concentration and Labor Earnings*, 56 AM. ECON. REV. 96 (1966). The unpublished appendix may be obtained from Professor Weiss, Economics Department, University of Wisconsin, Madison, Wisconsin.

[42] Unpublished files, U.S. Bureau of Labor Statistics, Dep't of Labor.

equipment as a source of injuries. The data for 1967 are from the 1968 *Annual Survey of Manufactures*[43] at the United States 4-digit SIC level of detail. Greater exposure to capital is hypothesized to result in more injuries.

EDUC = the level of formal education of the work force. This variable may indicate the development of skills which enhance the worker's ability to avoid accidents thus resulting in a negative coefficient. The available data closest to the injury data are from the 1960 *Census of Population*.[44] The data are classified by Census code categories which were translated into their 3-digit SIC code equivalents.

SEX = the percentage of women in the industry's work force. This variable is a measure of the extent to which women or men are more susceptible to injuries. The data are for 2-digit SIC industries in each state. The percentages were derived from the Social Security Administration's Continuous Work History Sample.[45]

OCC = occupational mix as measured by the percentage of production employees. To the extent workers are engaged in more hazardous occupations, we would expect them to sustain injuries disproportionate to the rest of the labor force. Although no data on the presence of hazardous occupations is available, a rough proxy may be the percentage of production workers. The data are from *Employment and Earnings*[46] and reflect a 3-digit SIC level of detail for the United States as a whole.

WAIT = the waiting period, the number of lost work days required before an injury is compensable under workmen's compensation.[47] This variable is intended to test whether a short waiting period encourages the reporting of injuries which would otherwise not be reported. It is hypothesized that the coefficient on this variable will be negative.

WAGE = the endogenous wage level. The relationship between wage levels and accidents has many facets—some of which may create opposing incentives. Factors manifested in the wage rate may influence the quantity of accidents while, in turn, the quantity of accidents determines the risk premium component of the wage rate. It is this simultaneous relationship which gives rise to the need for the multiequation model used to estimate the relationships. The aspect of the relationship which predicts that the quantity of accidents will determine a risk premium will be considered in the following section on the determinants of wages.

The wage rate represents the opportunity cost of time and since injuries cause a loss of work time, a higher wage implies a higher cost of lost time. As the potential loss from an accident increases, we would expect workers to devote more of their own effort to the prevention of that loss. We would

[43] U.S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, ANNUAL SURVEY OF MANUFACTURES, 1968-1969 (1973).

[44] U.S. DEP'T OF COMMERCE, UNITED STATES CENSUS OF POPULATION, 1960: INDUSTRIAL CHARACTERISTICS 98 (Bureau of the Census Rep. No. PC(2)-7F, 1967).

[45] Unpublished files, Office of Research and Statistics, Social Security Administration, U.S. Dep't of Health, Education, and Welfare.

[46] U.S. BUREAU OF LABOR STATISTICS, *supra* note 34, at 33-34.

[47] CHAMBER OF COMMERCE OF THE UNITED STATES, ANALYSIS OF WORKMEN'S COMPENSATION LAWS (1967).

also expect them to demand more prevention effort from the firm. As more effort is devoted to prevention, the quantity of accidents should decline. It is also plausible that the ability to avoid accidents is positively correlated with earnings ability and, therefore, wages. Such a correlation would reinforce the negative association between wages and accidents. The wage data were obtained from the records of workers covered by state unemployment compensation. The data are for the 4-digit SIC level of detail for each state from the first quarter of 1967.[48]

STANDARDS = an endogenous variable representing a composite index of the nature and extent of government regulation using safety standards. As discussed in the body of the paper, this variable is based on the first principle component of four dimensions of each state's system. These dimensions are extensiveness, strictness, budget per nonagricultural employee, and inspectors per nonagricultural establishment. The standards data are from the Bureau of Labor Standards' *State Safety Code Comparison Studies*[49] and cover the standards in effect during 1966 and 1967. The budget and inspectors data were obtained from the Labor Standards Bureau, Division of Programming and Research.[50] The index, although thought to be an accurate measure of the standards system, is essentially arbitrary and therefore a more straightforward measure was also tried. As a simple alternative to the relatively complex index, the safety budget per nonagricultural employee was used. This attribute was considered to be the single most descriptive aspect of the controls system. The safety budget was alternatively used as an exogeneous and endogenous variable.

