



Munich Personal RePEc Archive

Problems of market adjustments to occupational safety and health hazards

Chichilnisky, Graciela

U. S. Department of Labor

1978

Online at <https://mpra.ub.uni-muenchen.de/7998/>
MPRA Paper No. 7998, posted 31 Mar 2008 05:38 UTC

February 1978

PROBLEMS OF MARKET ADJUSTMENTS TO
OCCUPATIONAL SAFETY AND HEALTH HAZARDS

by

Graciela Chichilnisky*

Department of Economics

Columbia University

*This report was prepared for the Office of the Assistant Secretary for Policy, Evaluation and Research, U.S. Department of Labor, under Contract/Purchase Order No. B-9-D-6-3788. Since contractors conducting research and development projects under Government sponsorship are encouraged to express their own judgement freely, this report does not necessarily represent the official opinion or policy of the Department of Labor. The contractor is solely responsible for the contents of this report.

BIBLIOGRAPHIC DATA SHEET	1. Report No. ASPER/PUR-76/3788/A	2.	3. Recipient's Accession No.
4. Title and Subtitle Problems of Labor Market Adjustments to Industrial Health Hazards		5. Report Date March 1978	
7. Author(s) Graciela Chichilinsky		8. Performing Organization Repr. No.	
9. Performing Organization Name and Address Professor Graciela Chichilnisky Department of Economics 1125 SIA Building - Columbia University New York, N.Y. 10027		10. Project/Task/Work Unit No.	
12. Sponsoring Organization Name and Address U.S. Department of Labor/ASPER 200 Constitution Ave., N.W. Washington, D.C. 20210		11. Contract/Grant No. B-9-D-6-3788	
15. Supplementary Notes		13. Type of Report & Period Covered Final &-76 to 10-77	
<p>14.</p> <p>16. Abstracts This study analyses problems of labor market adjustments to occupational health and safety hazards. It provides models for the eventual measurement and empirical analysis of factors affecting the levels of occupational safety and health hazards in the workplace.</p> <p>From a public policy viewpoint the research reviews the conditions under which market forces could bring about a sufficient level of safety and health information and under what conditions it is necessary to have a government policy which would increase the level of information on occupationally related health and safety hazards.</p> <p>In addition to conditions under which it is a legitimate government function to provide health and safety information beyond that normally available in the labor market, the project explores the conditions and types of OSH hazards for which it is a sensible government policy to set standards and fines for non-compliance with the standards, as well as taxation and other incentive policies.</p>			
<p>17. Key Words and Document Analysis. 17a. Descriptors</p> <p>Attitudes. Benefit cost analysis. Business. Compensation. Competition. Cost effectiveness. Decision theory. Demand (economics). Discrimination. Economic analysis. Economic conditions. Economic factors. Economic models. Effectiveness. Employment. Evaluation. Experimental design. Health. Incentives. Industrial management. Information systems. Labor. Labor unions. Mathematical models. Performance standards. Regulations. Social organization. Social Welfare. Statistical decision theory. Taxes. Unemployment. Unionization. Workmens' Compensation. Efficiency. Ethics. Organization theory.</p> <p>17b. Identifiers/Open-Ended Terms</p> <p>17c. COSATI Field Group 5: C,E; 6: J; 14</p>			
18. Availability Statement Release unlimited - Available from National Technical Information Service, Springfield Virginia 22161		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages
		20. Security Class (This Page) UNCLASSIFIED	22. Price

TABLE OF CONTENTS

	page
EXECUTIVE SUMMARY	i
I. INTRODUCTION	
Statement of the Problem.	1
Outline of the Analysis.	6
II. OCCUPATIONAL SAFETY AND HEALTH : APPROPRIATE LEVELS. 8	
Tradeoffs with Other Objectives	11
Distribution	23
Cost Efficiency of Policies.	26
III. THE ROLE OF THE MARKET. 35	
Wage Differentials in Perfectly Competitive Markets.	37
Characteristics of Market Allocations:Efficiency and Distribution.	39
Markets for Risk Bearing.	42
IV. MARKET IMPERFECTIONS. 47	
Imperfect Information	48
Insurance Markets for Post Injury Compensation	48
Asymmetry of Information about OSH.	61
Firms with Risky Technologies.	67
OSH as a Quasi Public Good:	70
Institutional Rigidities.	73
OSH Externalities.	74
Externalities in the Production of OSH and of OSH Information	77
V. THE ROLE OF GOVERNMENT	
Objectives of OSH Policy.	80
Instruments	
Incentives: Workmen's Compensation , Taxation.	84
Standards.	97
Provision of Information.	104
VI. THE ROLE OF LABOR UNIONS. 107	
VII. CONCLUDING REMARKS. 113	
VIII. BIBLIOGRAPHY. 119	

EXECUTIVE SUMMARY

Introduction

This paper analyses problems of labor market adjustments to occupational safety and health (OSH) hazards. It also presents analytical models for the eventual measurement and empirical analysis of factors affecting the level of OSH hazards in the workplace. This study does not pretend to deal with the regulatory problem in operational terms. It nevertheless raises conceptual issues that may be relevant for regulatory strategy.

Section I contains a statement of the problem and an outline of the analysis.

Occupational Safety and Health: Appropriate Levels

Section II discusses the concept of appropriate levels of OSH. Tradeoffs of OSH policies with other objectives, such as employment and wage levels, are formalized. We also discuss tradeoffs with other government programs, and distributional and efficiency aspects of OSH.

A definition of cost-efficiency of OSH policies is proposed, taking into account the risk and imperfect information aspects of OSH. This is analysed in terms of allocations of OSH expenditures across standards, classes of workers and activities.

The Role of the Market

Section III studies the role of the market: wage differentials that compensate for OSH hazards; some characteristics of market allocations of wages

and safety such as efficiency and distribution.

From a public policy point of view Section III reviews conditions under which market forces could bring about an adequate level of OSH , and under what conditions it is necessary to have a government policy that would increase the level of information on occupationally related OSH hazards. It also studies the behavior of markets for risk spreading , such as insurance markets for post-injury compensation by firms.

Market Imperfections

Section IV studies market imperfections: market adjustments with imperfect information about OSH and about firms' actions regarding OSH ; the quasi public good aspects of OSH ; institutional rigidities such as lack of perfect mobility of workers ; OSH externalities such as spillover effects of OSH on the families of workers , the community near the workplace and society as a whole ; and also externalities in the production of OSH and of OSH information. The discount factors of firms (or managers) about future OSH costs , and collective incentives of firms to decrease OSH levels with asymmetric information are discussed also.

The Role of the Government

Section V studies the rôle of the government ; its objectives and instruments of OSH policies. In addition to conditions under which it is a legitimate government function to provide health and safety information beyond that normally available in labor markets (including information about firms' actions about OSH) we explore conditions under which it is a desirable government policy to set standards and fines for noncompliance with the standards , and/or

incentives (e.g. taxation , workmen's compensation) and provision of information to bring OSH to socially optimal levels. The relative efficiency and desirability of incentives and standards (and combinations of both) is analysed: for very irreversible costly and uncertain events standards are preferable to taxes while for more reversible, less costly and uncertain events taxation may be preferable. Of particular importance are distributional questions underlying different policies .

The informational role of the government is seen to be complementary rather than a substitute to the roles of providing incentives and setting standards. This informational role includes the production of OSH information (or incentives for private production) and the (facilitation of) gathering and dissemination of information to workers, firms, labor unions , and insurance companies (including information about firms' OSH actions).

The Role of Labor Unions

Section VI discusses the role of labor unions . It analyses reasons why it has been historically the case that labor unions did not put more emphasis on OSH, to detect possible government role in facilitating union's actions regarding OSH. More recently the trend is towards OSH being an element of contract bargaining : policy implications are analysed in this light. The role of government in obtaining OSH improvement for non-unionized workers is discussed.

Conclusions

The results suggest that there is no standard 'correct policy' for OSH

but a variety of policies are required. In the concluding remarks it is proposed that a classification of OSH cases and corresponding adequate policies is an important component of a cost-efficient policy for the attainment of socially optimal levels of OSH. The classification should involve factors such as size of the firm, mobility of workers, degree of unionization, level of unemployment, the effect of illness and death on the family of the worker , 'spillover effects' on the population as a whole through income security and medical programmes, degree of uncertainty or lack of information , and social risk aversion (i.e. the degree to which it 'cannot be afforded' to be even slightly off the mark).

I. INTRODUCTION

Statement of the Problem

At present there seems to be both more awareness of occupational safety and hazards and also a higher rate of introduction of new ones.

