

ON THE ECONOMICS OF INDUSTRIAL SAFETY

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INTRODUCTION

Articles on this subject often begin by citing the National Safety Council statistics that over two million workers are injured each year, 14,000 are killed, and 190,000 are permanently disabled by industrial accidents.¹ The passage of the Williams-Steiger Bill in 1970² which established the Occupational Safety and Health Administration (OSHA) clearly reflects our legislators' beliefs that this accident toll is intolerably high. Further, one can infer from the Report of the National Commission on State Workmen's Compensation Laws (NCSWCL)³ that the current compensation to victims of industrial accidents is grossly inadequate. Legislative actions at both federal and state levels have mainly been intended to achieve two objectives: (1) to reduce the frequency and severity of work-related injuries and diseases, and (2) to provide more equitable compensation to victims of these mishaps. The former has significance for economic efficiency, indicating that the present industrial accident toll exceeds some socially optimal accident toll. The latter is concerned with what constitutes "just and fair" compensation.⁴ An economist has something to say about the former issue, and I shall try to do so in this paper even though I agree with Professor Stigler who wrote, "[l]acking real expertise and lacking also evangelical ardor, the economist has had little influence upon the evolution of economic policy."⁵

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¹ NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 18 (1972). These data were based on the old Z16.1 standard—the BLS, pre-OSHA, injury data compilation technique—wherein a work injury was counted only if the injured worker was unable to report for work on the day following the accident. The reporting requirements under OSHA, 29 C.F.R. §§ 1904.1-.22 (1973), have expanded the scope to include more minor injuries as well as diseases which, in the last half of 1971, accounted for 5 per cent of all cases under the new standard. This shift in the definition of work injuries has roughly trebled the number of injuries. In the future, we should expect to read that over 6 or 7 million workers are injured each year. For further details on the comparability of the old and new data series, see Schauer & Ryder, *New Approach to Occupational Safety and Health Statistics*, 95 MONTHLY LAB. REV. 14 (1972).

² Pub. L. No. 91-596, §§ 2-34, 84 Stat. 1590 (Dec. 29, 1970) (codified in scattered sections of 5, 15, 18, 29, 42, 49 U.S.C.).

³ NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, THE REPORT OF THE NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS (1972).

⁴ Some policies that are addressed to the equity objective may also have an impact on efficiency. Thus, according to the NCSWCL Report, the workmen's compensation program may encourage safety by giving employers a monetary incentive to invest in safety—and thereby improve their safety records—in order to reduce premium costs. *Id.* at 87. No empirical evidence was offered to support this conjecture.

⁵ Stigler, *The Economist and the State*, 55 AM. ECON. REV. 1, 12 (1965). This is not to say that economists have had *no* influence. In the same article Stigler writes, "even when economists took an active and a direct interest in a policy issue, they did not make systematic empirical studies to establish the extent and nature of the problem or the probable efficiency of alternative methods of solving the problem." *Id.* at 11. It is a serious indictment of the profession, but the same absence

Calabresi has convincingly argued that the goal of public policy should be the minimization of the *sum* of accident costs and accident prevention costs.⁶ A legal limit on the heights of skyscrapers would surely reduce fatalities in the construction trades, but would it be consistent with the maximum welfare of society? Policies that reduce the frequency and severity of industrial accidents are desirable only if it can be demonstrated that industrial safety is presently below that socially optimal level which minimizes the sum of accident and accident prevention costs. In measuring accident costs, it is important to distinguish between *risks* and *outcomes*. How much additional compensation would be demanded by Jones to accept a job on which he knew he would lose a leg? Alternatively, how much additional compensation would be demanded by 100 Joneses if they knew that one of them was virtually certain to lose a leg? The latter is the pertinent question for workers who offer their labor services in hazardous employments. The value of a leg is not invariant to the probability of losing a leg. In evaluating accident cost savings, the relevant measure is thus the value to groups of workers of lower injury risks, not the value of fewer unfortunate outcomes to particular named individuals.⁷ The case histories which have been advanced in favor of more industrial safety have largely neglected the difficult problem of identifying and measuring accident prevention costs. And safety literature appears not to question the belief that whatever the prevention costs, they must be less than the benefits of lower accident costs.

Part I of the paper develops the concept of an optimum level of safety in a world of inherent injury risks. The model is relaxed in Part II where work injury risks can be influenced by accident avoiding actions by employers and workers. Since no one intentionally injures another, the observed work injury rates can be viewed as equilibrium rates that may differ from socially optimal rates. Part III then presents some empirical evidence on injury rate differentials over time and across industries, occupations, establishment sizes, and characteristics of workers. These empirical regularities are suggestive of some of the properties of the technological trade-offs between injuries and goods. In the light of the analytic framework of Part II and the empirical results of Part III, a final section evaluates the policies initiated by OSHA and the recommendations set forth by the NCSWCL.

of systematic empirical studies also characterizes other designers of public policy. Finally, "the extent to which safety in production processes and purity in products are achieved by a competitive market and by a regulatory body" is listed by Stigler as one of five subjects that has not been "investigated with even modest thoroughness." *Id.*

⁶ G. CALABRESI, *THE COST OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS* (1970).

⁷ This distinction is put nicely by Thaler and Rosen who develop empirical estimates of the value of *saving* a life as opposed to the value of *a* life. 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). The problem only arises for injuries that involve death or permanent disability. I have argued that the accident costs of temporary disabilities that do not change the injured worker's post-recovery productivity can be valued like objects with market values. With perfect insurance markets, a certain loss of \$500 is the same as the uncertain prospect of losing \$1,000 with a probability of 0.5. Oi, *An Essay on Workmen's Compensation and Industrial Safety*, in 1 NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, SUPPLEMENTAL STUDIES FOR THE NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS 41, 59 (1973).

I

OPTIMAL SAFETY IN A WORLD OF INHERENT INJURY RISKS

At the outset, attention is directed to a simple model in which work injury risks are inherent; that is, risks in each industry cannot be affected by actions of either employers or workers. Although the model can be generalized to many industries, the essential principles can be derived by invoking the following assumptions: (1) all work injuries are alike and result in temporary total disability of H working days; (2) there are only two industries with injury risks of π in industry 1 which produces good X and zero in industry 2 which produces good Y ; and (3) the welfare of consumers depends on outputs of the two goods (X, Y) where the relative demands (X/Y) are inversely related to relative product prices (P_x/P_y).

The accident costs for the economy as a whole can be expressed as the cost per disabling injury γ times the number of injuries A : $C_a = \gamma A$. By assumption injury risks are inherent (π in industry 1 and 0 in industry 2), so that the number of injuries A is determined by employment in the risky industry L_1 : $A = \pi L_1$. A worker who offers his labor to the risky industry is exposed to an uncertain income stream. In the event that he is injured, he incurs medical bills and loses wage income during the period of H days of temporary disability. If W_1 is the annual wage rate in the risky industry, the worker gets either W_1 if uninjured or $(1-h)W_1$ if injured.⁸ The injury cost γ for a risk neutral worker is simply hW_1 and something greater than hW_1 for a risk averse worker who incurs a utilitarian cost of risk-bearing.⁹ A lower bound to the accident costs is thus given by $C_a = \gamma A = hW_1 \pi L_1$.

In a world of inherent risks, accident prevention might appear to be infeasible. The economy can, however, reduce the aggregate injury risk (and hence accident costs) by shifting workers from the risky to the riskless industry.¹⁰ The impact of such a shift on the sum of accident and accident prevention costs depends on the initial allocation of labor and on consumer preferences for the products of the two industries. The maximum outputs of X and Y that can be produced with fixed supplies of labor and other resources can be de-

⁸ If there are T working days per year, then $h = H/T$ is the fraction of a year that is lost due to an injury. The cost of medical care can be incorporated into H . Thus, if the injury entails medical bills of \$100 and the daily wage is \$20, then we need only add 5 days to the duration of the temporary disability to incorporate this component of the accident cost.

⁹ The expected or average annual income \bar{W}_1 earned by workers in the risky industry is given by,

$$\bar{W}_1 = (1 - \pi)W_1 + \pi(1 - h)W_1 = (1 - \pi h)W_1.$$

Let $U = U(W)$ denote the worker's utility function. The expected utility \hat{U} from the uncertain income prospect of either W_1 if uninjured or $(1 - h)W_1$ if injured is simply,

$$\hat{U} = (1 - \pi)U(W_1) + \pi U[(1 - h)W_1].$$

For a risk averse individual, the marginal utility of income is diminishing, $U'' < 0$. There is some certain income stream, \bar{W}_1 , such that $U(\bar{W}_1) = \hat{U}$. It can be shown that when $U'' < 0$, \bar{W}_1 is less than \hat{W}_1 , and the difference, $(\hat{W}_1 - \bar{W}_1)$ can be interpreted as the utilitarian cost of risk-bearing. This point is amplified in Oi, *supra* note 7, at 51. Put in another way, if a risk averse individual had an uncertain income prospect, $[W_1, (1 - h)W_1]$ with an expected income of say $\hat{W}_1 = \$9,000$, he would be prepared to give up some of that expected income if he could be assured of a certain income of say $\bar{W}_1 = \$8,900$. In this example, the utilitarian cost of risk-bearing would be \$100.

¹⁰ Let $k_1 = L_1/(L_1 + L_2)$ denote the proportion of the labor force employed in the risky industry. The aggregate injury risks for all workers is then simply $A/(L_1 + L_2) = K_1\pi$.

scribed by a product transformation curve like AB in Figure 1. At point A, $X = 0$ implying that $L_1 = 0$, and hence accident costs will also be zero. By moving to the right along AB, the economy can get more output X from the risky industry but at a cost of less output of Y and more work injuries. Consumer preferences for the two goods can be described by a family of indifference curves like I_1 and I_2 where I_2 represents consumption bundles that yield a higher utility than bundles along I_1 . The maximum of consumer preferences (utility) that can be attained with fixed resources is achieved at the bliss point E where the highest indifference curve is just tangent to the product transformation curve. Since the loss of productive labor time due to injuries is already incorporated in the AB curve, the bliss point E corresponds to an optimum bundle of goods (X,Y) which, in turn implies the allocation of labor to the two industries. The aggregate injury rate, $k_1\pi$ that corresponds to point E, is thus an optimum level of industrial safety which maximizes consumer welfare.¹¹

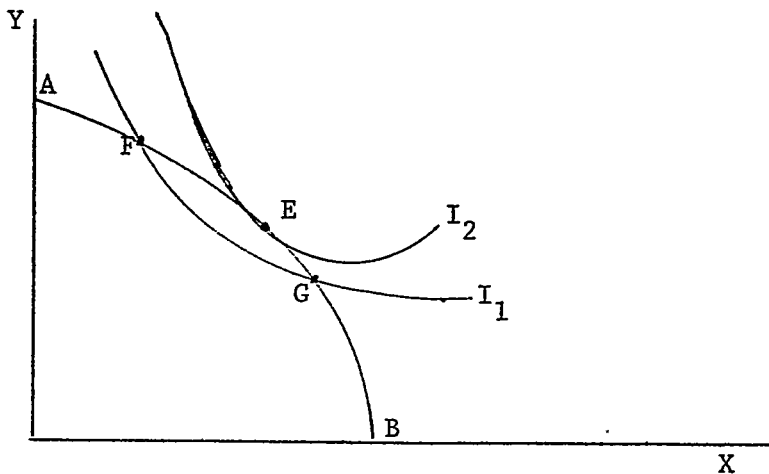


FIGURE 1

Various policies such as the imposition of an excise tax on good X could reduce output and employment L_1 in the risky industry thereby lowering accident costs. If we were initially at the bliss point E, an excise tax on X could induce a movement from E to F. However, at point F, consumers (who are also workers) are forced to a lower level of utility. Although accident costs are lower at F, the marginal value that consumers attach to the output X of the risky industry exceeds the opportunity cost (including the cost of more injuries) of producing more of X. The accident prevention cost in this model is thus seen to be derived from consumer preferences for the outputs (X,Y) of risky and riskless industries.