WC = an endogenous variable representing the level of benefits required by each state's workmen's compensation law. Variations in the level of benefits represent variations in the portion of employee accident costs for which the employer is liable. Each state's benefits were measured with an actuarial technique originally used to determine the impact of statutes on workmen's compensation insurance premiums. The statutes in effect on January 1, 1967 were used as the basis for the evaluation. Within each state, the laws were evaluated at each 2-digit SIC wage level to reflect the fact that many benefits are functionally related to wages. In order to allow for the possibility that nonstatutory factors such as generosity in interpretation, the average actual benefits per case (1967-68) were used as an alternative measure. These data were obtained from the American Insurance Association.[51]

μ_1 = error term.

(2) The determinants of wages:

$$\text{WAGES} = \alpha_{2.0} + \alpha_{2.1}\,(\text{UNION}) + \alpha_{2.2}\,(\text{SIZE}) + \alpha_{2.3}\,(\text{CAPITAL}) + \alpha_{2.4}\,(\text{EXPER}) + \alpha_{2.5}\,(\text{SEX}) + \alpha_{2.6}\,(\text{OCC}) + \alpha_{2.7}\,(\text{NW's}) + \alpha_{2.8}\,(\text{EDUC}) + \alpha_{2.9}\,(\text{AREA}) + \alpha_{2.10}\,(\text{HOURS}) + \alpha_{2.11}\,(\text{INJRATE}) + \alpha_{2.12}\,(\text{WC}) + \mu_2.$$

48 Unpublished files, U.S. Manpower Administration, Dep't of Labor.

49 U.S. BUREAU OF LABOR STANDARDS, DEP'T OF LABOR, STATE SAFETY CODE COMPARISON STUDIES (1966).

50 Unpublished files, Division of Programming and Research, U.S. Bureau of Labor Standards, Dep't of Labor.

51 Unpublished files, American Insurance Association, New York, New York.

Where:

WAGES = average weekly wages as defined above under determinants of injury rates.[52]

UNION = the percentage of employees in establishments where more than 50 per cent of production employees are covered by a collective bargaining agreement. The data are defined above.[53] This variable is based on the notion that unions have typically been found to increase wages.

SIZE = the number of employees in the establishment. The data are defined above.[54] It has been hypothesized that the number of employees in an establishment is positively related to wages.[55] A greater number of employees is said to require more interdependence among employees and, therefore, greater responsibility. More dependable employees, in turn, require higher wages.

CAPITAL = the gross book value of depreciable assets per employee. The data are defined above.[56] The ratio of capital to labor is important to the wage determination process in that a larger amount of capital per worker may require more dependable as well as more skilled workers.

EXPER = average years of work experience. Experience represents a human capital investment in workers. The extent to which a worker embodies this capital, his productivity, and hence, his wage, will increase. The data were obtained from Arthur J. Alexander, Economics Department, Rand Corporation.[57] The variable is derived from a 10 per cent sample of the 1 per cent file of Social Security system members in 1966. The data are at the 4-digit SIC level of detail for the United States. Due to sample limitations, only ten possible years of experience are considered. These are, however, the best available estimates of work experience.

SEX = the percentage of women in the work force. The data are described above.[58] This variable is designed to increase the impact of wage discrimination against women, hence, a negative coefficient is anticipated.

OCC = the percentage of production employees in the work force. The data are defined above.[59] This variable is a proxy for the occupational mix. To the extent an industry has more production workers, the industry's wage level should be lower.

NW's = the percentage of nonwhites in the industry's work force. This variable is designed to measure the impact of wage discrimination against nonwhites. The coefficient is, therefore, expected to be negative. The data are from the 1970 Census and are approximately equivalent to a 3-digit SIC level of detail.[60]

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[52] Unpublished files, U.S. Manpower Administration, Dep't of Labor.

[53] Weiss, *supra* note 41.

[54] Unpublished files, U.S. Bureau of Labor Statistics, Dep't of Labor.

[55] Masters, *An Interindustry Analysis of Wages and Plant Size,* 51 REV. ECON. & STAT. 341 (1969).

[56] U.S. BUREAU OF THE CENSUS, *supra* note 43.

[57] Unpublished files, Rand Corp., Santa Monica, California.

[58] Unpublished files, Office of Research and Statistics, Social Security Administration, U.S. Dep't of Health, Education, and Welfare.

[59] U.S. BUREAU OF LABOR STATISTICS, *supra* note 34, at 33-34.

[60] U.S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, 1970 CENSUS OF POPULATION: CHARAC-

EDUC = average level of education as described above.[61] Education represents an investment in human capital which should manifest itself in higher earnings.