The introduction of new potent chemical agents and in general new technologies which are largely untested for adverse safety and health effects both at the working places and their surrounding communities has increased in the last two or three decades.¹ The health effects include also cases with long 'latent periods' which may affect the future health of the population in unknown ways.²

The working place is particularly vulnerable because of the higher level of concentration of chemicals, and otherwise exposure experienced there.³ In some cases, workers appear to have the role of experimenting, for society as a whole, the risks associated with the introduction of new

¹Source: Testimony of Samuel S. Epstein, M.D., Case Western Reserve University Medical School. Hearings before the Selected Subcommittee on Labor of the Committee on Education and Labor, House of Representatives, 1975 [6].

²Sometimes the latent periods are of twenty to thirty five years, as in the case of vinyl chloride. OSHA has recently promulgated standards that permit almost no employee exposure at all.

³The list of chemicals that threaten occupational health is long. NIOSH has listed over 12,000 toxic materials, The Toxic Substance List, 1973 Ed., HEW [37]. Among cancer-linked substances are: chromates, used in paints, which pose a hazard of lung cancer. Rubber workers have an increased risk of leukemia from exposure to benzene. Lung cancer and lymphoma occur at a high rate among workers exposed to inorganic arsenic which is a basic material in more than 40 jobs from tinting windshields to spraying flowers. Arsenic, like vinyl chloride, has also been linked to liver cancer. Benzidine (use in dye making) has been known for 80 years to produce bladder cancer; it has been withdrawn in Great Britain, U.S.S.R. and other countries but it is still widely used in the U.S. Sources: U.S. Department of Health, Education and Welfare and the American Cancer Society.

chemicals or techniques⁴ that may be, in the longer run, of benefit to all.

Several decades ago the prevailing view was the 'assumption of risk' doctrine accepted by the legal institutions. In economic terms, it derives from viewing labor markets as perfectly competitive: workers choose to undergo risks inherent in certain jobs because of the wage differentials (wage premiums) that compensate for them, and these choices are made in an optimal way. A more recent view, expressed in the Occupational Safety and Health (OSH) Act passed by Congress in 1970, holds that the government ought "to assure as far as possible every working man and woman in the Nation safe and healthful working conditions". Implicit in this mandate of OSHA is a concern about the possible imperfections in the labor markets adjustments to health and safety hazards as well as distributional questions. Possible imperfections in labor markets have been mentioned in this context: lack of information, and, in general, uncertainty, about risks and dangers, lack of perfect mobility of workers and other institutional rigidities, externalities both in the production of OSH and of information about OSH risks and dangers.⁵ In addition to the above there are other sources of concern that require closer examination: One is the problem of persistent high unemployment rates, coupled with lower rates of economic growth of the last few years, and expected for the near future. There is an understanding that labor market choices by workers are constrained in high

⁴ Occupational (OSHA) standards are also not as rigorous as the standards of other regulatory agencies that regulate exposure to the same hazards by the population in general. For instance, for lead ($\mu\text{g}/\text{m}^3$) OSHA standards are 550; EPA's (Environmental Protection Agency) are 30 day/mean 1.5. For NO_2 (ppm) OSHA standards are 5; for EPA annual mean is 0.50. For SO_2 (ppm) OSHA standards are 5; EPA's annual mean 0.03. See Cornell, Noll and Weingart [19].

⁵ See, for instance, Cornell, Noll and Weingart [19], Smith [52], Settle and Weisbrod [53], Zekchauser and Nichols [72].

unemployment situations: the choice may be between a risky or unhealthy job or no job at all⁶. This persistence of high unemployment is viewed sometimes as imperfect market behavior; as such it lends relevance to arguments for OSH regulation. On the other side, because growth rates and increases in productivity are related to industrial technical innovation and sometimes to investment on more risky enterprises (such as nuclear power plants) more stringent OSH regulations may in some cases compound the lower growth-unemployment problem⁷. This latter effect is one instance in which OSH (and also environmental) regulating activities by the government are seen by some as misdirected paternalism. Impacts of OSHA's actions are also sometimes studied in terms of their effects on inflation and employment.⁸

A second source of concern about OSH relates to the environmental and public health effects for the population as a whole. For instance it is increasingly difficult in many instances to isolate the effects of toxic chemicals. Of considerable concern among the experts is the risk that hazardous substances pose for people living near plants or for families of workers. The bill for lack of OSH is increasingly being paid by

⁶The Council for the Society for the Plastic Industry, William D. Ruckelshaus (and former Environmental Protection Administrator) stated: 'A man (or woman) may prefer to risk cancer in 20 years rather than not to have a job' Boston Globe, 12/3/75.

⁷See, for instance, the Inflationary Impact Statements of OSHA [65], [66].

⁸Epidemiologists in South Africa and England have found mesothelioma in a number of men and women who had never inside an asbestos plant, including a few who had simply lived in the households of asbestos workers. In the U.S. people living in communities where there are copper-smelting facilities have a higher than expected average of lung cancer. Some experts are beginning to uncover what seems to be community wide effects from vinyl chloride. In three Ohio towns where vinyl chloride was used in industry, researchers have found an unexplainable high number of deaths from cancers of the central nervous system in the adult population as well as neural malformations in children. Source: U.S.H.E.W. and American Cancer Society.

society as a whole through several mechanisms. I shall discuss these next.

In addition to the total burden of the individuals immediately affected,⁹ there are other economic effects (externalities) on the whole family of the worker and the derived costs to society. In an economy in which social welfare uses a non-trivial and growing¹⁰ share of government expenditures, this can represent in itself an important cost of OSH shared by all the taxpayers. For instance, in the category of programs not directly based on need but to replace a proportion of wages lost as a result of retirement, disability, death or unemployment, are included the largest of all income transfer programs: old-age, survivors of death of parent or spouse, and disability insurance (OASDI). The source of funds for OASDI are federal payroll taxes on employers and employees. In the fiscal year 1976 the expenditures amounted to 71.4 billions of dollars and covered a monthly average of 32.1 million people. In the category of aid to families with dependent children (AFDC) are included families with children deprived of support because of death, absence from home, or incapacity of parent. The sources of AFDC expenditures are Federal-State-local revenues. In the fiscal year 1976 AFDC expenditures amounted to 9.8 billion dollars and the beneficiaries amounted to a monthly average of 11.4 million people.¹¹ While it is not precisely known the proportion of OASDI and AFDC that is due to deaths, disability or health deterioration of working members of

⁹The total cost of occupational hazards in terms of lost wages, medical expenses, insurance claims, production delays, lost time of workers, and equipment damage was estimated by the National Safety Council at \$9.3 billion during 1971, nearly 1% of GNP. According to Ashford [7] this figure grossly understates costs which should be more realistically twice as high as the National Safety Council estimate.

¹⁰Forty years ago there were virtually no federal income security programs.

¹¹See B. Chiswick and J.A. O'Neill [17], Chapter 4, Source: Council of Economic Advisers (based on program information.)

the recipient families, the concern exists that it may be considerable.¹² Empirical work in this area would be needed to ascertain economy-wide costs of OSH hazards.

A third source of concerns relates to medical costs. A less healthy population requires more medical care. U.S. health expenditures have accelerated rapidly in the last few years and are at present more than 8% of GNP. Public spending increased sharply and at a much higher rate than private spending for health care. It is by now accepted that these increases in health expenditures are in part related to increase in the demand for health services¹³. Thus, the social costs for a less healthy population can be seen to spread to larger segments of society in terms of increased medical costs. The extent to which OH hazards affect medical expenditures still needs to be ascertained--and further empirical work is needed in this area. For instance, the more generalized spillover effects on the communities near plants, or the families of workers should also be computed as part of the economic costs of OSH hazards.

In view of the above, in addition to the usual studies on the inflationary effects of regulation for increased OSH (because of their tendency to increase costs to producers and perhaps decrease productivity) the opposite effects of lack of OSH on inflation and lack of productivity should also be taken into consideration.

¹²As reported by Ashford [7], National Safety Council estimates that 14,200 deaths and 2,300,000 disabling injuries (100,000 of which cause permanent disability) resulted from accidents only during 1971. Since the ratio of serious injuries to reported ones is about 10 to 1, Ashford concludes that the true national level of serious but not disabling injuries is nearer to 25 million per year.

¹³See for instance Zubkoff [73].

Outline of the Analysis

In this paper we analyse the problems of labor market adjustments to occupational safety and health (OSH) hazards. This study does not pretend to deal with the regulatory problem in operational terms. It nevertheless raises analytical issues that may be relevant for the eventual measurement and empirical analysis of factors affecting the levels of OSH as a whole, and for regulatory strategy.