Is there any reason to expect that competitive forces will lead to a market equilibrium at the bliss point E? If workers are informed about the inherent

¹¹ The problem of maximizing utility subject to a resource constraint is the dual to the problem of minimizing resource inputs to attain a given level of utility described by a particular indifference curve. When consumer utility (welfare) is maximized the economy is also minimizing the sum of accident and accident prevention costs.

injury risks, they realize that employment in the risky industry entails a potential income loss of $\gamma = hW_1$ which will occur with probability π . Assume that workers are liable for all accident costs. Under risk neutrality, a worker would supply his labor to the risky industry only if the wage in that industry W_1 exceeded the certain riskless wage in the other industry, W_2 , by an amount equal to the expected income loss due to injury. Hence, in equilibrium, $(1-\pi h)W_1 = W_2$, and the risk premium (or equalizing wage differential) will be $(W_1 - W_2) = \pi h W_1 = \pi \gamma$. The higher wage will increase the marginal cost and hence the price of X, the product of the risky industry. Given competitive product and labor markets, product prices will be equated to marginal costs, and since the marginal cost of X (given $W_1 - W_2 = \pi \gamma$) fully incorporates all of the accident costs, the resulting market equilibrium will be at a bliss point E. The same optimal safety level will also be attained in a world of risk averse workers if insurance is fair.¹² However, with risk averse workers and no insurance market, the risk premium in the risky industry must exceed the expected injury cost by an amount equal to the utilitarian cost of risk-bearing for the marginal worker. In this event, the market equilibrium will be at a point to the left of E.¹³

Consider next a situation in which workers are initially ignorant and believe that the risks are the same in the two industries. Wage rates would then be the same, $W_1 = W_2$, and the equilibrium would be at a point like G in Figure 1. At G, the economy is allocating "too much" labor to the risky industry and suffers a high aggregate injury toll. But is this a stable equilibrium? The uninformed workers in the risky industry earn, on average, less than their peers in the riskless industry Y because some fraction π of them will be injured each year and incur wage losses. Employers in the riskless industry Y clearly have an incentive to point out this fact to workers in industry X. If $W_1 = W_2$, employers who inform workers about the injury risks in industry X, could attract those workers at any wage exceeding $(1-\pi h)W_1$. As more workers are attracted to the riskless industry Y, wage rates there, W_2 , will fall until eventually the equalizing wage differential, $(W_1 - W_2) = \pi \gamma$, that prevailed with fully informed workers is reestablished. Full information by all participants is not essential to establish an optimum competitive market equilibrium.

Finally, it should be noted that the assignment of liability for accident costs has no effect on the allocation of labor and hence on the equilibrium number of disabling injuries. If employers were liable, there would be a dis-

¹² By fair insurance, I mean that the premium rate p per dollar of coverage is just equal to the injury risk π . Eisner and Strotz, Smith, and others have proven that with actuarially fair insurance rates, risk averse individuals will always demand full coverage against all potential losses. See, e.g., Eisner & Strotz, *Flight Insurance and the Theory of Choice*, 69 J. POL. ECON. 355 (1961); Smith, *Optimal Insurance Coverage*, 76 J. POL. ECON. 68 (1968). Hence, with fair insurance, fully insured, risk averse workers behave just like neutral workers who maximize expected income irrespective of the variance of income. A fuller discussion of this point can be found in Oi, *supra* note 7, at 52.

¹³ It will still be the case that the least risk averse workers, who incur the lowest utilitarian cost of risk-bearing, will end up in the risky industry. The equilibrium with no insurance market is not a socially optimal one because risk averse workers are unable to spread the accident costs. Since the added cost of risk-bearing, $(W_1 - W_2) > \pi \gamma$, must be incorporated into the marginal cost of producing X, this non-optimal equilibrium results in a contraction in the output of X and fewer injuries.

crepancy between the wages paid to workers (I shall refer to these as earnings) and the wage costs to employers in the risky industry. The earnings of workers in the risky industry will be equal to the wages in the riskless industry, but wage costs in the risky industry will be higher by the amount of the expected injury cost. Moreover, the presence of workmen's compensation in this world of inherent risks also has no effect. If workers receive benefits from workmen's compensation in the event of an injury, the expected value of these benefits will simply reduce the size of the equalizing risk premium needed to attract workers to the risky industry.

II

EQUILIBRIUM INJURY RATES UNDER ENDOGENOUS RISKS

While industrial accidents are random events, the probabilities (injury risks) of these regrettable events can be influenced by employers and workers. Technology, however, constrains the extent to which injury risks can be controlled. Some jobs, such as drilling and tunneling or refuse collection, are inherently more dangerous than others. The incentives and information available to the involved parties will affect injury risks (and hence injury rates) within these technological constraints. The observed injury rate differentials over time and across industries, occupations, and types of workers can thus be viewed as equilibrium injury rates that were simultaneously determined by the interaction of the demand for, and supply of, industrial safety by employers and workers. The equilibrium will obviously be affected by compulsory insurance schemes and mandatory safety standards.

Industrial accidents and the injuries that they inflict can properly be viewed as undesirable by-products.¹⁴ Textbook production functions describe how inputs of labor and capital can be transformed into outputs of economic goods. A more accurate picture is one in which firms face joint production functions wherein inputs generate two joint products, economic goods X and work injuries or accidents A. If instead of injuries A, we measure their complement, uninjured workers B, then for a given outlay for inputs, there is a negative technical trade-off between goods X and uninjured workers B. Given its outlays for labor, capital, and other inputs (including safety), a firm can expand its "output" of uninjured workers B (achieving a lower injury rate) only by reducing output of its principal product X. These technical trade-offs can be achieved in a variety of ways. A firm could purchase safety inputs such as installing guards, hiring safety engineers, or paying new employees to attend orientation lectures on safe work practices. Alternatively, it could initiate safety practices such as slowing down the speed of its assembly lines or giving liberal sick leave privileges to guard against the possibilities of accidents caused by workers who return to work before they have fully recovered from an illness. The firm's safety expenditures S must include not only the identifiable costs of safety inputs but also the implicit opportunity costs equal to the value of output X that could have been produced in the

¹⁴ See text at pp. 672-74 *supra*.

absence of the safety practices. The rational firm will choose that combination of safety inputs and practices which minimize the total safety expenditures S needed to achieve any given injury risk π .¹⁵

In this manner, the technical trade-offs between goods and injuries can be incorporated into the firm's safety expenditures S which include both the explicit costs (of inspectors, safety devices, and so on) and the implicit costs (of slowing assembly lines, rest periods, and so on). We can thus specify an injury risk function which describes the accident prevention cost function for the firm:

$$(1) \quad \pi = g(S, L) \quad \frac{d\pi}{dS} = g_s < 0, \quad \frac{d\pi}{dL} = g_L > 0 .$$

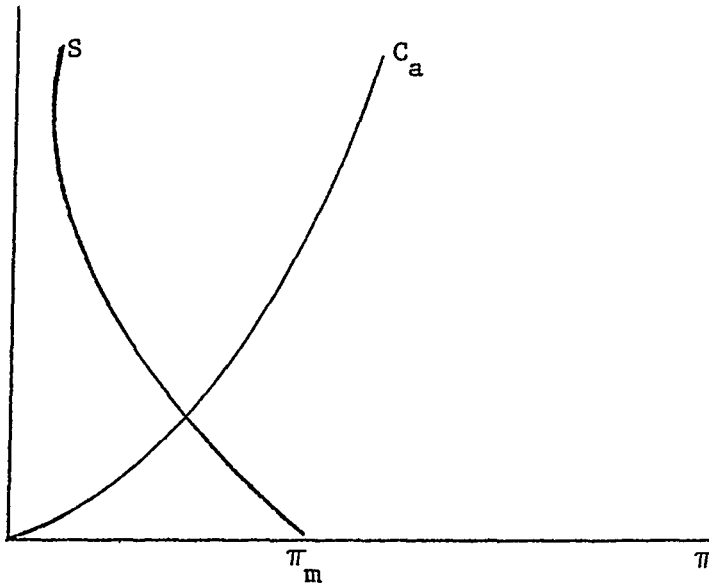


FIGURE 2

Holding employment L constant, an increase in safety expenditures will reduce the injury risk π . Conversely, when safety outlays S are held constant, an increase in employment L can be expected to increase the injury risk π because the firm now spends less on industrial safety for each worker.¹⁶ Within certain technological limits, the firm can, in principle, alter its injury risks by allocating more or less resources to safety. For a given size of the

¹⁵ For analytic simplicity, I have assumed that the injury risk can be described by a single parameter π , the probability of being injured. The wide diversity of work-related injuries could have been described by a vector of probabilities for each type of injury ranging from cuts and bruises through loss of limb to deaths. I felt that the simplifying assumption was warranted in the light of the modest objectives of the analysis set forth here.

¹⁶ Equation (1) can be derived in another way. Let A = injured workers, while $B = L - A$ = uninjured workers that are "produced" by combining safety S and labor L via the production function,

$$B = f(S,L) \quad \frac{dB}{dS} > 0, \quad \frac{dB}{dL} > 0.$$

labor force L , the inverse of equation (1) is depicted by the S curve in Figure 2 above. The position and shape of the S curve will obviously vary across firms and industries being higher for the innately more hazardous industries.¹⁷ The S curve thus describes the firm's accident prevention costs; the firm must allocate more to safety expenditures S in order to achieve a lower injury risk π .