AREA = a regional dummy variable contrasting northern and southern states. The variable has a value of 1 if a state is in the south. The expected sign of the coefficient is negative reflecting the lower cost of living in the south.

HOURS = average weekly hours as described above.[62] Since wages are measured on a weekly basis it is necessary to account for differences which are due to differences in the hours of work.

INJRATE = the endogenous injury rate as described above.[63] This is one of the key factors in the model. If private markets control the level of safety, variations in the injury rate will be manifested in higher wages.

WC = the endogenous workmen's compensation index as described above.[64] To the extent that an employee's accident costs are covered by the employer, the costs that need be covered by the employee are decreased. Therefore, it is expected that as workmen's compensation benefits increase, the level of wages will decrease.

μ_2 = error term.

(3) STANDARDS = $\alpha_{3.0} + \alpha_{3.1}$ (INC) + $\alpha_{3.2}$ (UNIONST) + $\alpha_{3.3}$ (DEATHS) + $\alpha_{3.4}$ (POP) + $\alpha_{3.5}$ (EXPINJ) + $\alpha_{3.6}$ (COMP) + μ_3.

(4) WC = $\alpha_{4.0} + \alpha_{4.1}$ (INC) + $\alpha_{4.2}$ (UNIONST) + $\alpha_{4.3}$ (DEATHS) + $\alpha_{4.4}$ (POP) + $\alpha_{4.5}$ (EXPINJ) + $\alpha_{4.6}$ (COMP) + $\alpha_{4.7}$ (WAGES) + μ_4.

Where:

STANDARDS = the index of the states' safety standard system as described above.[65]

WC = the workmen's compensation index as described above.[66]

INC = the states' level of income. Several authors have observed that the relative wealth or availability of resources to a decision-making unit is related to its willingness to adopt new and progressive policies.[67] Since safety regulation appears to be generally viewed as progressive public policy, it is, therefore, hypothesized that higher levels of both safety standards and workmen's compensation result in part from higher relative in-

TERISTICS OF THE POPULATION Table 184 (1973). Table 184 is consistent only throughout parts 2-52 of volume 1 (corresponding to each of the fifty states and the District of Columbia). The parts and their respective states used for the purposes of this study were: pt. 2, Alabama; pt. 5, Arkansas; pt. 8, Connecticut; pt. 11, Florida; pt. 17, Iowa; pt. 21, Maine; pt. 32, New Jersey; pt. 34, New York; pt. 40, Pennsylvania; pt. 42, South Carolina; pt. 45, Texas; pt. 48, Virginia; pt. 57, Wisconsin.

[61] U.S. DEP'T OF COMMERCE, *supra* note 44, at 98.

[62] U.S. BUREAU OF LABOR STATISTICS, *supra* note 34, at 35.

[63] Unpublished files, U.S. Bureau of Labor Statistics, Dep't of Labor.

[64] Unpublished files, American Insurance Association, New York, New York. *See also* text at note 51 *supra*.

[65] U.S. BUREAU OF LABOR STANDARDS, *supra* note 49; unpublished files, Division of Programming and Research, U.S. Bureau of Labor Standards, Dep't of Labor.

[66] Unpublished files, American Insurance Association, New York, New York. *See also* text at note 51 *supra*.

[67] Walker, *The Diffusion of Innovations Among the American States*, 63 AM. POL. SCI. REV. 880, 883 (1969).

come levels. The relative income level variable is based on 1967 mean total earnings for workers covered by Social Security. The source of the data is *Earnings Distributions in the United States.*[68]

UNIONST = the number of union members as a percentage of the state's total labor force. Labor unions are a significant source of the political pressure for enactment and change in safety regulation. It is, therefore, hypothesized that the political strength of the labor movement within a state is a determinant of both forms of safety regulation. The percentage of union members is designed as a measure of the political power of the organized labor movement in each state. Therefore, the expected coefficient is positive. The data are from the *Directory of Labor Unions.*[69]

DEATHS = the average accidental death rate in each state for the period 1962 through 1966. A recurring theme in commentaries about safety regulation is that it results from specific disasters which aroused the public. The disaster or shock factor as a determinant of the status of regulation in each state is extremely difficult to measure. By definition, the shocks are often isolated and unique tragedies. The proxy chosen for this phenomenon is the average accidental death rate in the state for the period 1962-66. The notion behind this variable is that a relatively high death rate from accidents may lead states to strengthen regulation in anticipation of lowering the rate. The source of the data is the National Safety Council.[70]

POP = the states' population in 1960. Studies have indicated that organizational size is related to the propensity for innovation.[71] It is, therefore, hypothesized that larger states have greater safety regulation. The data are from the 1970 *Census of Population.*[72]

EXPINJ = the expected injury rate. The industry mix of a state may also be a factor in explaining the character of regulation in each state. States with a dominance of relatively safe industries may not feel a need to have strong regulation. Similarly, the presence of dangerous industries may create an incentive for strong regulation.