We begin our analysis with a discussion of the concept of appropriate levels of OSH, Section II.

Section III studies the role of the market: wage differentials to compensate for OSH hazards; some characteristics of market allocations for wages and safety such as efficiency and distribution.

From a public policy viewpoint Section III reviews the conditions under which market forces could bring about an adequate level of safety and health, and under what conditions it is necessary to have a government policy that would increase the level of information on occupationally related health and safety hazards. It also studies the behavior of markets for risk spreading, such as insurance markets for post-injury compensati

Section IV studies market imperfections: market adjustments with imperfect information about OSH and about firms actions regarding OSH; the behavior of large firms in setting OSH standards, institutional rigidities such as lack of perfect mobility of workers, and OSH externalities, and also externalities in the production of OSH and of OSH information.

Section V studies the role of the government objectives and instruments of OSH policy. In addition to conditions under which it is a legitimate government function to provide health and safety information beyond that normally available in labor markets, we explore conditions under which it is a sensible government policy to set standards and fines for noncompliance with the standards, and/or taxation incentives, provision of information or legislation to bring OSH to socially optimal levels. The relative efficiency and desirability of taxation and standards is studied; for very irreversible, costly and uncertain events, standards are preferable to taxes while for more reversible, less costly and uncertain events, taxation may be preferable.

In Section VI we discuss the role of unions in the possible decentralization of decisions about OSH.

The results suggest that there is no standard 'correct policy' for OSH, but a variety of policies are required. In the concluding remarks it is proposed that a classification of cases and corresponding adequate policies is an important component of a cost-efficient attainment of socially optimal levels of OSH. The classification should involve factors such as size of the firm, mobility of workers, degree of unionization, level of unemployment, the effect of illness and death on the family of the worker, 'spillover effects' on the population as a whole, degree of uncertainty or lack of information, and social risk aversion (i.e. the degree to which 'it cannot be afforded' to be even slightly off the mark).

II. OCCUPATIONAL SAFETY AND HEALTH: APPROPRIATE LEVELS

The determination of appropriate levels of OSH is perhaps one of the more complex questions in the OSH area. From the economist's point of view it carries several layers of difficulties.

The first one is that it contains normative questions, as expressed for instance in the mandate of the Act of Congress that established OSHA "to assure so far as possible...safe and healthful working conditions for every working man or woman..."¹⁴ Economists, by tradition or training, tend to dissociate from such questions and resort to individual rather than social decision making, with the help of well established tools of economic theory that prove the global optimality of individual decisions mediated by the market mechanism. The nature of this optimality is discussed in more detail in Section III. Basically, in this context it refers to 'Pareto optimality' of market equilibria. As we discuss below, Pareto optimality is a concept more related to efficiency and stability than to optimality in a social welfare or normative point of view. Therefore, much of the content and social mandate behind the OSH Act is not well represented by analysing individual decisions and the corresponding allocations as mediated by markets. However, surely it should be the preoccupation of the government to carry its functions efficiently. In fact, efficiency is an implicit normative concern, since resources are very needed and scarce. Therefore the study of efficient allocation of resources is itself of fundamental importance.

¹⁴ Section 2(b) OSH Act.

Another difficulty is that markets with risks and with imperfect information, with institutional rigidities and with externalities are imperfect. The above list of characteristics applies very much to labor markets when OSH is considered. Imperfect markets tend to be more difficult to analyse in terms of optimality or efficiency and from the policy viewpoint only second best solutions can be expected.

Another major difficulty is the choice of economic tools. A conventional economic tool, benefit-cost analysis, generates sometimes controversy and negative reactions in many sectors concerned with OSH. This is because the measurement of the value of human life is, at best, arbitrary and may not be a reliable quantifiable variable, and at worst, could be subject to value judgments opposed to the very nature of the concerns at stake. In any case, there is wide disagreement on issues of interpretation and measurement of surveys or market studies which use a "willingness to pay" approach to establish the shadow prices of lost lives. Some question 'whose' willingness to pay; others, whether it should be measured before or after the injury, etc.¹⁵

Finally the question of appropriate OSH levels (as in the OSH Act mandate) seems to refer implicitly to a social consensus that does not exist in practice with respect to the tradeoffs between OSH and other social goals.

Under the circumstances, one role of economic analysis should be to disclose and improve understanding of the economic problems and the options available, what are the costs and the tradeoffs with other goals. This way the analysis may

¹⁵ For a discussion of methods of valuing lost life or life-saving policies, see for instance Zeckhauser [71].

become a useful element in the development of a policy.

Another important role is to disclose policy instruments, study their relative impacts and effectiveness.

For the first role, the tradeoffs and costs should be studied both at the individual and at the social level. For the second role the policy instrument should be thought as an aid to both individual and social action.

Tradeoffs with Other Objectives

We now discuss by means of some examples the issue of possible tradeoffs with other objectives in determining appropriate levels of OSH.

In the first case we examine the case of an individual worker. At some level of information, a tradeoff may be between higher wages or higher OSH, since in general within each skill or salary range, premiums are paid for assuming risks. In general, this represents a choice between less OSH risks and more consumption of all other goods. This is represented by the $w(\text{OSH})$ curve in Figure 1. This curve represents what may occur as an outcome of the competitive market mechanism. If for instance workers utilities depend on wages and levels of OSH on the job, i.e. $u \equiv u(w, \text{OSH})$, the $w(\text{OSH})$ curve could also represent an indifference curve for the individual.

If now more information is obtained that reveals more risks, and if the previous OSH schedule graded the previously perceived OSH levels for different firms in an area, a different set of tradeoffs may occur. For each firm in the area the OSH levels perceived are now lower. If there is sufficient mobility of workers, the curve $w(\text{OSH})$ may shift to the right to $(w(\text{OSH}))_1$ (see Figure 1): for every firm the now perceived level OSH has decreased and the workers, who can choose since they are mobile, require a premium Δ .

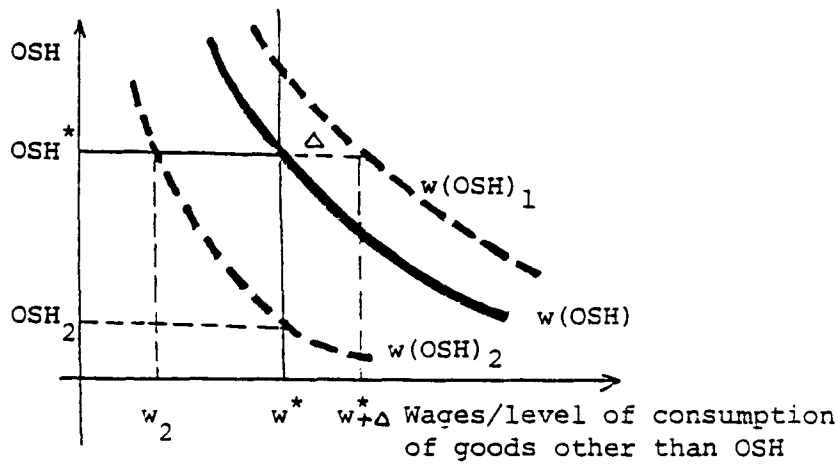


Figure 1

Another set of w/OSH tradeoffs, however, may arise when more information is gathered and standard or taxes on the firm are adjusted to the new higher perceived levels of OSH hazards so as to be consistent with economy-wide standards. Since employees may lower demand for workers, because of the now higher cost per unit of hired labor (in the same group) induced by the now higher cost of OSH, this gives rise to $(w(OSH))_2$. For the same OSH levels, wages would be lower than before (w_2) (See Figure 1). An additional longer run effort on the firms behavior may be the shifting towards more labor saving techniques and hence an even lower labor demand. This would occur provided the new techniques either don't increase OSH hazards with the lower labor utilization ratios, or else are not

known to produce higher OSH hazards. If this latter effect occurs, the total level of uncertainty may be increased.