A higher work injury risk π can lead to larger accident costs to the firm in terms of both labor and material costs. Industrial accidents are often accompanied by destruction of machinery and materials, disruptions in production schedules, and so on. In terms of labor costs, the replacement of injured workers unavoidably raises the firm's labor turnover with an accompanying increase in the fixed employment cost of recruiting and training new employees. Furthermore, a firm that can offer safer working conditions can attract workers at lower wage rates that contain smaller risk premium components. If the wage rate is related to the injury risk via the relationship, $W = W(\pi)$ with $W'(\pi) > 0$, the accident costs to the firm C_a , can be written:¹⁸

$$(2) \quad C_a = [F\pi + W(\pi)]L, \quad C'_a = \frac{dC_a}{d\pi} [F + W'(\pi)]L > 0,$$

where F is the sum of the material costs and the fixed employment cost per accident. If equation (1) is inverted to yield, $S = G(\pi, L)$, where $(dS/d\pi) = G\pi < 0$, we write the sum of accident and accident prevention costs for the firm as follows:

$$(3) \quad C_a + S = [F\pi + W(\pi)]L + G(\pi, L).$$

An increase in safety expenditures S which lowers the injury risk π will reduce the sum of accident and accident prevention costs if $(C'_a + S') > 0$, that is,

$$(4) \quad -S' < C'_a, \quad -G\pi(\pi, L) < [F + W'(\pi)]L.$$

If this function is homogeneous of the first degree, it can be rewritten as,

$$\frac{B}{L} = h\left(\frac{S}{L}\right).$$

An increase in safety per worker, (S/L) should lead to a larger fraction of uninjured workers (B/L) ; that is, $h' > 0$. The injury risk is simply $\pi = A/L$, but since $B = L - A$, we have,

$$\pi = 1 - \frac{B}{L} = 1 - h\left(\frac{S}{L}\right).$$

It is apparent that this expression (given $h' > 0$) will yield the same derivatives as that attributed to the g function of equation (1).

¹⁷ The S curve depicted in Figure 2 incorporates the plausible assumption of diminishing returns to safety outlays. In terms of equation (1), diminishing returns means that $(d\pi/dS) < 0$, and $(d^2\pi/dS^2) > 0$. It also seems reasonable to suppose that even when the firm spends nothing on safety, there is some upper limit to the injury risk π_m .

¹⁸ If the fixed employment cost is R , we can write,

$$\text{total labor cost} = RH + WL,$$

where H is the flow of new hires needed to sustain a labor force of L workers. We can relate H to L via,

$$H = (q + \pi)L,$$

The marginal prevention cost curve, $-S'$, and the marginal accident cost curve, C'_a , are shown in Figure 3. From the firm's viewpoint, an equilibrium injury rate $\hat{\pi}$ is attained when $-S' = C'_a$.

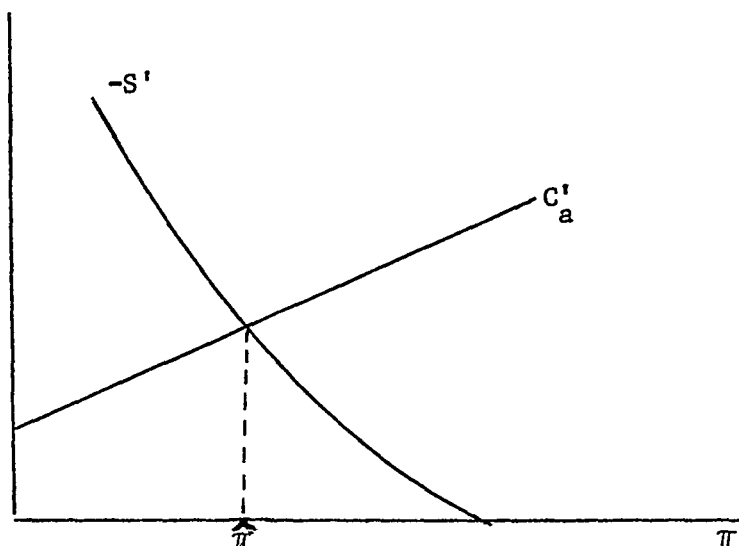


FIGURE 3

If workers do not fully incorporate the costs to them of higher injury risks, $W'(\pi)$ will be close to zero implying a downward shift and a flattening of the C'_a curve. In this event, $\hat{\pi}$ will climb because employers have less incentive to spend resources on safety. To the extent that the wage structure, $W = W(\pi)$, does not fully incorporate the accident costs to workers, the equilibrium injury rate $\hat{\pi}$ exceeds a socially optimal injury rate π^* . It is believed that workmen's compensation brings us closer to socially optimal injury risks because a firm's premium costs are linked to its injury experience, at least for the largest firms.¹⁹ Two remarks are in order

where q is the quit rate and π is the injury rate. Notice that the quit component of total labor costs, RqL , has been omitted in equation (2). I have skimmed over some rough edges of this model including (a) that the injury risk must be converted to annual losses of workers, and (b) that if injuries only involve temporary disabilities, the fixed cost of replacing injured workers will be below R . The importance of fixed employment costs is more fully discussed in Oi, *Labor as a Quasi-fixed Factor*, 70 J. POL. ECON. 538 (1962). The parameter F is the sum of R and the material cost M . Finally, the relationship, $W = W(\pi)$, should strictly only pertain to that part of the wage rate that consists of the risk premium. The convex shape of the C_a curve in Figure 2 incorporates the assumptions that,

$$\frac{dW}{d\pi} = W'(\pi) > 0, \quad \frac{d^2W}{d\pi^2} = W''(\pi) > 0.$$

In terms of the discussion in Part I, if W_0 is the wage in a riskless industry (with $\pi_0 = 0$), then we have,

$$W(\pi) = \left(\frac{1}{1-\pi h} \right) W_0,$$

which yields the desired convex shape for C_a .

¹⁹ This argument is more fully developed in Russell, *Pricing Industrial Accidents*, in 3 NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, SUPPLEMENTAL STUDIES FOR THE

here. First, if the premium costs—which are merely a portion of the accident costs to injured workers—comprise only a small part of the marginal accident costs, even a full assignment to firms of costs to victims will lead to only a small shift in C'_a , meaning only a small change in equilibrium injury rates $\hat{\pi}$.²⁰ Second, if the compulsory partial insurance under workmen's compensation is a close substitute for private insurance (purchased by either the worker or employer), any change in benefit levels under workmen's compensation will simply result in a substitution of public for private insurance with very little change in the risk structure of wage costs, $W = W(\pi)$.

This model can also be used to analyze how a change in the size of a firm's labor force L will affect $\hat{\pi}$. Equation (4) tells us that a rise in L will lead to upward shifts in both the marginal accident cost C'_a and accident prevention cost $-S'$ curves. The upward shift in C'_a will be directly proportional to the increase in L , but the magnitude of the shift in $-S'$ depends on the properties of equation (1). If there are increasing returns to accident prevention as many allege (meaning that if S and L were increased by the same proportion, π would fall), the $-S'$ curve rises by less than the rise in L . In this event, the equilibrium injury risk $\hat{\pi}$ will fall as the size of the labor force is increased. To the extent that technical properties of joint production functions for goods and injuries vary across industries and occupations (and possibly even over time), we should expect to observe variations in equilibrium injury rates. The important question is, however, under what conditions will these equilibrium injury risks correspond to socially optimal work injury risks?

If, for the moment, we assume that the fraction of accidents due to contributory negligence by workers is the same in all industries and is unaffected by employer actions, I believe that two conditions must be met to realize the equality between equilibrium and socially optimal injury risks. First, the marginal accident cost curve, C'_a , must represent the social costs of additional increments to risk that are incurred by injured workers and by injured employment sites. This condition will be met if the risk structure of wage cost, $W = W(\pi)$ incorporates all accident costs to victims and if F is equal to the social costs of replacing injured workers and repairing damaged employment sites. Second, firms must be efficient in the provision of accident prevention; otherwise, the $-S'$ curve will not represent the social costs of accident prevention. It is sometimes argued that ill-informed employers are unaware of the technology of accident prevention or its effectiveness. This argument can be translated into the curves of Figure 3. The ill-informed firm perceives a $-S'$ curve that is to the right of the true marginal accident prevention cost curve. Given this misperception, the firm spends too little

NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS 27 (1973). The internalization of the compensation costs offers a partial explanation for the variations in injury rates across establishment size groups, but it cannot explain why the smallest establishments in many industries have lower injury rates than middle-sized establishments.

²⁰ Surry states that the indirect costs (of damaged machinery, lost labor time by supervisors and fellow-workers, output losses, and so on) may be two to five times the workmen's compensation costs for an accident. J. SURRY, *INDUSTRIAL ACCIDENT RESEARCH: A HUMAN ENGINEERING APPRAISAL* (1971). Her estimates are in line with those reported by Simonds and Grimaldi. R. SIMONDS & J. GRIMALDI, *SAFETY MANAGEMENT, ACCIDENT COST AND CONTROL* (1963).

on safety resulting in an equilibrium risk $\hat{\pi}$ that exceeds the optimal risk. Such firms can either be induced to allocate more resources to safety (through persuasion or public information programs) or be coerced to do so by the imposition of mandatory safety standards backed by inspection enforcement. But in discussing optimality, we cannot ignore my earlier assumption of proportional contributory negligence.

The blame for the current industrial accident toll must be shared by employers and workers. Work injury risks surely depend on the safety characteristics of both work environments and workers. The risks can be affected by a worker's physical and mental health, his exercise of care on the job, or the matching of job and personal attributes—all factors that can best be controlled by the worker.²¹ It might well be the case that the work injury toll could be even more sharply reduced by policies which tried to affect worker conduct. According to a recent Wisconsin study, nearly 45 per cent of the industrial accidents in their sample were due to dysfunctional acts by workers (what might have been called contributory negligence), while less than 25 per cent were due to identifiable physical hazards.²² Accident researchers agree that both work environment and worker behavior are important contributing factors, but without good empirical evidence, they cannot agree on the relative importance of each. In formulating industrial safety policies, we have shied away from policies that try to impose costs on dysfunctional acts by workers.²³ If the workers' estimate of the private accident and accident prevention costs to them are below the social costs, there is a clear possibility that they will not exercise enough care, resulting in higher equilibrium injury risks.

²¹ In chapter 4, Surry provides us with a summary of numerous studies that relate work injury rates to the physical health and psychological attributes of workers under various environmental conditions. J. SURRY, *supra* note 20. Some studies relate smoking, alcoholism, and drugs to the incidence of industrial accidents, and I suspect that these factors are even more closely correlated with the incidence of occupational diseases. If my suspicion is correct, it raises an interesting legal issue; can an employer be sued for discriminatory hiring practices if he denies employment to a worker who smokes? Some data contained in a brief report by Simonds suggests that a firm's overall injury rate is inversely correlated with the percentage of its labor force that is married; that is, single and divorced individuals may be innately less safe. Simonds, *OSHA Compliance: "Safety Is Good Business"*, 50 PERSONNEL, July-Aug. 1973, at 30. Before I believe this conjecture, I would very much want to control for other variables such as age, sex, length of time on the job, and occupation.

²² See WISCONSIN STATE DEP'T OF LABOR, INDUSTRY, AND HUMAN RELATIONS, INSPECTION EFFECTIVENESS REPORT (1971). In the conclusions to this study, the authors propose that since inspections can only correct easily identifiable hazards like the absence of a safety guard (and if the guard is removable, the inspections cannot compel the firm always to use the guard; that is, physical hazards are often transitory in nature), a policy of safety instruction and information to workers might be more effective in lowering the frequency of work-related injuries.