The variable chosen to measure this phenomenon is the expected injury rate. The rate was measured as follows. First, for the total United States an average frequency rate of injury was calculated for each 2-digit SIC manufacturing industry. These data were based on the period 1958 through 1966. This represents the years for which comparable data are available. Second, for each state, employment by 2-digit industry was averaged over the same time period. Third, the expected injury rate is the weighted

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[68] SOCIAL SECURITY ADMINISTRATION, OFFICE OF RESEARCH AND STATISTICS, EARNINGS DISTRIBUTIONS IN THE UNITED STATES, 1967 (DHEW Pub. No. (SSA) 72-11900, 1971).

[69] U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1665, DIRECTORY OF NATIONAL AND INTERNATIONAL LABOR UNIONS IN THE UNITED STATES, 1969, at 76 (1970).

[70] NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1967); NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1966); NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1965); NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1964); NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1963).

[71] Walker, *supra* note 67.

[72] 1 U.S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, 1970 CENSUS OF POPULATION: CHARACTERISTICS OF THE POPULATION pt. 1 (U.S. Summary), § 1 Table 8, at 1-48, 1-49 (1973).

average of the U.S. total industry frequency rates where, for each state, the weights are the states' 2-digit employment averages. The source of the frequency rates for the United States is the *Handbook of Labor Statistics, 1970.*[73] The source for each state's employment mix is *Employment and Earnings, States and Areas, 1939-69.*[74]

COMP = political competitiveness within a state. Political science studies suggest that the competitiveness of political parties is a factor in the formulation of public policy. This notion is based on the concept that a political party facing a closely contested election will be more prone to offer new and progressive legislation as a means of rallying support to their party. The measure of party competitiveness chosen is the average percentage of votes going to the dominant political party in statewide elections over the period 1940 to 1964.[75] If neither party in a two-party system is dominant, the measure would equal 50 per cent. A negative coefficient would indicate that competitiveness does result in more regulation.

WAGES = the endogenous average weekly level as described above.[76] This variable is applicable only to workmen's compensation benefits. As wages increase, potential benefits increase because benefits are often stated as a percentage of wages.

μ_3 and μ_4 = error terms.

The model was estimated using a cross-sectional data base of 2,627 firms from 13 states in 1967. Two-stage least squares was the estimation procedure used. The determinants of injury rates equation is not based on well established theory or previous empirical work; therefore, an analysis of covariance across industries was performed on the reduced form equation. This analysis demonstrated that, while the specified independent variables perform similarly across the industries within the sample, factors not specified are causing inter-industry variations. Such a circumstance implies that dummy variables representing the inter-industry structure should be placed in the equation. The covariance analysis indicates that the inter-industry variations occur at both a durable-nondurable level and at a 2-digit SIC level.

In the estimation of the full four equation model, the industry dummy variable structure was limited to the durable-nondurable categorization[77] rather than the more detailed 2-digit SIC categorization. The 2-digit SIC categorization would require sixteen dummy variables which when added to the other independent variables would exceed the available computational capacity for simultaneous equations.

The model was estimated with alternative subsets of the data base. To test the possibility that the hypothesized relationships are different for

[73] U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. No. 1666, HANDBOOK OF LABOR STATISTICS 364 (1970).

[74] U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. No. 1370-7, EMPLOYMENT AND EARNINGS: STATES AND AREAS, 1929-69 (1970).

[75] Pfeiffer, *The Measurement of Inter-Party Competition and Systematic Stability,* 61 AM. POL. SCI. REV. 457, 459 (1967).

[76] Unpublished files, U.S. Manpower Administration, Dep't of Labor.

[77] *See* EXECUTIVE OFFICE OF THE PRESIDENT, *supra* note 36.

larger and smaller firms, the model was estimated with data bases which included only the largest 10 per cent and the smallest 10 per cent of sampled firms. The model was also estimated for the middle 80 per cent of sampled firms.