The fact that the w/OSH schedule has changed with more information does not mean that the previous market outcome was inefficient. The market does not provide premium pay for exposure to unknown hazards. One example is the case of vinyl chloride which is now known to increase the changes of angio sarcoma. For several decades workers were exposed to the hazard before the information was available. The fact that those workers exposed to vinyl chloride were not paid premiums or otherwise compensated for the extra hazards they faced does not mean that the market was inefficient. Until the risks became known, there was also no government regulation. This is a case where even though markets may be perfectly competitive, the government role as a generator of new information or restriction of use of substances or techniques of unknown risks may increase OSH.¹⁶

As we can see from the above example the issue of the possible welfare loss or gain to the individual worker cannot be ascertained in general, especially if only a partial equilibrium analysis is studied or when only one side of the market is considered. Whether the unemployment/decreased demand for labor effect may be strong enough that it undoes the welfare gains of increasing information and obtaining higher premiums, is a question that reflects the market behavior as a whole

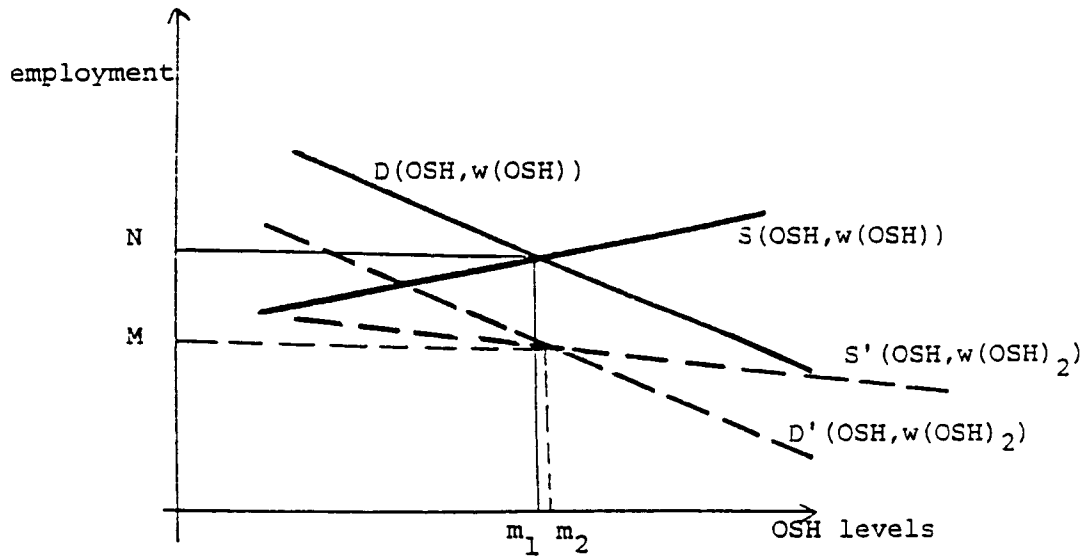
¹⁶OSHA has promulgated asbestos and vinyl chloride standards that permit almost no employee exposure at all. The degree of compliance still needs to be established.

More information, with the corresponding adjustment of OSH policies for consistency, may lead to welfare as well as OSH losses. Since, if w^* is a minimum required salary for a given worker, for that worker $OSH_2 < OSH^*$ (see figure 1).

In fact, the addition of new OSH information and corresponding adjustment of OSH standards could reduce equilibrium levels of wages and also employment by a firm or industry; in certain cases no equilibrium with positive employment may exist. Furthermore, this effect may be more likely to occur in case the firm or industry has a larger component of lower income workers. This can be seen as follows. Assume that with previous information the standards of OSH were such that a firm's tradeoff between wages and average OSH levels was given by a curve $w(OSH)$ as in Figure 1 above. The set of w/OSH combinations given by $w(OSH)$ correspond to a one level of demand for labor by the firm. Assume further that the utility function of the worker depends on leisure, wages and OSH levels, so that his or her supply of labor function is of the form $S(OSH, w)$. If the tradeoff between w and OSH is given by $w(OSH)$, then the supply of labor function is $S(OSH, w(OSH))$. Demand for labor can similarly be represented as a function of OSH and of wages, or their equivalent levels of SOH according to $w(OSH)$, i.e. $D \equiv D(OSH, w(OSH))$. A labor market equilibrium will determine the level of OSH , by equating supply with demand:

$$S(OSH, w(OSH)) = D(OSH, w(OSH))$$

Now assume that there is new information with the corresponding adjustment of standards, that implies another schedule of tradeoff between wages and



The possibly negative slope of $S'(OSH, w(OSH)_2)$ can be derived as follows:

$$d/d \text{ OSH} (S') = \partial/\partial \text{ OSH} (S') + \partial/\partial w (S') \cdot \partial w/\partial \text{ OSH}$$

Since in the above expression the second term is negative, because

$$\partial/\partial w (S') > 0$$

and

$$\partial w/\partial \text{ OSH} < 0 ,$$

if the slope of $w(OSH)$ is large in absolute value, then, as in the figure 2 above, S' will have a negative slope.

Figure 2

OSH, given as in $w(\text{OSH})_2$ in Figure 1. For a certain amount of labor demanded, for each level of OSH the firm offers now lower wages: some of the difference goes to defray costs to comply with the new (higher) standards.

Let $D'(\text{OSH}, W(\text{OSH})_2)$ and $S'(\text{OSH}, w(\text{OSH})_2)$ be the new demand and supply for labor functions derived from the new schedule of wages and OSH, $w(\text{OSH})_2$ in Figure 1. Then, as OSH increases, the corresponding wage level w may decrease proportionally so much (as indicated in $w(\text{OSH})_2$) that, since S is an increasing function of both m and w , $S'(m, w(m))$ may be a decreasing function of OSH, see Figure 2.

Similarly since for each OSH level the firm has now higher OSH costs (some of these costs may be transferred to the workers in the form of lower wages offered), $D'(\text{OSH}, w(\text{OSH})_2)$ is now the relevant demand for labor curve, see Figure 2. The effect of the new information (and corresponding new standards) has been to reduce employment from N to M and change OSH levels from m_1 to m_2 , see Figure 2.

In fact, if these effects are pronounced enough, no equilibrium with positive employment level may exist. This may happen either because the negative effect on wages of increased OSH requirements is so strong that it reflects on a significantly negatively sloped labor supply function (as in Figure 3-a) or else because the costs to the firm on increased OSH requirements are so high that it reflects in a significantly lower demand for labor (see Figure 3-b).

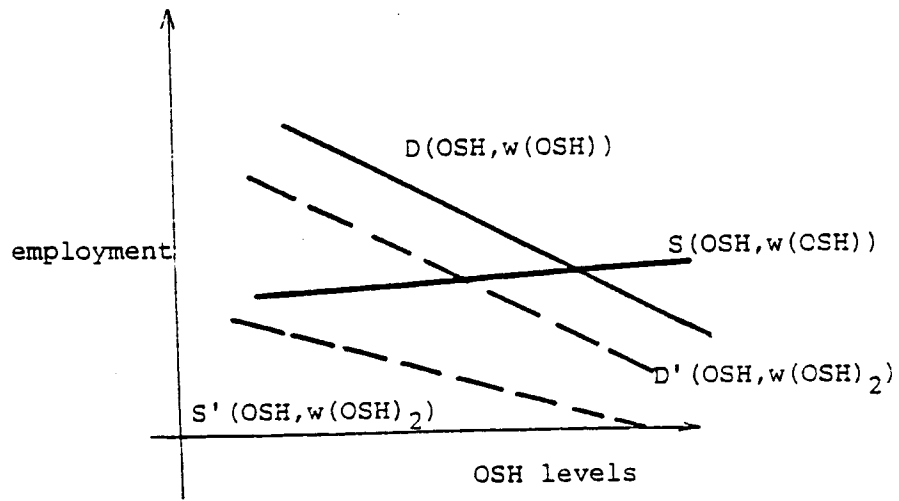


Figure 3a

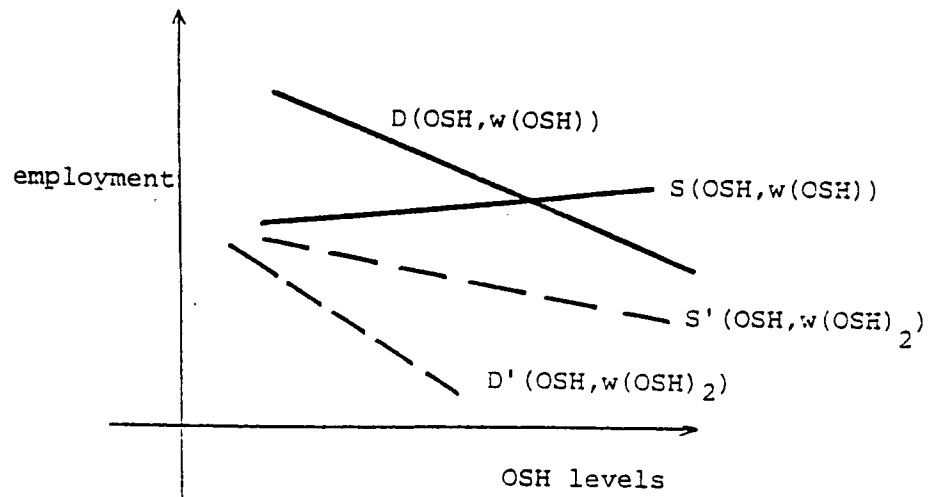


Figure 3b

Figure 3

Notice that the negative effect on employment in that firm or industry of increased OSH requirements may be more pronounced for lower income workers. This may happen for instance if their utility functions imply a low elasticity of substitution between wages and OSH, so that decreases in wages and employment even if accompanied by increases in OSH significantly lower their welfare.