²³ Aside from exceptions under union contracts and firm-initiated supplemental fringe benefits, the wage losses due to disabling work injuries are typically shared under current state workmen's compensation laws. I believe that there are at least two reasons why public policies do not try to control injury risks by increasing the share of accident costs borne by the worker or by imposing minimum negligence standards on worker conduct. First, such policies often involve a conflict between the objectives of equitable compensation to victims and reduction of industrial accidents. Second, the administrative and enforcement costs of a minimum negligence standard on worker conduct may be (or at least imagined to be) inordinately high. One could add a possible third reason, namely that such policies which try to affect worker behavior are likely to be ineffective anyway.

The model of equilibrium injury rates set forth here is one of partial equilibrium. A more sophisticated model has been developed by Thaler and Rosen.²⁴ Given some risk structure of wage costs, $W = W(\pi)$, each worker is assumed to choose that combination of a wage rate and injury risk that maximizes his expected utility. The distribution of workers who confront different risks π thus depends on worker preferences and the shape of the risk structure of wages $W(\pi)$. Conversely, given any risk structure $W(\pi)$ firms choose that combination of (W, π) which, given their accident prevention functions, maximizes profits. The supply prices of workers reflecting their risk premiums for added risks, and the offer prices of firms which reflect their ability to avoid accident costs, jointly determine an equilibrium risk structure of wage rates, $W = W(\pi)$.²⁵ Neither my model nor the Thaler-Rosen model adequately copes with the general equilibrium problem. If consumer preferences shift so that at prevailing "prices" consumers want garbage collected thrice weekly, this increase in consumer demands will lead to more industrial accidents as more workers are attracted into the hazardous industry of refuse collection. When the private and social costs of accidents and accident prevention are the same (as viewed by employers and workers), the rise in disabling work injuries due to a larger demand for garbage collection will be socially optimal.

III

SOME EMPIRICAL EVIDENCE ON INDUSTRIAL SAFETY

Good empirical studies are neither necessary nor sufficient for the evolution of public policy. Sensational reports about tragic events and anecdotal evidence are often more effective in eliciting legislative action. Indeed, the paucity of pertinent and reliable data poses a serious problem for anyone even attempting to measure accident and accident prevention costs. The published injury statistics are, however, quite informative and reveal some striking empirical regularities. In this section, I present some of these empirical regularities and try to interpret them in the light of a model of equilibrium injury risks.²⁶ Two caveats about the published data are in order before beginning: work injuries are defined according to the Z16.1 standard,²⁷ and the reporting of injury data to the Bureau of Labor Statistics

²⁴ R. Thaler & S. Rosen, *supra* note 7.

²⁵ The Thaler-Rosen model is based on a theory of hedonic prices developed by Rosen. Rosen, *Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition*, 82 J. POL. ECON. 34 (1974). In equilibrium, $W = W(\pi)$ must be an increasing function of π ; that is, $W'(\pi) > 0$. Some writers such as O'Connell assert that even fully informed workers do not trade-off higher wages for larger injury risks. According to O'Connell, workers are deterred from hazardous jobs only by the fear of injury. O'Connell, *Elective No-Fault Liability Insurance for All Kinds of Accidents: A Proposal*, INS. L.J., Sept. 1973, at 495. As I remarked in the Introduction, one cannot identify the underlying motives by asking workers why they chose particular jobs.

²⁶ The materials here are mainly condensed from two earlier studies, Oi, *supra* note 7; Oi, *Economic and Empirical Aspects of Industrial Safety* (forthcoming, currently on file with the author).

²⁷ See note 1 *supra*. Under nearly all state laws, a compensable work injury is one "arising out of and in the normal course of employment" which is a superficially straightforward def-

prior to 1971 was entirely voluntary.²⁸ It has been argued that the Z16.1 standard grossly understated the true number of work injuries, while the voluntary reporting induced some measurement errors.²⁹ While the BLS injury statistics undoubtedly do contain measurement errors, they nevertheless appear to be sufficiently accurate for our purpose—description of the major variations in work injury rates.

A. Secular Trends in Work Injury Rates

Attention is first directed to the data on accidental deaths. According to the National Safety Council, accidents of all types accounted for 6 per cent of all deaths in 1970.³⁰ The overall accidental death rate per 100,000 population (including motor vehicles, home, and work) fell from 80.8 in 1929 to 56.0 in 1970.³¹ The secular decline was even sharper for the work fatality rate per 100,000 employed persons which fell from 42.0 to 18.1 between 1929 and 1970.³² One of every five accidental deaths in 1929 occurred at work, and this figure was one in every eight by 1970.³³ Improvements in medicine and industrial safety, as well as a changing composition of employed persons, all contributed to this sharp reduction in industrial fatalities.

The conclusion that there has been a substantial secular improvement in industrial safety is confirmed by the total work injury frequency rate for all manufacturing for the period 1926-60. The conclusion does not stand up as well when the data are extended to 1970 or when they are disaggregated. In Table I, the BLS injury rate data for selected industries over the period 1949-70 is presented. Some industries, such as logging and highway construction, have exhibited steady reductions in injury rates while others, such as meat packing and retail trade, have become more hazardous over time. While explanations may be attempted for trends in specific industries—for example, construction has become safer because of the mechanization of many materials handling and lifting operations—such attempts do not come to grips with a model of equilibrium injury rates. In addition to these secular trends, Kossoris has shown that there is a definite cyclical pattern.³⁴

initiation. An example illustrates the complexities not only with respect to the compilation of statistics but also to the litigations over contested claims. In climbing out of his car, Smith steps on a rock and sprains his ankle. If his car was parked in a lot that was owned or leased by his employer for the use of employees, Smith's sprain is a compensable work injury. However, if Smith parked his car in a public parking lot, the sprained ankle cannot be included as a work injury statistic and is ineligible for any compensation benefits.

²⁸ The BLS data on employment, hours, and earnings are also based on establishment reports that are voluntarily supplied to BLS. The industry-wide aggregates and averages that are published are, however, weighted sums and means where sampling methods are employed in deriving the weights.

²⁹ J.B. GORDON, A. AKMAN & M. BROOKS, *INDUSTRIAL SAFETY STATISTICS: A RE-EXAMINATION* (1971).

³⁰ NATIONAL SAFETY COUNCIL, *ACCIDENT FACTS* 18 (1970).

³¹ *Id.* More detailed data for intervening years as well as the age/sex breakdown of work fatalities can be found in Oi, *supra* note 7, at 101-02, Tables 5.1 & 5.2.

³² NATIONAL SAFETY COUNCIL, *ACCIDENT FACTS* (1970).

³³ *Id.*

³⁴ KOSSORIS, *Changes in Injury Frequency Rates and Employment in Manufacturing, 1936-41*, 56 MONTHLY LAB. REV. 949 (1943); Kossoris, *Industrial Injuries and the Business Cycle*, 46 MONTHLY LAB. REV. 579 (1938).

Work injury rates are positively correlated with economic activity, rising in the upswing and falling in the downswing.³⁵

TABLE I
INJURY FREQUENCY RATES FOR SELECTED INDUSTRIES, 1949-70
(rates per million man-hours)

Industry	1949	1960	1965	1970
<i>Manufacturing</i> ¹	15.0	12.0	12.8	15.2
Meat packing	23.2	25.4	35.4	46.9
Canning and preserving	20.8	22.6	23.1	25.7
Logging	92.2	58.8	52.6	42.4
Structural clay products	36.8	31.1	32.8	30.5
Motor vehicles	6.7	3.3	2.3	2.0
<i>Non-manufacturing</i>				
Highway construction	45.5	35.0	30.6	28.9
Public warehousing	31.2	28.8	26.0	31.1
Banking	2.4	2.4	2.2	2.4
Retail general merchandise	5.1	6.8	7.8	8.0

Source: U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1735, HANDBOOK OF LABOR STATISTICS 1972, at 361, Table 163 (1972); U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1016, HANDBOOK OF LABOR STATISTICS, 1950 EDITION 180, Table G-4 (1951).

¹ Historical data for all manufacturing from Table G-3 were as follows:

1926	24.2
1930	23.1
1935	17.9
1940	15.3
1945	18.6

U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. NO. 1016, HANDBOOK OF LABOR STATISTICS, 1950 EDITION 179 (1951).

B. The Industrial Dispersion of Injury Rates

The data appearing in several special BLS studies of specific industries suggest that the dispersion of work injury risks across occupations within a given industry is considerably larger than the dispersion of industry-wide rates across industries. However, since the available data are reported on an industry basis, researchers have emphasized the industrial dispersion.

³⁵ It is beyond the scope of this paper to try to explain the mixed patterns exhibited by the time series data where injury frequency rates are falling in some industries, rising in others, and following other time paths in still other industries. Berkowitz has argued that the secular decline in the injury rate for manufacturing is a response to the rising cost of industrial accidents. Berkowitz, *Allocation Effects of Workmen's Compensation*, in INDUSTRIAL RELATIONS RESEARCH ASSOCIATION, PROCEEDINGS OF THE TWENTY-FOURTH ANNUAL WINTER MEETING 342 (1971). However, his measure of the accident cost is the real wage rate (the ratio of average hourly earnings in manufacturing to the consumer price index). His model cannot explain the reversal in the trend from 1960 to 1970, nor can it explain the rising trend in meat packing or canning and preserving. Although Smith provides us with a somewhat better model, Smith, *Intertemporal Changes in Work Injury Rate*, in INDUSTRIAL RELATIONS RESEARCH ASSOCIATION, PROCEEDINGS OF THE TWENTY-FIFTH ANNIVERSARY (ANNUAL WINTER) MEETING 167 (1973), I have argued that we still do not have a satisfactory model which explains the time series variations in work injury rates. Oi, *supra* note 26, pt. III.

Anyone who has studied the BLS injury statistics knows the magnitude of the industrial dispersion. To cite but a few figures, the injury rates per million man-hours in 1970 were 2.4 in banking, 63.9 in refuse collection, 8.0 in retail trade. Further, the time series data exhibit a strong autocorrelation; that is, the high injury rate industries in 1960 were also the high injury rate industries in 1970. Given the strong temporal stability in the ranking of industries by injury frequency rate, workers should have fairly good ideas about relative injury risks.³⁶

C. Age and Sex Differentials

That the incidence of industrial accidents is systematically related to the age and sex of the worker has been empirically established.³⁷ By using the work injury and employment data for California, estimates of injury frequency rates per 1,000 employed persons by sex for eight age groups have been constructed. These data for 1960 and 1968 are presented in Table II. If the injury rates for the youngest and oldest age groups are ignored,³⁸ Table II reveals a clear age profile of male injury rates which fall with increasing age. The injury rate in 1968 for 20-24 year old males was roughly twice as high as that of males 45 and older. The female age profiles are essentially flat tending to rise slightly with age. It will also be noticed that over all ages, males are three times as likely to be injured at work as females.