There was also concern that the estimates are influenced by the uneven distribution of firms across states. To test this possibility, data bases were created which weighted the number of observations in each state so as to approximately equalize their interstate distribution. This weighting procedure was used on the original sample as well as the top 10 per cent, bottom 10 per cent, and middle 80 per cent samples.

The wage equation yielded coefficients which generally conformed to expectations. Positive coefficients which were large relative to their standard errors[78] were found for the measures of unionization, capital-labor ratio, experience, and education. The coefficients on the percentage of women, the percentage of production employees, and the southern state dummy variable (area) were negative and large relative to their standard error. The coefficient on the number of employees was small relative to its standard error except in the model estimated with the severity rate. Contrary to expectations, the percentage of nonwhites and the level of workmen's compensation benefits had positive coefficients. The benefit level coefficient was large relative to its standard error in the estimates using the severity and frequency rates but not with serious injury frequency rate. The negative sign on each of the alternative measures of the endogenous injury rate variable was also contrary to expectations.[79]

The estimation of the equation with workmen's compensation benefits as the dependent variable yielded five coefficients which conformed to hypotheses and two which did not conform. As hypothesized, the level of state income, the percentage of the labor force unionized, the number of industrial deaths, the measure of expected injuries, and the endogenous wage rate all had positive coefficients that were large relative to their standard errors. The coefficient on the states' population was negative and the coefficient on the index of political competition was positive, both of which are contrary to the hypotheses. The independent variables in the regulation via controls equation all had coefficients which were small relative to their standard errors.

The use of alternative measures of the injury rate demonstrated some important differences in the injury rate equation. Although the frequency rate of all injuries and the frequency rate of serious injuries produced generally similar results, the severity rate did not. The equation with the severity rate produced positive coefficients for the capital-labor ratio, the length of the waiting period, and the level of workmen's compensation bene-

[78] Standard tests of significance are not applicable to the second stage equations of two-stage least squares estimation. However, with a large sample such as that used to estimate these equations, the usual standards of significance are generally regarded as an indication of reliability.

[79] The low correlation coefficients among independent variables indicate that multicollinearity is not a problem.

fits which were all large relative to standard errors. There were negative coefficients on the percentage of women and the wage rate. All other coefficients were quite small relative to their standard errors. This relative lack of significant variables is consistent with the insurance industry's claim that severity rates contain a larger random component than other measures and, therefore, are a less desirable measure of a firm's injury experience than frequency rates.

As hypothesized the coefficient on the new hires rate was positive and large relative to its standard error in both the frequency rate and serious injury frequency rate equations. Negative coefficients which conform to hypotheses were found in both equations for the unemployment rate and the number of employees in the establishment. The percentage of women coefficient which had no hypothesis as to sign was negative and reliable. The capital-labor ratio was negative and large relative to its standard error. Contrary to expectations the unionization and workmen's compensation variables had positive significant coefficients. Also contrary to expectations, the production employees and wage variables had negative coefficients that were large relative to their standard errors. The change in average weekly hours and waiting period variables had coefficients that were small relative to their standard errors. The regulation via controls index had a positive coefficient large relative to its standard error in the serious injury equation, but it was insignificant in the frequency rate equation. The average age variable was insignificant in the serious injury equation but negative and large relative to standard error in the frequency rate equation. The education variable had a negative coefficient in the serious injury frequency rate equation but an insignificant coefficient in the frequency rate equation.

The model was also estimated using alternative measures for other variables whenever available. The use of actual benefits as a measure of workmen's compensation also produced results similar to the original specification. The use of safety budget per nonagricultural employee rather than the index of regulation produced no important change in results; however, the R^2 in the controls equation which contains no endogenous independent variables dropped from .33 with the index as the dependent variable to .16 with budget. In order to determine whether these results were related to the fact that the determinants of controls equation had no significant independent variables, the model was re-estimated with controls assumed to be exogenous rather than endogenous. Under this assumption the controls index and safety budget variables remained insignificant in the frequency rate and severity rate equations. The controls index was insignificant in the serious injury rate equation but the safety budget remained positive (the ratio of the safety budget coefficient to its standard error was 3.8).

The data base contains 2,627 observations which are not evenly distributed across states. This unequal distribution gives rise to concern that the estimated relationships between state regulation and the injury rates were dominated by the experience of a subset of states. To investigate this possibility a sample was created which resulted from weighting the original observations in each state so as to approximately equalize the number of observations in each state. The state with the largest number of observations was New York with 628 firms. The weighting procedure was to multiply the observations in every other state by a factor which resulted in approximately 628 observations. For example, Texas has 215 observations and was, therefore, weighted by a factor of 2.9.