In some cases the above mentioned tradeoffs can be compensated. For instance, the new information could produce higher demand for certain skills or new equipment that compensates for the initial decrease in demand for labor when higher standards are imposed. This is seen for instance in the U.S. Department of Labor IIS study on proposed regulation of coke oven emissions [65] discussed below. The final direction of the effect on employment varies from case to case.

A case study of proposed standards for exposure to inorganic arsenic illustrates possible effects of standards on employment. In the case of inorganic arsenic, the U.S. Department of Labor Inflationary Impact Statements [65] and [66] estimate that up to 3,700 jobs may be lost if the standard is imposed. In the arsenical wood preservative industry the standard would have especially severe effects: 1,700 jobs may be lost, roughly 30% of the production force.

The case of coke oven emissions, however, illustrates a case where the opposite effect on employment could occur. The IIS estimates that employment could rise by 5,000 due to a decline in productivity of between 18 and 29%, see [65].

In the present U.S. economy, in the aggregate these effects are probably small. However in regions where workers are not perfectly mobile, or there are other institutional rigidities (in wages or prices) the employment effects could be persistent. This is a discomfoting picture because there may be some perverse effects to policies. For example, there are two cases in which regulation is generally supported: when workers are not mobile enough to leave dangerous jobs, or when they work at the lowest paid jobs, the group which suffers the highest OSH risks.¹⁷ The arguments above show that regulation that has negative effect on unemployment is likely to affect the less mobile workers the hardest. Also, in the above example, it is those with the lowest wages that may be most hurt by the effects of increased information and regulation.

At the level of society as a whole other tradeoffs may occur. One can consider the question of the appropriate level of OSH as an investment decision on the part of the government, whose goal is to maximize a social welfare function. The provision of OSH information and the administration of regulatory activities to increase OSH take resources

¹⁷See for instance [72].

away from other social goals. In addition if low unemployment and the derived increased level of aggregate demand is a government goal, as we saw above, there may be relationships between those goals independently of budgetary considerations. Another tradeoff may exist if OSH policies are inflationary. However, the evidence about supply induced inflation (due to higher costs) gathered by the U.S. Department of Labor IIS (see [65] and [66]) suggest that at least in the cases studied individual OSH standards have negligible effects on the price level as a whole, even though their effect could be more noticeable in a particular sector.¹⁸

Another tradeoff may exist between OSH expenditures and expenditures in other social services, such as income security programs.

As these tradeoffs are examined, the importance of the issues of distribution and efficiency becomes clear. Employment and inflation are very important economic variables in many ways, not the less important of which is their effect on distribution and welfare. To the extent that OSH policies are addressed to improving distribution if OSH policies conflict with employment policies, the tradeoffs between them becomes more pointed. An example is the case of OSHA's impact on job related injuries.

¹⁸The inflationary effect estimated for the proposed inorganic arsenic standard is a one-time rise between 10.4 and 25% of the price of arsenic trioxide; the price of arsenic-based wood preservatives could increase more than three times and increase the price of treated good 5 to 20%. The price impact of coke oven emissions may affect iron and steel manufacturing prices up to 2.3%, and raise total person consumption expenditures 0.01 to 0.07%.

Several works have studied the impact or effectiveness of OSHA Inspection Program on injuries. Owing to the lack of data on illnesses, most of the existing analysis of impact of OSHA is on safety, although, probably, the more general findings apply to health as well. See for instance the works of Walter Oi [41], John Mendeloff's recent report to the U.S. Department of Labor [26], and Aldona di Pietro, of ASPER in the U.S. Department of Labor [20]. The results are far from being conclusive; however, they seem to indicate that OSHA's impact on injury rates is not very significant. In some cases an explanation is given that since OSHA's inspections give priority to 'non compliers', this biases the sample towards more 'non-compliers' and has the effect of relatively increasing incidence of injuries overall. Also, the definition of OSHA's injuries has changed since OSHA was established and this biases the measurement of impact as well. However, the low levels of effectiveness of OSH implied by the evidence of these works may make the tradeoffs between OSH expenditures and other government expenditures seem more severe than they are.

In the light of the above, any discussion about tradeoffs is incomplete without careful analysis of efficiency and distribution.

Distribution

As mentioned above, one part of the current concern for OSH has to do with distribution. It is known that if workers are classified by the level of wages, those who suffer the highest OSH risks are differentially those with low wage rates [72]. This does not imply that there are no premiums for risk. For a number of reasons, including differences in marketable skills, workers are paid different wages. For each one of these groups, more risks may command higher wages. Low income workers may receive lower wages and also have higher OSH hazards.

As discussed above, in certain cases more OSH may actually hurt equity. If it implies higher government expenditures on OSH, it may imply less income security transfers. If it produces more unemployment it may have other maldistribution effects. Furthermore, it is sometimes argued that it may be inefficient to use OSH policies to attempt to bring about redistribution of welfare. However, it is a more or less established tradition that economists tend to overemphasize the inefficiency inherent in any form of transfers for more equality which affect markets. The argument is that the most (or only) efficient way to proceed would be to redistribute initial resources and then allow the market to proceed unhindered to decide prices, and equilibrium levels of output and of allocations. These levels of market allocations are, in a competitive market, Pareto optimal, i.e. any move away from such an

allocation is bound to decrease someone's welfare. The next step in this argument is to show that if welfare depends on individual choices according to individual preferences (for instance between OSH and wages) then a deviation from Pareto optimality (market equilibrium) is bound to leave someone more dissatisfied with the level of OSH chosen for him or her in the regulatory process. As stated in [72], "the critical question for the equity discussion is if workers wish to make a well-informed choice to assume a higher level of risk in return for greater wages, and if there are no externalities, does society have the right or the obligation to interfere with that decision. If the answer is no ..."

However it is not necessarily true that there must be a tradeoff between greater equity and (Pareto) efficiency as indicated above. It is known that under certain conditions there can be Pareto optimal (or Pareto efficient) allocations which are extremely unequal. As in the present cases, certain groups may have the higher wages and lower risks and others the lower wages and higher risks, in a Pareto optimal way. However, there are Pareto optimal allocations in which both the distributions are more equal than in others-- and the Pareto efficiency conditions set forth in the previous paragraph are satisfied. Of course, the individuals (or groups) that prefer the second allocation to any other are not in general the same individuals (or groups) that prefer the first to any other.

This is discussed in more detail in the next section. Here it suffices to note that there may be several Pareto optimal allocations and

that some of them are more consistent with the redistributive goals towards equality of OSH, while having all the optimality properties assigned to market equilibria. Furthermore, when externalities exist, to move to a more egalitarian Pareto optimum may require to proceed through a sequence of allocations which are not Pareto optimal. For more details, see Section IV.

Cost-Efficiency of Policies

In the previous discussions about tradeoffs with other policy objectives and about distribution, the importance of the efficiency of OSH policies was underlined. In the case of the tradeoffs with other policies, for instance, it was seen that lack of efficiency may make tradeoffs seem more serious than they are. Similarly, lack of efficiency could make redistributive costs seem very high. This, in turn, could bias public opinion against OSH policies. Because of the present antiregulatory mood in the U.S., this makes efficiency a more important factor yet.

One definition of efficiency results from considering the question of allocation of resources to improve OSH as one of optimal allocations under uncertainty, the uncertainty derived from imperfect information about OSH and about the associated health and other economic costs mentioned above. We describe this next, leaving the more technical aspects for subsequent chapters. For a discussion of related theoretical issues of optimal allocation under uncertainty, see for instance Arrow [2] , [3] .

Suppose there are s states of nature representing degrees of health (including death) in the different occupations. In the s -state a total amount \bar{x}_{sc} of (medical and other economic) resources available to Sector c ($c=1\dots$ is given. Assume that each individual acts on the basis of subjective probabilities as to the states of nature (which may differ from the real ones because of lack of information). Let p_{is} be the subjective probability of state s according to the i -th individual, where $i = 1, \dots, I$.