TABLE II
NON-FATAL INJURY RATES BY AGE AND SEX:
CALIFORNIA, 1960 AND 1968
(rate per thousand employed persons)

Age Group	Males		Females	
	1960	1968	1960	1968
14-17	19.1	17.6	5.3	5.1
18-19	52.2	54.6	9.4	11.0
20-24	50.6	50.2	9.2	11.0
25-34	37.1	39.8	10.8	11.7
35-44	31.0	29.9	11.7	12.3
45-54	29.1	26.2	13.2	13.6
55-64	26.7	25.5	12.4	12.1
65 and over	16.0	13.2	7.1	6.6
All Ages	34.8	34.5	12.0	12.4

Source: Constructed from data in CALIFORNIA STATE DEPT OF INDUSTRIAL RELATIONS, CALIFORNIA WORK INJURIES (1970); 1 U.S. BUREAU OF THE CENSUS, DEPT OF COMMERCE, 1970 CENSUS OF POPULATION pt. 6, § 2, at 2117, Table 187 (1973).

³⁶ They may not be able to express their estimates in terms of injury frequency rates, severity rates, or probabilities, but they probably know that on the average, trucking and fire prevention involve more hazards than say auto assembly or aluminum extrusions. In the Michigan Survey Research Center study, there was a close positive correlation across industries between the workers' perception of injury risks and the percentage of workers actually injured. MICHIGAN SURVEY RESEARCH CENTER, SURVEY OF WORKING CONDITIONS (1970).

³⁷ See, e.g., J.B. GORDON, A. AKMAN & M. BROOKS, *supra* note 29; Kossoris, *Relation of Age to Industrial Injuries*, 51 MONTHLY LAB. REV. 789 (1940).

³⁸ The injury rates of Table II are not comparable to the BLS rates per million man-hours

The total injury frequency rates conceal the composition of work injuries. At least two studies have shown that the percentage of serious injuries climbs with age. According to the 1965 California data, the work fatality rate per 100,000 employed persons was only 14.4 for the 20-24 age group compared to an overall fatality rate of 19.5; the rate for the 50-54 age group was 21.6.³⁹ Data from workmen's compensation files for New York City for 1955-56 have been used to estimate a truly serious injury frequency rate of 1.45 per million man-hours which ranged from 1.14 for the 20-24 age group to 1.92 for the 45-49 age group.⁴⁰ The nimble young man is far likelier to be injured at work, but his health and youth somehow enable him to avoid being seriously maimed or killed.

The observed age/sex differentials in work injury rates revealed by Table II (and corroborated by other data sets) could have been generated by several structural forces. Age and sex can properly be viewed as proxy variables that happen to be correlated with systematic differences in such causal factors as (1) innate accident liability, (2) perceived costs of work injuries, (3) attitudes toward risk-bearing, (4) occupational and industrial affiliation, or (5) job experience.

The first explanation argues that, other things being equal (the industry, occupation, firm, safety of the work site, fellow workers, and so on), certain workers are innately more liable to be involved in industrial accidents. Most safety researchers reject the thesis of accident proneness,⁴¹ but it is difficult to separate reckless behavior, job inexperience, and misperceptions of accident costs from an innate attribute of accident proneness. I am unaware of any empirical study which has convincingly presented a test of the hypothesis that the innate injury risks are the same for young versus old males or males versus females.

According to a second model, workers distribute themselves across jobs of varying riskiness by weighing the benefits of higher pay (due to risk premiums) against their perceived costs of being injured, $C = \pi\gamma$. Individuals with lower perceived costs (due either to a low subjective estimate of the injury risk π or a low cost of being injured γ) will tend to be concentrated in the more hazardous jobs. Bits of casual evidence lend some support to this model. The ratio of serious to total work injuries and the duration of temporary disability both rise with increasing age implying that the cost per injury γ will be higher for older workers. The allegation that young men are more reckless and embrace a philosophy of "those things happen to the other

of exposure. If the California rates per 1,000 workers are divided by two (1,000 employee years are approximately equal to two million man-hours), the California rates can be converted to the BLS measure of injury frequency rates. To the extent that the youngest, 14-17, and oldest, 65 and over, age groups contain larger fractions of part-time employees, average annual man-hours per employee will be lower imparting a downward bias in the injury frequency rate per million man-hours. I assume that the variations in annual man-hours per employee across the six middle groups is small.

³⁹ These data were compiled by Gordon and his co-workers, J.B. GORDON, A. AKMAN & M. BROOKS, *supra* note 29, and were reproduced in Oi, *supra* note 7, at 94.

⁴⁰ Jaffe & Day, *Some Illustrative Rate Tables on Seriously Disabling Work Injuries*, in BUREAU OF APPLIED SOCIAL RESEARCH, RESEARCH CONFERENCE ON WORKMEN'S COMPENSATION AND VOCATIONAL REHABILITATION 83 (A. Jaffe ed. 1973).

⁴¹ See J. SURRY, *supra* note 20, at 155-68, for a critical discussion of this point.

guy," suggests that they would underestimate injury risks. The model is, however, less plausible in explaining the sex differential.

That individuals differ in their attitudes toward risk-bearing is surely correct. Other things being equal, risk averse workers would choose safer jobs even though this meant lower but more stable wage incomes. Individuals in our economy express their attitudes toward risk-bearing in many ways, of which their choice of more or less risky employment is but one. The behavior of young males suggests that they have the least risk aversion and may indeed prefer risk. They drive fast, ride motorcycles, engage in crime, and buy little insurance relative to older males and females. Choosing riskier jobs fits into this general behavioral pattern, but its quantitative importance is a matter of conjecture.

The industrial and occupational distribution of female workers is very different from that of males. Females are more heavily concentrated in the safer clerical jobs, and even as blue-collar workers in manufacturing they tend to be in the safer industries. Aggregation over these different distributions could thus generate a substantial sex differential in economy-wide injury rates even if the injury risks were the same for the two sexes in each industry and occupation.⁴² But this explanation fails to answer the question of why females end up in the safer industries. A complete analysis must develop a theory of occupational choice in which injury risk is only one of several factors.⁴³ I had initially conjectured that part of the difference in injury rates between young and old male workers might be due to differences in the industrial distribution of employment. An examination of the California injury data revealed, however, that the shapes of the age profile (with injury rates monotonically declining with age) were the same in contract construction, manufacturing, and transportation/public utilities.⁴⁴

Finally, age and sex differentials in work injury rates may be due to age and sex differences in job experience. In the next section the empirical evidence showing that injury risks are higher for new, inexperienced workers is discussed. To the extent that labor turnover rates are higher for young males, they will, on average, have less job experience and hence confront higher injury risks.

D. Labor Turnover and Injury Risks

Labor turnover provides us with what I regard as the most convincing explanation for the cyclical fluctuations in work injury rates. A simple learning model could generate an inverse relationship between injury risks and job experience as measured by the length of time that a worker has been on

⁴² Surry cites several wartime studies of injury risks on manufacturing production jobs, welders, assembly, and so forth. These showed that given job experience, females, if anything, had higher work injury rates. *Id.* at 13. It would be useful to assemble more recent data to verify this finding.

⁴³ Comparative advantage must surely influence job choices. Men are relatively better at jobs requiring physical strength. Sex discrimination may affect not only pay for the same job but also availability of types of jobs; employers may simply refuse to hire women for hazardous jobs.

⁴⁴ It should be pointed out that the heights of the age profiles differed, being higher in construction. The estimated injury frequency rates can be found in Oi, *supra* note 26, at Table 2.5.

a particular job. Given the characteristics of the work environment and fellow workers, industrial accidents result from errors by the worker. Newly hired workers who are unfamiliar with their jobs and the peculiarities of the work site are far more likely to commit errors of which some will result in disabling injuries. As they gain experience, the frequency of errors (and hence injuries) falls. The direct empirical evidence indicates that the injury rates of workers with one month of job experience are one and a half to two times as high as the rates for workers with six months of job experience.⁴⁵ Implications with respect to both cross-sectional and time series variations in injury rates can be derived from this inverse relationship.

An increase in the accession rate during a period of rising employment means that the firm's labor force will, on average, have less job experience, implying an increase in the overall work injury rate. Most time series regression models do, indeed, reveal significant positive correlations between the injury frequency rate and the accession (or new hires) rate even when other variables are included in the equation.⁴⁶ These time series regressions provide additional indirect evidence supporting the hypothesis that job experience (which is related to labor turnover) is an important factor.

The cross-sectional implications are even more suggestive. Consider two firms in the same industry with identical joint production functions. Firm A adopts personnel policies which reduce labor turnover so that inexperienced workers with less than one year of job experience comprise only 10 per cent of A's labor force.⁴⁷ Conversely, firm B with its higher turnover rate ends up with 40 per cent inexperienced workers. If the injury rate of inexperienced workers is twice as high as that of experienced, the injury rate for firm B's labor force will be 27.3 per cent higher than that of A. Although the height and shape of the relationship between injury rates and job experience will depend on the technology of production, safety outlays, and so on, part of

⁴⁵ Using data from two earlier studies, L. CHANEY & H. HANNA, *THE SAFETY MOVEMENT IN THE IRON AND STEEL INDUSTRY, 1907 TO 1917* (BLS Bull. No. 234, 1918), and Van Zelst, *The Effect of Age and Experience on Accident Rate*, 38 J. APP. PSYCH. 313 (1954), Surry depicts these inverse relationships for two industrial plants. J. SURRY, *supra* note 20, at 14. It is not a surprising empirical finding. The faculty advisor to a student sailing club informed me that "[i]f a kid is going to tip over a boat, 95 times out of 100, he'll do it within the first 300 yards from the dock." We do not have the requisite data to determine an appropriate measure of job experience. Is it the individual's time on a specific job with a particular firm, his experience in a particular occupation (for example, lathe operator), or simply general work experience in the labor force? It should also be noticed that the existence of a stable inverse relationship between injury rates and job experience would generate age differentials wherein younger workers suffer higher work injury rates.

⁴⁶ A regression model for the manufacturing sector can be found in Smith, *supra* note 35, and for two-digit manufacturing industries in Oi, *supra* note 26, at pt. III. My preliminary results suggest that the response of injury rates to changes in the accession rate differs across industries; this latter finding is not surprising if different industries confront different joint production functions for injuries and goods.

⁴⁷ Personal attributes such as marital status, sex, age, and so on may be closely correlated with job tenure. If so, a firm could affect its turnover rate by adopting a selective (possibly discriminatory) hiring policy. Pencavel and Oi have argued that a firm can reduce turnover by paying higher wages. See J. PENCAVEL, *AN ANALYSIS OF THE QUIT RATE IN MANUFACTURING INDUSTRY* (1970); Oi, *supra* note 18. It is my understanding that under the 1973 United Auto Workers contracts, new workers who remained with the company for six months would be rewarded by pay incentives. This feature was introduced by management for the express purpose of reducing the high costs of labor turnover.

the high injury rates in logging or canning and preserving is undoubtedly due to the seasonal nature of employment resulting in high labor turnover rates. Previous attempts to measure the costs of labor turnover have ignored the fact that accident costs are positively correlated with labor turnover. The implementation of policies that encourage lower labor turnover may, in the end, be even more effective in reducing industrial accidents than federally mandated safety standards and inspections.