To achieve the 2.9 weighting, each original observation was reproduced twice, reflecting the integer component of the factor. In order to achieve the fractional component of the factor, a random sample of the original observations was drawn so as to yield an additional 90 per cent sample. These files were then combined to yield a state sample of 2.9 times as large as the original.

As a further test of generality, subsamples of the original data were drawn based on the number of employees in the firm. The subsamples were the 10 per cent largest firms, the 10 per cent smallest firms, and the remaining 80 per cent of middle-sized firms. Each of these subsamples was also weighted so as to approximately equalize the number of observations in each state.

The controls equation was not subjected to weighting in either the full sample or the firm size dependent subsamples. All variables in this equation were dependent only on the state, and the original estimation was based on one set of observations from each of the 40 states for which data were available. Hence, equal weighting of states was implicit in the original estimation.

The following results are based on the full unweighted sample of 2,627 firms with the frequency rate as the measure of the injury rate, the composite index as the measure of standards, and the benefit level index as the measure of workmen's compensation. The numbers in parentheses are the ratios of the coefficients to the standard errors.

$$\text{(1) INJRATE} = \underset{(.22)}{-3.57} + \underset{(7.05)}{3.72}\,\text{(NEWHIRES)} - \underset{(3.46)}{15.60}\,\text{(UNE)} + \underset{(4.86)}{1.32}\,\text{(HOURS)}$$

$$- \underset{(2.20)}{.38}\,\text{(AGE)} + \underset{(5.09)}{.13}\,\text{(UNION)} - \underset{(4.35)}{.001}\,\text{(SIZE)} - \underset{(.92)}{.04}\,\text{(CAPITAL)} - \underset{(3.38)}{2.0}\,\text{(EDUC)}$$

$$- \underset{(4.69)}{.16}\,\text{(SEX)} - \underset{(.91)}{.04}\,\text{(OCC)} + \underset{(.10)}{.04}\,\text{(WAIT)} - \underset{(1.39)}{.83}\,\text{(WAGE)} - \underset{(1.10)}{.000007}\,\text{(STANDARDS)}$$

$$+ \underset{(3.84)}{.01}\,\text{(WC)} + \underset{(2.86)}{2.80}\,\text{(DURABLES)}$$

$R^2 = .165$
Standard Error 294.10

$$\text{(2) WAGES} = \underset{(1.82)}{-36.27} + \underset{(4.18)}{.17}\,\text{(UNION)} + \underset{(.07)}{.00004}\,\text{(SIZE)} + \underset{(5.24)}{.32}\,\text{(CAPITAL)}$$

$$+ \underset{(3.90)}{.25}\,\text{(EXPER)} - \underset{(10.98)}{.55}\,\text{(SEX)} - \underset{(8.47)}{.47}\,\text{(OCC)} + \underset{(5.60)}{3.46}\,\text{(NW's)} + \underset{(5.50)}{4.80}\,\text{(EDUC)}$$

$$- \underset{(10.28)}{22.59}\,\text{(AREA)} + \underset{(8.33)}{3.44}\,\text{(HOURS)} - \underset{(8.38)}{1.18}\,\text{(INJRATE)} + \underset{(4.44)}{.01}\,\text{(WC)}$$

$R^2 = .405$
Standard Error 704.31

$$\text{(3) STANDARDS} = -86613.51 + \underset{(.62)}{31.12}\,\text{(INC)} + \underset{(1.45)}{376.82}\,\text{(UNIONST)}$$

$$- \underset{(.70)}{113.35}\,\text{(DEATHS)} - \underset{(1.05)}{4.89}\,\text{(POP)} + \underset{(.82)}{231.53}\,\text{(EXPINJ)} - \underset{(.43)}{890.45}\,\text{(COMP)}$$

$R^2 = .337$
Standard Error 87285.14

$$\text{(4) WC} = \underset{(45.66)}{-4001.40} + \underset{(69.17)}{.77}\,\text{(INC)} + \underset{(11.23)}{7.69}\,\text{(UNIONST)} + \underset{(40.04)}{.17}\,\text{(DEATHS)}$$

$$- \underset{(70.68)}{.05}\,\text{(POP)} + \underset{(19.54)}{2.78}\,\text{(EXPINJ)} + \underset{(21.76)}{13.22}\,\text{(COMP)} + \underset{(33.01)}{2.70}\,\text{(WAGES)}$$

$R^2 = .886$
Standard Error 11227.00