Let x_{isc} be the expenditures allocated to individual i if state s occurs (e.g. workmen's compensation, income security, health care costs). These expenditures are limited by available resources (for instance government resources from taxation) so that:

$$(1) \quad \sum_{i=1}^I x_{isc} \leq \bar{x}_{sc}$$

A first problem of optimal allocation of risk bearing is that of choosing the allocation of resources \bar{x}_{isc} subject to the constraint (1) so that no other choice will make every individual better off according to his/her preferences.

There are other ways to attempt to achieve optimal allocation of risk bearing. One is to change the probabilities p_{is} (the probability of state s to occur). This can be done in several ways. One is by regulation that decreases the probabilities of some events, and increases the probabilities of others); this policy has its own costs which should be included in the budget constraint (1) as follows:

$$(2) \quad \sum_{i=1}^I x_{isc} \leq \bar{x}_{sc} - c(p_{is})$$

where $c(p_{is})$ is the cost of changing probability of state s .

Another way could be to improve the individual's perception of this probability; this second change is of the nature of producing and distributing new information.

Note that in all this \bar{x}_{SC} are fixed (e.g. government) budgets. Therefore the tradeoffs with other goals have already taken place: the amount \bar{x}_{SC} that will be allocated to OSH has already been selected. The above defines an optimal allocation of risk bearing, after the budget decision \bar{x}_{SC} was reached.

Ideally, one would consider a production as well as consumption model where the agents produce the resources \bar{x}_{SC} as well as consume it. The sum \bar{x}_{SC} should then also be decided in an optimal way, derived from individual preferences, or from a social welfare function. As this example shows, efficiency criteria for regulation or for disseminating information, can be used to derive optimal rules of allocation without necessarily using cost-benefit approaches.

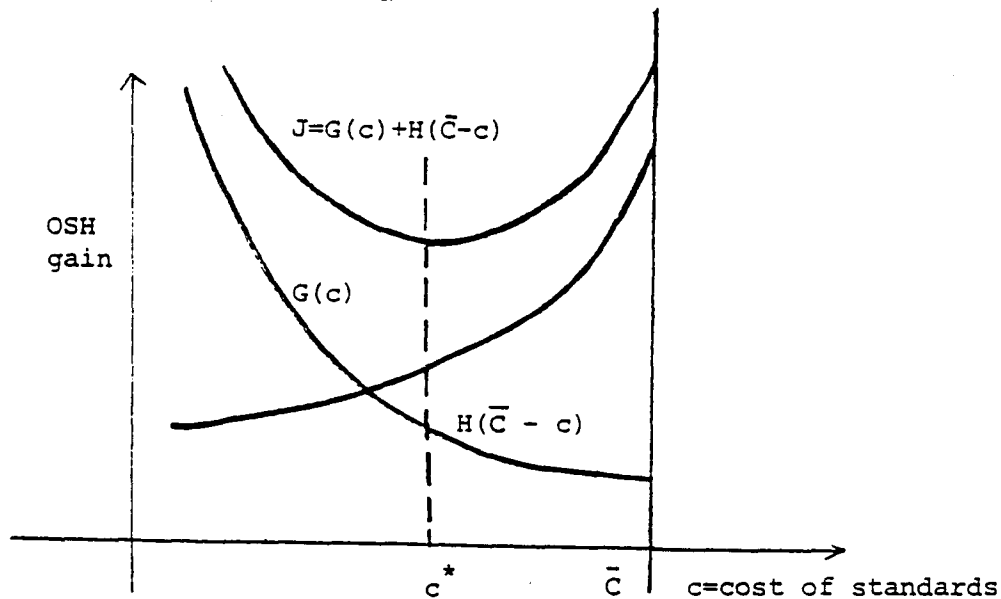
The above criterion can be somewhat complex to apply since it would require some knowledge (through econometric analysis) of the individual's preferences.

One can alternatively use another, related cost-efficiency criterion. Assume that as before there has been a social decision about the total amount of funds to be used to promote OSH. A goal for the government could be to try to obtain as much a total increase of OSH as possible.

We leave for Section VI the secondary efficiency problem of how to best use the funds to monitor policy, and what are the best instruments

to use in each case to concentrate here on the conceptual issue of rules for efficient overall use of OSH funds.

For every sector and activity under consideration there is a curve that gives the cost of promoting OSH. See Figure 4.



$G(c)$ = Expected increase in OSH by use of standard 1 up to cost c
 $H(\bar{C}-c)$ = Expected increase in OSH obtained by use of standard 2 up to a cost $\bar{C}-c$.
 $J(c) = G(c) + H(\bar{C}-c)$.

c^* solves $\text{Max}_c J(c)$, and satisfies $G'(c^*) = H'(\bar{C}-c^*)$

Notice that we have assumed that each standard is used in its most efficient way, i.e. minimizing cost per unit of OSH gain.

Figure 4

A cost-efficient procedure would be one that attempts to achieve the greatest OSH gain for the level of expenditure. See also Zeckhauser and Nichols [72]. For a total sum of money allocated, \bar{C} , the largest benefits in terms of increased OSH will be obtained if the marginal costs of promoting a certain OSH gain were equal across standards. For example,

in Figure 4, the point c^* indicates a cost-efficient solution; for a total sum of money allocated \bar{C} , the sum of the OSH gains obtained by both standards is maximized at c^* , therefore the standard 1 is applied up to where it reaches the cost c^* , and the standard 2 up to where it reaches the cost $\bar{C} - c^*$. The reasoning implicit in Figure 4 above is as follows: If for a certain standard an additional dollar can bring about a higher expected increase in OSH than for another, efficiency indicates the first standard should be given priority over the second. Here the word 'standard' is used to indicate the instrument of regulation, and not a goal of the regulation or level of OSH.

If we similarly apply this criterion across sectors or activities, or across classes of workers, and if the goal is to maximize the total expected amount of lives saved or of prevented illness for the total given allocation of OSH funds, efficiency indicates that the marginal cost of (a unit of) OSH gain (lives saved or lost workdays prevented) be equalized across sectors or activities, or classes of workers. If gains of lives saved are going to be measured in some unit, to compare (for purposes of efficiency of allocation of OSH resources) across activities or classes of workers, then life valuation should be equalized across the different areas. If an additional dollar can bring about a higher expected increase in the amount of lives saved in one class of worker or activity than in another, to maximize total expected gains indicates that the dollar should be allocated in the first class of workers or activity. To the extent that the different classes of activities or workers are given different life

valuations, a cost benefit analysis could indicate the contrary. For instance, if the life saved in the second activity had a higher 'shadow price' than the one in the first activity cost benefit analysis may favor the allocation of the dollar into the second activity.

The above described criteria however apply only when the secondary efficiency problem referred to above is solved: we assumed that each standard is used in the most efficient way, i.e. minimizing cost per unit of OSH gain. This gives the curves G and H in Figure 4.

A related analysis has been proposed in a U.K. study at the Science Policy Research Unit of the University of Sussex by C. Sinclair, P. Mastrand and P. Newick, "Innovation and Human Risk". This study is of interest here because a cost-effective (rather than a cost benefit) approach is used to study appropriate OSH risks and the empirical studies carried there were based on this criterion. It thus demonstrates practical utilization of a cost efficient approach. The case-studies carried out were of worker safety in agriculture, pharmaceuticals, steel handling and trawling in Great Britain (see [47]).

The method can now be summarized as follows. It is assumed that each level of expenditure on prevention 'P' entails a corresponding level of OSH damage 'A' at a risk level 'r' (see Figure 5). Increasing 'P' could reduce both 'A' and 'r'.