E. The Establishment Size Profile

A number of researchers have directed our attention to the wide dispersion in work injury rates across establishment size categories.⁴⁸ In a recent study⁴⁹ I found that, except for printing and publishing, the relationship between injury rates and establishment size (hereafter called the establishment size profile) for the twenty two-digit manufacturing industries⁵⁰ could be described by either (1) an inverted U-shaped curve with the smallest and largest establishments reporting lower injury rates or (2) a monotonically declining curve with the largest establishments being the safest. The magnitudes of the injury rate differentials were impressively large. These size profiles for five industries (based on unpublished BLS data for the period 1968-70) are presented in Table III. In the primary metals industry, workers in establishments with 50 to 99 employees suffered an injury frequency rate that was 19 times larger than that of workers in establishments with 2,500 or more employees; the corresponding ratio in transportation equipment was 16. It has been alleged that, under the Z16.1 standard, the reported injury statistics for large firms were biased downward because workers with minor injuries were simply transferred to less arduous jobs within the same large firm and were never reported as being injured. If true, the percentage of serious injuries (which excludes temporary disabilities of 1-3 days duration) should be higher for larger firms. The data in the bottom panel of Table III tend to confirm this allegation, but the magnitude of the differences in these percentages is small.

The shape and dispersion of injury rate differentials are maintained when the data are disaggregated into finer industry classifications. The injury rate differentials across size categories within an industry are frequently larger than the injury rate differentials across industries holding establishment size constant. The mixed pattern of these profiles (most exhibiting the inverted U-shape and a large minority exhibiting the declining

⁴⁸ See, e.g., J. SURRY, *supra* note 20; Russell, *supra* note 19.

⁴⁹ Oi, *supra* note 26.

⁵⁰ The Standard Industrial Classification (SIC) was developed to promote "uniformity and comparability in the presentation of statistical data collected by various agencies of the United States Government, State agencies, trade associations, and private research organizations." EXECUTIVE OFFICE OF THE PRESIDENT, OFFICE OF MANAGEMENT AND BUDGET, STANDARD INDUSTRIAL CLASSIFICATION MANUAL, 1972, at 9 (1972). The classification makes use of a numerical scheme to differentiate among industries depending on the level of detail required; there are eleven divisions (A-K) which are further divided into major groups (two-digit codes), industry groups (three-digit codes), and industries (four-digit codes).

profile) reveals that workers in the smallest establishments do not always confront the largest injury risks.

TABLE III
INJURY FREQUENCY RATE AND PERCENTAGE OF SERIOUS INJURIES
(by establishment size for five industries, 1968-70)

Establishment with an Avg. Employment	Food 20.	Textile Mills 22.	Primary Metals 33.	Machinery 35.	Transportation Equipment 37.
<i>Injury frequency rate Y</i> (per million man-hours)					
1-19	17.90	9.27	30.13	15.10	25.97
20-49	27.00	13.00	46.97	20.20	32.67
50-99	32.67	15.60	53.60	22.53	35.80
100-249	32.97	16.87	47.17	23.87	34.87
250-499	30.83	11.93	34.97	19.67	23.73
500-999	20.97	7.33	19.13	14.47	14.77
1,000-2,499	19.17	5.97	10.10	12.90	8.47
2,500 or more	16.90	3.63	2.73	5.07	2.83
<i>Percentage of serious injuries S</i>					
1-19	61.9	63.4	61.8	71.6	51.4
20-49	56.9	66.7	59.4	55.0	55.8
50-99	57.1	61.0	60.9	56.2	52.7
100-249	62.2	69.0	65.1	59.1	59.4
250-499	64.1	71.1	71.9	65.2	70.6
500-999	71.9	76.0	79.3	68.9	74.9
1,000-2,499	76.1	77.2	86.9	73.4	77.0
2,500 or more	66.9	76.1	86.3	84.9	90.6

Source: Oi, *Economic and Empirical Aspects of Industrial Safety* (forthcoming, currently on file with the author).

Several hypotheses can be advanced to explain the lower injury frequency rates for larger establishments. The larger manufacturing establishments may (1) have lower labor turnover rates, (2) have larger fractions of employees in the safer clerical and sales occupations, (3) hire fewer young males, (4) substitute capital for labor in particularly dangerous operations, and so on. Further, in the context of the model outlined in Part II, the larger firms may be more efficient in producing accident prevention or may confront a higher marginal accident cost curve. We do not have published data by establishment size on labor turnover rates and the composition of employed persons⁵¹ thereby precluding meaningful tests for the first set of hypotheses. We have some fragmentary data for New York on the inputs of safety and medical personnel. According to the 1972 New York data for all

⁵¹ Data on the percentage of workers in nonproduction jobs (mainly supervisory, clerical, and sales) are available by size from the *Census of Manufactures*. I had anticipated that the larger the percentage of workers in the safe nonproduction jobs, the lower would be the injury rate for all workers. A regression model to test this hypothesis yielded implausible results generally opposing my prior anticipations. See Oi, *supra* note 26, at Table 4.6. The broad categories of production versus nonproduction workers may conceal a considerable heterogeneity of the detailed occupations and jobs within each.

industries,⁵² 15.0 per cent of all establishments employed some safety personnel. The percentage climbs with establishment size rising from 7.6 per cent for establishments with 100-249 employees to 37.5 per cent for establishments with 10,000 or more employees. The 1,023 respondents who had some safety personnel employed a total of 2,033 safety workers of whom only 38.8 per cent were classified as safety engineers or industrial hygienists. In addition, the ratio of safety workers to all employees (adjusted for the percentage of establishments with safety personnel) fell with increasing size. If there are increasing returns to safety personnel, the New York data could help to explain the lower injury rates of larger firms, but the implied productivity of safety workers is implausibly large. Finally, I am unable to explain the lower injury rates for the smallest establishments with the available data on the input of safety personnel and the percentage of nonproduction workers.⁵³

TABLE IV
INJURY FREQUENCY RATES FOR SELECTED INDUSTRIES
(rates per million man-hours)

Industry	1960	1965	1970
<i>Five target industries</i>			
176 Roofing and sheet metal work	40.8	45.9	43.0
201 Meat products	29.3	37.0	43.1
24 Lumber and wood products	38.0	36.0	34.1
379 Misc. transportation equipment	—	31.6	33.3
4463 Marine cargo handling	—	68.8	—
<i>Other industries</i>			
161 Highway and street construction	35.0	30.6	28.9
203 Canned and preserved fruits and vegetables	22.6	23.1	25.7
371 Motor vehicles and equipment	5.2	4.7	5.3
3732 Boat building and repairing	29.5	36.1	35.2
422 Public warehousing	28.8	26.0	31.1
9349 Refuse collection	46.7	53.8	63.9
9390 Police	34.1	43.1	45.6
9390p Fire protection	33.4	31.4	41.7

Source: U.S. BUREAU OF LABOR STATISTICS, DEP'T OF LABOR, BULL. No. 1735, HANDBOOK OF LABOR STATISTICS 1972, at 361, Table 163 (1972).

Under the OSHA inspection program, five target industries have been singled out as being especially hazardous. The basis for choosing these industries is unclear. Table IV presents the published BLS injury rates for the

⁵² The New York data was based on 6,836 voluntary responses to a mail survey of establishments employing 100 or more employees. NEW YORK STATE DEP'T OF LABOR, HEALTH AND SAFETY PERSONNEL IN INDUSTRY IN NEW YORK STATE (1972). These data are reproduced in Oi, *supra* note 26, at Table 4.10.

⁵³ The presumably close personal relationships between employer and employees in the smallest establishments has been offered as a conjectural hypothesis to explain the inverted U-shaped size profile. That worker moral and the social climate of the work environment matter has been studied by psychologists.

five target industries as well as rates for other arbitrarily selected industries. If one looks only at these industry-wide averages, the injury rates in the target industries are well above the national average for all industries which, in 1970, probably involved an injury rate of 12 to 14 per million man-hours. In addition to local government enterprises such as refuse collection, police, and fire protection which are shown in Table IV, many of the mining industries entail risks that are considerably higher than those included in the target group.⁵⁴ Furthermore, the use of industry membership as the basis for inclusion in a target group can be misleading. In 1970, the injury frequency rate for blast furnaces (SIC 331) was only 6.5, but employees in establishments with 50 to 99 employees suffered an injury rate of 48.7.

TABLE V
INJURY STATISTICS FOR THE FIVE TARGET INDUSTRIES: 1966-70*
(classified by establishment size)

Industry	Estabs. with Avg. Employment of:			
	1-99	100-999	1,000 or more	All Sizes
<i>Total injury frequency rate F</i>				
176 Roofing and sheet metal work	44.66	22.99	—	38.38
201 Meat products	42.36	44.83	28.78	39.32
24 Lumber and wood products	42.83	32.91	11.96	35.24
379 Misc. transp. equipment	38.29	35.54	11.37	35.81
4463 Marine cargo handling	54.17	63.90	69.20	62.69
<i>Serious injury frequency rate Z</i>				
176 Roofing and sheet metal work	26.72	12.44	—	22.58
201 Meat products	23.39	27.57	18.61	24.00
24 Lumber and wood products	28.02	23.53	9.33	23.89
379 Misc. transp. equipment	20.57	20.91	8.53	20.49
4463 Marine cargo handling	42.59	58.10	66.30	56.15
<i>Fatality rate D</i>				
176 Roofing and sheet metal work	.206	.081	—	.170
201 Meat products	.029	.041	.024	.034
24 Lumber and wood products	.227	.136	.149	.173
379 Misc. transp. equipment	.061	.128	0	.103
4463 Marine cargo handling	.081	.153	.193	.144

Source: Unpublished files, U.S. Bureau of Labor Statistics, Dep't of Labor.

*All rates are per million man-hours of exposure. The rates for "All Sizes" are weighted averages based on the man-hours data in the raw sample counts. The fatality rates D per million man-hours can be converted to fatality rates per 100,000 employed persons by multiplying them by 200 for all industries, the fatality rate per million man-hours in 1966-70 was around D = .09.

In Table V, I present data on (1) the total injury frequency rate F, (2) the serious injury frequency rate Z which excludes temporary disabilities of one to three days, and (3) the death or fatality rate D per million man-hours of

⁵⁴ Safety in mining is under the control of the Department of the Interior and is thus outside of the jurisdiction of OSHA. Hence, mining industries do not appear in the target group.

exposure for three broad size groups in the five target industries.⁵⁵ When the data were disaggregated into eight size categories, the size profiles of total and serious injury rates followed an inverted U-shape in four industries. The exception was marine cargo handling in which the injury rates (F,Z) tended to climb with increasing firm size. If the voluntary samples can be regarded as random samples, the fraction of total employment in large establishments (with 1,000 or more employees) is considerably smaller in these target industries.⁵⁶ Since the largest firms also happen to be the safest in nearly all industries, the smaller average firm size may account for the high industry-wide injury rates. The injury rate differentials between the largest firms (with 1,000 or more employees) and the rest of the industry are substantial—between a half to a third of the rates for the smaller firms. As I noted earlier, we still do not have a satisfactory explanation for these wide discrepancies in injury risks across size categories within the same industry.

Finally, numerous other empirical regularities can be found in the literature on industrial safety. There is, for example, a diurnal cycle of injury rates wherein work injury risks are highest in the mid-morning and mid-afternoon. Physical fatigue is not a significant factor. The interested reader is strongly encouraged to consult Surry for further details on other factors related to work injury risks.⁵⁷

IV

PUBLIC POLICY TOWARD INDUSTRIAL SAFETY

Legislative actions over the last decade appear to embrace as fact that if left to themselves, competitive labor markets would generate equilibrium injury rates that are, in some sense, non-optimal.⁵⁸ In this section, the theory

⁵⁵ The injury rates shown in Table V are weighted averages of the raw sample data for the period 1966-70. To the extent that the percentage of establishments in each size category which voluntarily supplied injury data to BLS may vary, the weighted averages for "All Sizes" may differ from the published BLS statistics.

⁵⁶ Based on data from 1 U.S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, 1967 CENSUS OF MANUFACTURES ch. 2, Table 2 (1971), 32.8 per cent of all employees in all manufacturing industries were in establishments with 1,000 or more employees. The sample data for the five years, 1966-70, indicated the following percentages of employment in establishments with 1,000 or more employees in the five target industries:

Industry	Per cent in 1,000 + size group
176 Roofing and sheet metal work	0
201 Meat products	31.6
24 Lumber and wood	11.2
379 Misc. trans. equipment	2.5
4463 Marine cargo handling	6.8

Id., ch. 2, Table 3.

⁵⁷ J. SURRY, *supra* note 20.

⁵⁸ It is unclear whether the legislators' concept of optimal work injury risks is the same as that of the economists; that is, injury risks that minimize the sum of accident and accident prevention costs. There are reasons to suspect that the legislators' concept of optimality is some normative concept in which their legislatively perceived "costs" of disabling injuries and diseases far exceed the social "costs."

and evidence developed above are used to analyze two developments:⁵⁹ (1) the recommendations of the NCSWCL with respect to the scope of covered employment and the levels of benefit payments to disabled workers, and (2) programs designed to increase industrial safety which have been adopted by OSHA pursuant to the Occupational Safety and Health Act of 1970.

A. Benefits and Coverage Under Workmen's Compensation

Workmen's compensation is basically a system of compulsory no-fault insurance. If an injury is classified as a compensable work injury, the employer is liable for part of the injured worker's accident costs for medical care, rehabilitation, and wage losses irrespective of who was at fault. Further, the employer is legally compelled to assure the funds for his share of the cost by purchasing insurance from a state insurance fund, private insurance carriers, and for the largest firms, via self-insurance. In return, the employer's liability is ordinarily limited to fixed schedules of benefit payments prescribed under the particular law.⁶⁰ Although the vast majority of workers are presently covered under state or federal workmen's compensation laws, the NCSWCL Report recommended that the scope of covered employment should be expanded to include agricultural workers, domestic servants, and employees of small firms presently excluded. The administrative and transaction costs of expanding coverage are large, and if these administrative costs are included in the cost of accident prevention,⁶¹ it is probable that the NCSWCL proposal for expanded coverage would not lower the sum of accident and accident prevention costs.

By linking premium costs to the firm's industrial accident experience, workmen's compensation is supposed to give employers an incentive to prevent accidents. The higher the share of accident costs to victims that is borne by employers, the greater is this supposed incentive. This argument tacitly assumes that in the absence of workmen's compensation, differences in accident costs will not be reflected in the structure of wage costs facing employers with different injury risks. In this event, the marginal accident cost curve, C'_a in Figure 3 above, will be flat (because $W'(\pi) = 0$ meaning no risk premiums) so that employers have less to gain from investing in accident prevention. The validity of this argument depends on answers to two empirical questions. (1) Are differences in injury risks reflected in the structure of wage costs, $W = W(\pi)$, with riskier jobs commanding higher risk premiums? (2) How does the provision of compulsory workmen's compensation insurance affect $W(\pi)$?

⁵⁹ The historical facts surrounding the evolution of state workmen's compensation laws and the details and programs under recent state and federal legislation are obviously also important, but are subjects beyond the scope of this paper.

⁶⁰ If the injured party can prove that the employer was at fault, he can sue for additional damages in a private legal suit. The employer, however, waives his common law defenses of contributory negligence, assumption of risk, and the fellow-servant doctrine. Even under workmen's compensation, litigations may arise about which injuries or diseases are "compensable." The issue is especially difficult in cases involving industrial diseases.

⁶¹ Calabresi calls them the costs of secondary cost avoidance. G. GALABRESI, *supra* note 6.

Several recent studies have shown that when the effects on wages of age, sex, race, education, and experience are controlled in a regression model, wage rates are systematically higher in occupations or industries that entail larger work injury risks. According to Thaler and Rosen, if the fatality risks could be reduced, the lower risk premium component in wages implies a value to saving a life of roughly \$250,000.⁶² Gordon found that the wage differentials across different Class I railroads were roughly equal to the actuarial value of differences in wage losses due to different injury risks across railroads.⁶³ Although wage rates paid to workers differ from wage costs (by the amount of the fringe benefits and supplements), these studies strongly support the existence of a risk structure of wages, $W = W(\pi)$ with $W'(\pi) > 0$.

Protection against the contingent costs of disabling work injuries can be provided by either public or private insurance. Workmen's compensation and Social Security are the two principal sources of public insurance. If these fail to cover all accident costs, they can be supplemented by private insurance purchased either by the individual worker or by his employer. For a variety of reasons, the difference between total employee compensation (wage costs) and wage payments to workers has increased over time with much of the growth attributable to employer-financed supplements in the form of group health, accident, and life insurance for their employees.⁶⁴ It is surely reasonable to suppose that public and private insurance are very close substitutes. If they were perfect substitutes, an increase in public insurance coverage via higher legislated benefit payments would be accompanied by a decrease in private insurance. In this event, more compulsory public insurance under workmen's compensation would have little effect on the risk structure of wage costs, $W = W(\pi)$. However, when workers initially had no private insurance, and risk premiums did not fully cover the actuarial costs of different injury risks, the imposition of more public insurance may have had the desired effect of internalizing accident costs.

The efficacy of more public insurance as a means of lowering the industrial accident toll has also been questioned by Chelius.⁶⁵ Benefit levels and hence premium costs for workmen's compensation vary widely across states. If the theory behind the NCSWCL proposal is correct, one should find that injury rates for firms in high-benefit states should be lower than those for firms in low-benefit states. The results of his regression model (fitted to data for individual establishments) were just the opposite. Injury

⁶² R. Thaler & S. Rosen, *supra* note 7.

⁶³ K. Gordon, *The Relationship Between Employee Accident Rates and Wages on U.S. Class I Railroads, 1971* (unpublished paper on file with the author).

⁶⁴ At the present time, unionized workers and those in the larger firms receive the largest fringe benefits. The compulsory fringe benefits under Social Security have shown the sharpest relative increase in the last decade. The magnitude and composition of these fringe benefits can be found in Oi, *supra* note 7, at 99-100.

⁶⁵ Chelius, *An Empirical Analysis of Safety Regulations*, in 3 NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, SUPPLEMENTAL STUDIES FOR THE NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS 53 (1973). See also Chelius, *The Control of Industrial Accidents: Economic Theory and Empirical Evidence*, 38 LAW & CONTEMP. PROB. 700 (1974).

rates were higher in the high-benefit states, and if one were bold (or foolish) enough to attach causality to this result, it implies that benefit levels should be reduced to get lower injury rates; Chelius did not draw that inference. Nevertheless, his findings must, in my opinion, be regarded as highly tentative for at least two reasons. First, the method of controlling for other contributing factors, such as the age/sex/occupational composition of the labor force, and labor turnover rates, tacitly assumes that firms of varying sizes and in different industries confront the same technological trade-offs between injuries and goods. Second, his measure of injury frequency rates was based on only a single year's experience. Although Chelius limited his analysis to establishments with 100 or more employees, the sampling variability from year to year in injury rates, especially serious injury rates, is large for firms with 100 to 500 employees.

Further, the NCSWCL proposals that would raise benefit levels can only be justified on equity grounds.⁶⁶ The Commission failed to provide any empirical evidence that its proposal would operate to reduce the frequency and severity of industrial accidents. I suspect that the NCSWCL recommendations to expand the scope of covered employment and injuries⁶⁷ will also prove not to be consistent with the goal of minimizing the sum of accident and accident prevention costs, when the administrative costs of implementing these programs are taken into account.

B. Statistics, Standards, and Surveillance Under OSHA

The Occupational Safety and Health Administration, which has been in operation for three years, has attempted to design and implement federal policies to lower the industrial accident toll. Its three principal activities have been: (1) implementing a mandatory system for reporting work injuries and dis-

⁶⁶ The NCSWCL argued that the scheduled maximum weekly benefits in many states were well below 66% per cent of average weekly wages and that benefit levels had failed to keep up with the secular increases in wages. If benefits are defined to include all payments to injured workers (that is, wage losses and medical bills), they will be equal to premium costs to employers less the costs and profits of insurers which are a fairly constant proportion of premiums over time. According to data in NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, COMPENDIUM ON WORKMEN'S COMPENSATION 279, Table 17.1 (1973), premium costs for workmen's compensation as a percentage of wages were as follows:

1940	1.19%
1950	0.89%
1960	0.93%
1970	1.13%

Over the period, 1948-70, this percentage exhibits a significant positive trend; the correlation for a linear trend line was +.7065. Although benefit levels may lag behind wage changes in a particular state, the aggregate data do not support the latter contention; premium costs have increased faster than payrolls of covered workers.

⁶⁷ In reading the NCSWCL Report, I get the impression that the Commission wanted all workers to be covered, and the scope of compensable work injuries and diseases greatly enlarged. In summarizing their recommendations on extending workmen's compensation to self-employed persons, proprietors, and partners, the Commission recommends "that the term 'employee' be defined as broadly as possible." NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS, THE REPORT OF THE NATIONAL COMMISSION ON STATE WORKMEN'S COMPENSATION LAWS 48 (1972).

eases, (2) promulgating existing and new federal safety and health standards, and (3) enforcing compliance through a program of OSHA inspections.⁶⁸

1. *Statistics*

The lack of reliable and relevant injury statistics that would enable us to describe and analyze the industrial safety problem was one of the major concerns in the hearings preceding the establishment of OSHA. Under the 1970 Act, firms are legally compelled to maintain and report work injury statistics according to definitions and procedures set forth by OSHA. From a purely descriptive viewpoint, the new OSHA injury statistics are likely to be more reliable, as judged by conventional sampling theory criteria. However, the switch from ANSI to OSHA definitions makes it difficult to compare injury statistics to earlier data prior to 1971.⁶⁹ Further, the requirement that each establishment must post the annual summary of its injury experience for the preceding year may or may not make it easier for workers to get better information about the injury risks for a particular firm.⁷⁰

From an analytic viewpoint, the comprehensive reporting requirements for OSHA are unlikely to assist the accident researcher who is attempting to determine the causal factors that generate industrial accidents. As I argued in Part III, fragmentary evidence suggests that work injury frequency rates are higher for younger male workers, are probably higher for production and newly hired workers, lower for females (although perhaps not if one controls for occupation), and higher in particular occupations. Although the characteristics of seriously injured workers may be recorded in the logs, these data are of little value in the absence of additional data on exposure times for all workers in each category. It is regrettable that the design of the mandatory OSHA reporting requirements will result in injury statistics that will only aid in describing the magnitudes of the frequency and severity of industrial injuries and diseases in various industries. Thus, the OSHA data will make no significant contribution to our understanding of how to reduce the industrial accident toll.