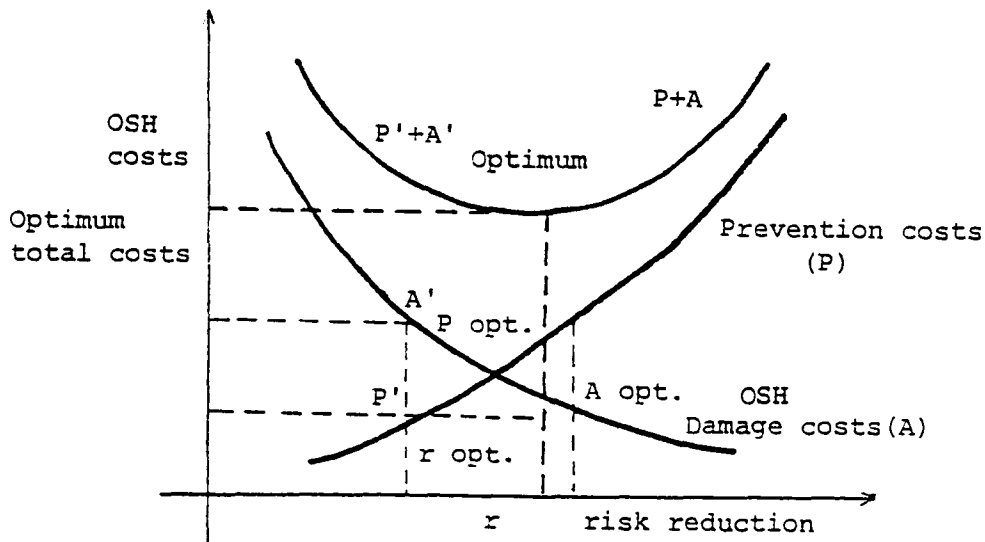


Figure 5

For a given technological situation there will be decreasing returns to 'P' as the additional measures become more expensive or less effective in reducing risk. Cost arising from legal and administrative methods should also be included. If it is decided to call the risk cost the sum of prevention cost plus damage cost, A and P, then some risk level will give a minimum value for the sum ('optimum' in Figure 5).

Damage costs 'A' are made up of ascertainable costs, i.e. material damages, administration costs, medical charges, and also less tangible or more subjective ones such as the 'value' of life. In Figure 6 below two values have been given to the subjective item producing two 'total' curves

(T_1 and T_2) and hence two minima. Similarly, if the prevention cost curve is uncertain for a given damage curve, different minima and hence optimum risk levels will be found. If we however assume that the prevention curve is known, then for present prevention damages and assuming the present situation is optimal, a particular damage curve is fixed and a particular life valuation is implicit. Applying this analysis to expenditures of different kinds made in different activities and industries, a range of implicit life valuations emerges. The costs of altering these implicit life valuations can be inferred from the prevention curve and numerical indicators obtained for policy making in this field. By taking the above described criterion that wide variation of valuations obtained in this way are unsatisfactory, we have a criterion for risk setting. Under certain conditions this coincides with the equalization of marginal costs of promoting OSH. Areas where valuations are low become the target for further OSH effort.

It is very difficult to optimize over a wide range of activities so that both benefits and risks are rationally distributed. It is possible by using the above method, however, to suboptimize across a set of sectors and activities so that at least the distribution of expenditures attempts to achieve the greatest OSH gain for the level of expenditure it entails.

Determination of implicit life valuation

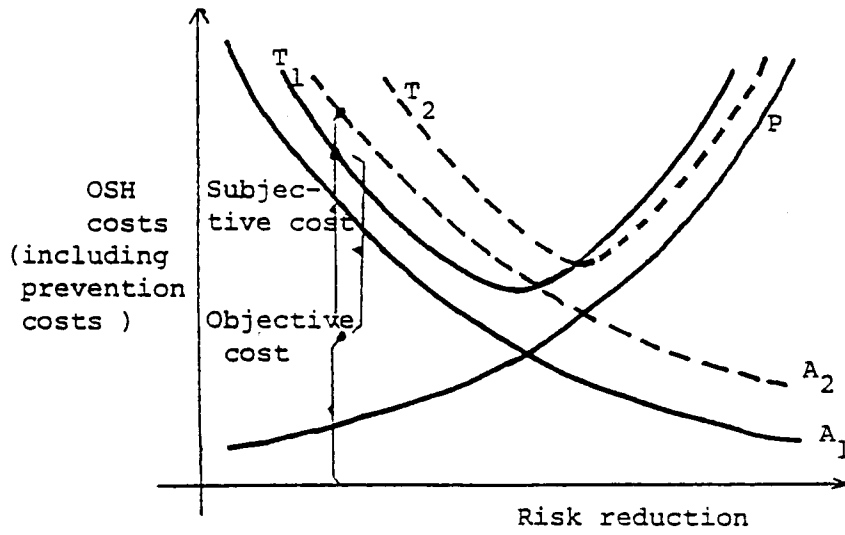


Figure 6

III. THE ROLE OF THE MARKET

The advantages of decentralized decision making are significant. These advantages are even more evident when the costs of more centralized policy making are taken into account. The competitive market mechanism provides one form of decentralized decision making which has attained impressive accomplishments in some areas. In an economy with a very large free enterprise component, any efficient policy should be designed with the market behavior in mind for at least two reasons. One is that whenever the decentralized market mechanism can be expected to bring about an efficient outcome, there may be significant cost savings if the market is allowed to operate unhindered. The other reason is that markets do react to policymaking by the government, and these effects have to be taken into account when planning policies. Otherwise, as in the examples given in the last section, policymaking may end up producing results which are further away than before from the very objective it is supposed to reach.

Because of these reasons, it is important in order to determine the appropriate regulatory role for the government to understand what is the most that can be expected from markets, where do markets succeed and where they may fail.

The OSH characteristics of competitive market outcomes depend on individual choices (both workers and employers) in situations of risks and uncertainty (or imperfect information). These two properties are different: because even if fully informed about the probability of accident or sickness associated with a technique or exposure to a

substance, there is a risk since it is not known whether the event will occur or not. Uncertainty appears when the risks (i.e. the probability of different events to occur) are not fully known. We may have an idea of the risk involved. However, in general, there is uncertainty. Our information about the risks is imperfect, if only because it is only valid in statistical terms. In addition, in the OSH area our lack of information, even in statistical terms, is very large.

Market outcomes when there are risks have special characteristics; however under certain conditions the competitive market outcomes can be expected to assure Pareto optimal distribution of risks. See for instance Arrow [3]. However, as mentioned above, a Pareto optimal distribution may be quite unequal; since in general there are many Pareto optimal allocations, some with more equal distributions than others, a government role may be to attempt to bring the economy to a more equal but Pareto optimal distribution of risk.

In the case of deadly accidents, for instance, an allocation of OSH resources geared towards a more equal distribution of risk may be in addition preferable under certain conditions from the point of view of the cost-efficiency criterion discussed in the previous section (e.g. of maximizing the total expected number of lives saved for a given budget).

Wage Differentials in Perfectly Competitive Markets

In an ideal market situation each worker is well informed and everybody shares the same information. The worker is confronted with a schedule of wages and risks in different occupations. The worker has a utility function depending on wages, OSH, and leisure, of the form $u \equiv u(w, OSH, l)$, whose indifference surfaces are as in Figure 1 of Section II. For each level of leisure the worker trades higher OSH for higher wages according to his/her preference. The choice of the worker is determined by the maximization of his/her utility within the obvious constraints.

With perfect information the worker's utility can be thought of as being dependent on the expected value of OSH at a certain job choice, this expected value being determined by the well informed probabilities of states of the world to occur.

In the same ideal situation described above, the firm chooses the expected level of OSH (with the minimal costs levels associated to bring these about) and the wages it offers. Since higher OSH costs may mean lower wages (because workers may be willing to provide labor for lower wages provided OSH is higher) the firms' problem is symmetrical to that of the worker. In a perfect market equilibrium the results of well informed choices of workers and firms is Pareto optimal--no other choice will make everybody better off. In addition, the firm sets an optimal level of risk since it minimizes the sum of expected OSH hazards and the costs incurred in attaining those expected OSH levels.

Evidence of the existence of wage differentials for hazardous work is contained, for instance, in the U.S. Bureau of Labor Statistics publication [60] and the works of R.E.B. Lucas [24], W. Thaler and S. Rosen [58], and in R. Smith [48]¹⁹. However, the fact that market forces lead to higher wages for workers in risky jobs does not mean that a premium actually given for risk is the one that would occur if the market was perfectly competitive. Certain characteristics of the market may prevent a fully competitive outcome. An argument put forth by Smith [52] is that firms are the 'middlemen' between the ultimate consumers of safety, their employees, and the producers of it (suppliers of safe equipment). Unless the costs and benefits of different OSH levels can be transferred fully to employees, he argues, there will be an undersupply of safety--employees may not produce the amount of safety that their workers are 'willing to pay'. This may occur, for instance, if workers would not be fully mobile.

There are many instances where these imperfections of the market may occur; they are studied in more detail in Section IV.

¹⁹In [52] it is reported that J. Chelius who used data on individual firms in thirteen states, found, in contrast, no evidence of wage premiums in high-risk industries [15], 1974. Furthermore premiums are in general less responsive to health than they are to safety hazards.