2. *Standards*

No one, to the best of my knowledge, has studied the economics, politics, and psychology behind the conception and enactment of federal and state

⁶⁸ The full range of activities is described in EXECUTIVE OFFICE OF THE PRESIDENT, THE PRESIDENT'S REPORT ON OCCUPATIONAL SAFETY AND HEALTH (1973). OSHA is also involved in training more industrial safety specialists who can staff positions either as regulators (employees of OSHA) or as employees of the regulated. Funds are being allocated to the National Institute on Occupational Safety and Health (NIOSH) to study mainly health hazards.

⁶⁹ The Z16.1 standard mentioned in note 1 *supra* was a development of the forerunners of the American National Standards Institute (ANSI). In 1971 it was superseded by the OSHA definitions outlined in 29 C.F.R. §§ 1904.1-.22 (1973). For a treatment of this subject, see Schauer & Ryder, *supra* note 1.

⁷⁰ A worker could, conceivably, go from plant to plant and examine the posted annual summaries to see which plant had the best industrial safety record last year. He would have to know the difference between permanent partial versus temporary total disabilities. Since truly serious work injuries are rare events, the injury record for any one year is not a terribly accurate estimate of the firm's long-run injury risks.

health and safety standards.⁷¹ Hazards that are easily identified, and that appear to be easily correctable, seem to be the ones for which standards are set irrespective of the true economic costs and benefits. We thus have standards for elevators, machine guards, catwalk railings, shatter-proof glass, the chemical composition of various industrial compounds, and so on, but no standards for the speed of assembly lines or the characteristics that workers must possess to hold certain jobs. Asbestosis may be far more likely to cause disease in workers who smoke, but federal standards do not prevent smokers from working in asbestos factories.

Many existing safety standards are either ineffective or obsolete, but little effort is made to appraise their efficacy. The larger issue of whether mandated safety standards can reduce the frequency and severity of industrial accidents has been questioned in a study which found that the injury rates for 25 construction companies in Michigan were approximately the same as injury rates for a sample of 25 Ohio construction firms even though Ohio had far stricter safety standards and a larger bureaucracy to oversee its safety and workmen's compensation program.⁷² In a review of some unpublished studies evaluating the benefits of proposed safety standards, I was struck by the failure to distinguish between marginal and average savings. This shortcoming derives, I suspect, from the absence of a model of accident causation. A hypothetical example serves to illustrate this point. The absence of a railing on a particular type of landing was found to be responsible for 50 accidents during a year. If railings are installed, the presumed savings are the costs of 50 disabling accidents. If the landing is part of a stairway system, the landing could easily have constituted the "bottleneck" or point of highest accident risk. The risks of falling on the stairs below the landing were below what they otherwise would have been because the less agile workers were caught at the landing. By installing the railing, the frequency of accidents due to falling down steps will surely increase. The correct benefit that should be attributed to the railings is the marginal (or incremental) reduction in all accidents.

Finally, OSHA seems to have a tendency to embrace the most stringent existing or proposed standards without even attempting to measure the costs and benefits of the more stringent standards. The lavatory standard promulgated by OSHA in 1973 illustrates this point:⁷³

The standard, . . . requires industrial establishments with one to 100 employees to provide one lavatory for every 10 employees. Firms with more than 100 employees must provide one fixture for each additional 15 employees.

When the standard was proposed, the association objected pointing out that New York State required only half as many lavatories for industrial employment and there was no evidence of "adverse physiological effects or employee complaints."

. . . Spencer Foods, Inc., attacked the numbers scheme as being far the strictest standard in existence, unsupported by health needs, economically

⁷¹ Morey, *Mandatory Occupational Safety and Health Standards—Some Legal Problems*, 38 LAW & CONTEMP. PROB. 584 (1974).

⁷² Sands, *How Effective Is Safety Legislation?*, 11 J. LAW & ECON. 165 (1968).

⁷³ 29 C.F.R. § 1910.141(d)(2) (1973).

onerous, and insufficiently discriminating in types of employment. Several companies suggested some kind of grandfather clause covering existing facilities.⁷⁴

In *Associated Industries of New York State, Inc. v. United States Department of Labor*,⁷⁵ the Second Circuit, after examining the basis for the lavatory standard,⁷⁶ vacated the pertinent portion of the OSHA standard and remanded the case to the Department of Labor "for further proceedings consistent with this opinion."⁷⁷ The number of federal safety and health standards is already astronomically large and continues to grow; it would seem prudent to insist that henceforth OSHA prove the efficacy and economic desirability of any new standards.

3. Surveillance

The largest part of the OSHA budget is devoted to its inspection program. As of December, 1973, OSHA employed 556 field officers to enforce compliance with OSHA safety and health standards. Some 36,100 inspections were made in 1972, and penalties of over \$3 million were levied against firms that violated the OSHA standards.⁷⁸ Given budget constraints and a population of roughly 5 million establishments, OSHA must establish a priority system for determining which establishments are to be inspected. External factors, such as work fatalities or catastrophes and employee complaints, determine the first priorities. Establishments that fall under the Target Industry Program and the Target Health Hazards Program are then singled out for more frequent inspections. Finally, a random sampling scheme of the remaining establishments is used to assign inspectors to plants.

If, for the moment, we assume that OSHA safety inspections are indeed effective in reducing injury rates F , does the present priority system lead to the largest reduction in the incidence of industrial accidents? Two features of the OSHA assignment scheme lead me to suspect that it does not. First, emphasis is placed on the injury frequency rate and not on the total number of injuries per year. Second, the chances that an establishment will be inspected are not appreciably different for small and large establishments in a given industry. A numerical example illustrates the first point. Suppose that there are 100 firms in both industries A and B. The injury rate in industry A is twice as high as that in industry B, say $F_A = 40$ per million man-hours and $F_B = 20$. The OSHA scheme would assign more inspectors to

⁷⁴ The Associated Industries of New York State, Inc. filed suit to rescind this standard. See Daily Labor Report, Oct. 15, 1973, § A, at 11.

⁷⁵ 487 F.2d 342 (2d Cir. 1973).

⁷⁶ "The only legitimate reliance [for the lavatory standard] is on (1) the codes of five states . . . of which the Department could take official notice but to which petitioner opposes twelve." *Id.* at 352.

⁷⁷ *Id.* at 354.

⁷⁸ More detailed data were available for the last half of 1972 in which 16,756 inspections identified 57,527 violations. Roughly 58 per cent of the inspections resulted in the issuance of citations. However, only 0.73 per cent of all violations were classified as serious. Additional data can be found in EXECUTIVE OFFICE OF THE PRESIDENT, THE PRESIDENT'S REPORT ON OCCUPATIONAL SAFETY AND HEALTH 33-42 (1973).

industry A. But this fails to account for possible differences in the exposure to risks. If industry A employs 10,000 workers (20 million man-hours) and industry B hired 30,000 (60 million man-hours), then the annual number of disabling work injuries would be 800 in industry A and 1,200 in industry B. If a safety inspection could lower the injury rate by 20 per cent, (and the budget only allowed us to conduct 100 inspections), we could save more disabling work injuries by assigning inspectors to industry B which experiences a lower injury rate but also has larger numbers of workers exposed to risks. A similar exercise can be carried out to demonstrate the principle that larger establishments should be inspected more frequently.⁷⁹

The more important question is whether safety inspections are effective and desirable at all. What are the costs and benefits of OSHA inspections? We can get a rough idea of the social costs of inspections from some back of the envelope calculations, which suggest a lower bound guesstimate of around \$500 per inspection.⁸⁰ The benefits are harder to gauge because we lack the data to estimate the net savings in accident and accident prevention costs resulting from OSHA inspections. The published data in *The President's Report on Occupational Safety and Health* allows us to determine the nature of the violations and the industry and size of inspected establishments. However, we cannot, for example, compare the previous work injury experiences of establishments cited for violations with those not cited. Furthermore, it seems that OSHA follow-ups are mainly concerned with determining whether the cited violations have been corrected rather than with the larger and more pertinent issue of measuring the post-inspection safety record against the firm's previous work injury experience. The benefits of the OSHA inspection program might well exceed the costs, but we simply do not have the requisite data to make this empirical determination.⁸¹ Published accounts of the activities of OSHA, including its outside contracts, reveal no attempts by the agency either to evaluate the efficacy of its inspection program or to estimate its costs and benefits. I find this rather distressing.

⁷⁹ I have carried out these illustrative calculations using the 1968-70 size profiles of injury frequency rates for three two-digit manufacturing industries. Although establishments with 50 to 99 employees typically reported the highest injury rates, it turns out that the productivity of an inspection is larger when establishments with say 250 to 499 employees are inspected first. See Oi, *supra* note 26, at pt. V.

⁸⁰ I assume that the annual cost of each inspector (his wages and fringe benefits and the costs of supporting personnel and equipment) is around \$25,000. Each inspector probably makes around 100 inspections a year implying a cost to OSHA of \$250 per inspection. Travel may add another \$50. To this, we must add the costs to the inspected establishment that must assign supervisory and clerical staff to accompany the inspector (and typically either a union representative or conversations with workers), as well as the value of any lost output due to disruptions in the normal productive process. I assume that these costs to the firm are at least \$200. I believe that these guesses are on the low side, and I would not be surprised to learn that the social cost per inspection (including costs to both the inspecting and inspected) could go as high as \$1,500.

⁸¹ At a minimum, we would have to have data on (1) the reduction in the number and kinds of disabling work injuries due to inspections, (2) the costs to workers and firms of the various kinds of industrial accidents, and (3) the prevention costs of eliminating the hazards. It will be remembered that, according to the Wisconsin Report, at most 25 per cent of all industrial accidents were caused by physical hazards that could be identified by inspections. WISCONSIN STATE DEP'T OF LABOR, INDUSTRY, AND HUMAN RELATIONS, *supra* note 22.

CONCLUSION

The public concern about industrial safety is understandable. Industrial accidents—or for that matter, any accidents—are tragic events. We do not like to attach monetary values to the outcomes of truly serious accidents; what is the proper monetary sum to compensate a man for the loss of his sight? As a result, many rally to the slogan of “safety at any cost” when they are told about the plight of seriously disabled workers. However, “safety at any cost” carried to its logical conclusion has socially unacceptable economic implications. The production of goods, such as meat, coal, oil, lumber, and garbage collection, which involves high work injury risks would be outlawed in order to reduce the frequency of severe industrial accidents. But this is an extreme position, and moderates should contend that more industrial safety is all that is needed. Yet, in the light of the available empirical evidence, I am unable to conclude whether the current equilibrium work injury rates are above or below the socially optimal injury risks. What I have tried to emphasize in this paper is that the socially optimal injury risks are those which minimize the *sum* of accident costs and accident prevention costs. Only if the current levels of industrial injury risks exceed (or fall below) these optimal levels is there a basis for public intervention.