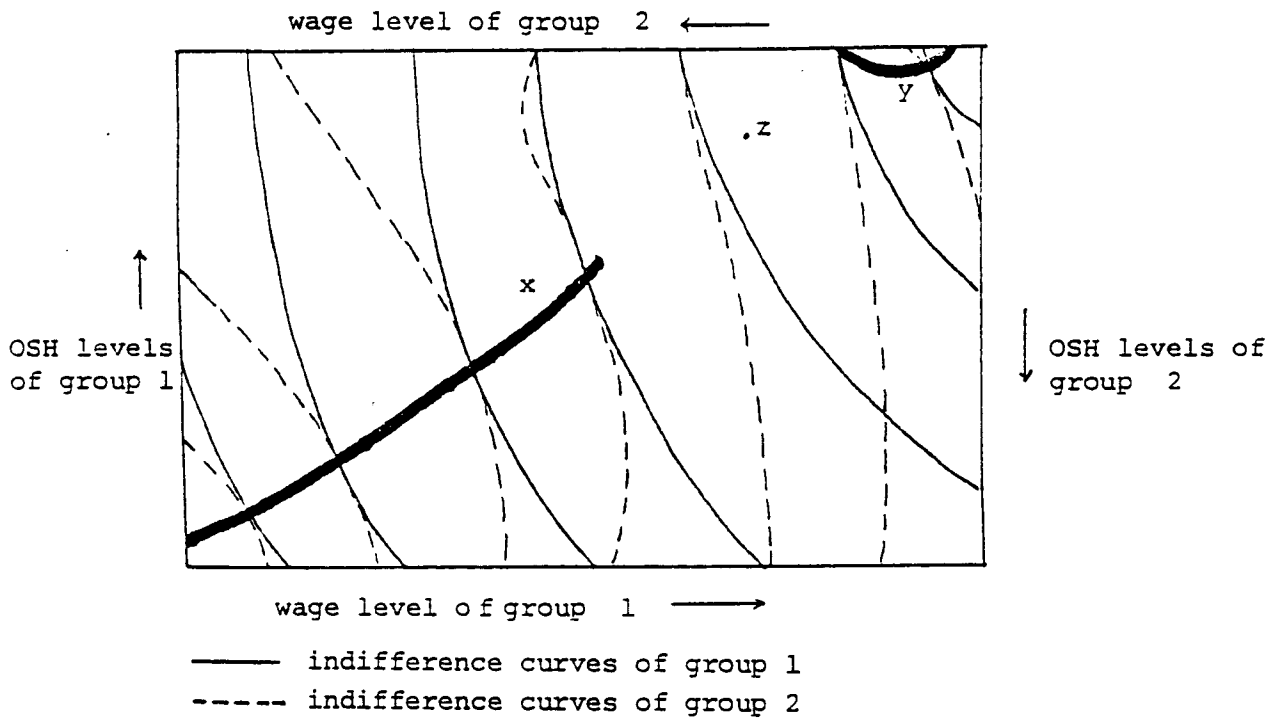
Characteristics of Market Allocations: Efficiency and Distribution

The perfect competitive market equilibrium described above has very desirable properties of efficiency. When individual preferences and firms' production functions are continuous and convex, there is perfect divisibility of all goods (including OSH) produced and traded, utilities are an increasing function of their arguments, no externalities or increasing returns exist and everybody has perfect information, a competitive market equilibrium is Pareto optimal, or Pareto efficient.²⁰ No other allocation will make every individual better off. As we discussed above, this applies to allocation of risks as well.

With respect to distributional questions, however, even if the outcome of a perfect competitive market is Pareto optimal there is no presumption that it produces allocations which are fair or desirable from a social welfare point of view. As said above, an allocation of the economy is Pareto optimal if no other reallocation of available resources will improve everybody's situation including OSH levels. Such an allocation can be considered optimal in the sense of efficient use of resources; it has also a stability property: the actors are 'locked in' at such an allocation if everyone has veto power. For someone will always lose, and hence oppose, if there is a move away from that allocation. However, in such an allocation the relative shares of one group may be very small compared with those of the other group.

²⁰Cases where externalities, increasing returns to scale and imperfect information exist are studied in Section IV.

See point y in Figure 7 below.



The thick curved line indicates the set of Pareto optimal allocations

Figure 7

In addition, with externalities in the market, utility functions may be non-convex and the Pareto optimal set may be discontinuous, as in Figure 7. In such cases, a gradual transition from 6 to a more egalitarian Pareto optimal position such as x in Figure 7 may not be possible without sidestepping to non-Pareto optimal allocations in the way (e.g. the point z in Figure 7). In that case one must temporarily forego certain competitive market equilibria in order to reach others equilibria outcomes which are both efficient and more egalitarian. Externalities in the cases of markets where one of the goods is OSH come naturally: the health of one individual, for instance, affects the utility of his or her whole family. If there are, as in the U.S. at present, already existing income security transfers for families where the working member which contributes mainly to the support is disabled, then (through taxes) the disability of this individual affects all other members of society. Therefore the OSH of an individual cannot in general be considered a private good.

Markets for Risk Bearing

As discussed above, even when there are risks competitive market equilibria could reach Pareto efficient allocations if the appropriate conditions are satisfied. Since existence of risks is a general phenomenon across the economy, and there exists special parts of the market that deal with it, such as insurance markets and securities markets, it is worth examining the parts of the market that could deal with OSH risk bearing.

An insurance market is a natural candidate for a market for OSH risk bearing. In fact such a market exists to insure against post-injury compensation to employees as provided by Workmen's Compensation laws. If Workmen's Compensation laws were comprehensive enough, the questions are: what prevents these markets from being adequate providers of risk spreading in the case of OSH? If they are not offering a necessary insurance coverage, can their ability be expanded?

By understanding their restrictions on the insurability of OSH risks for firms, we can be in a better position to understand what could be the government role in improving the market for risk bearing as a whole.

There are some major problems that limit the ability of OSH insurance as a risk bearing market. We shall discuss this next.

Leaving aside problems of distribution for a moment, we concentrate now on efficiency. Insurance is not a material good; although it is usually thought of as a service its value to the buyer is different in kind from the utility derived from consumption of goods, or health care. Insurance is a kind of contract that involves an exchange of money now for money payable contingent to the occurrence of certain events. In that sense, the closer the losses are from having money as a possible substitute, the better can insurance play its role. We now describe this role in some detail to be able to study better the OSH insurance market limitations. For a more complete description, see, for instance, Spence and Zeckhauser [55].

Let there be s states of the world, $s = 1, \dots, S$. Assume the insurance company gives the individual a payoff $p(s)$ in state s . This payoff is added to the individual wealth in that state $w(s)$, to give the total wealth of the individual as an argument to his/her utility function in state of nature s . Under this scheme, the individual expected utility is

(1) $\int u(w + p(s), s) f(s) ds$, where $f(s)$ is the probability of state s to occur. The break-even constraint is that the expected value of insurance payments are equal to zero

$$(2) \int p(s) f(s) ds = 0.$$

The insurer tries to maximize (1) subject to (2). The marginal efficiency

condition for this constrained maximization problems is that there exists a constant λ (the 'lagrange multiplier') such that

$$u' = \lambda$$

for all values of s . Therefore the optimal insurance scheme keeps the marginal utility of income constant.

The dependence of this marginal utility value u' on the probability of occurrence of the different states of nature is represented by the parameter λ that depends on (z) . If the individual's utility function has wealth as its only argument, then $u(w,s) \equiv u(w + s)$ and the optimizing condition is

$$u'(w + s + p(s)) = \lambda$$

which implies $p(s) = k - s$ where k is constant. By (2) $k = \text{mean of } s$. Therefore in this latter case the optimal insurance is one that gives the individual his/her expected income at all states.

The role of money as compensating for losses of commodities is of course extremely important, since money is a unit of value and can be exchanged for other goods. However, money cannot be considered as good a means to compensate for losses when there is serious damage (illness or death) at one state that cannot be adequately reversed by incurring in expenses. This case is not as general as it may seem: many illnesses and losses can be improved if means are available. Loss of life, however, is a more difficult case, but, nevertheless, life insurances are very widely purchased. This is because of externalities as described above: the loss of the life of a

worker is a loss for his/her whole family and an important part of the loss is material unless society has a very well furnished social welfare system. Even in this latter case, loss of a supporting family member may imply a big drop in the level of income, and consumption. However, the problem of existence of goods which may not be exchangeable for money for any individual is not peculiar to OSH; it is generally present in society.

It may not be possible to equalize marginal utility u' at all states if death, loss of limb or irreversible illness are some of them, and hence the optimal insurance rule given above may not be attainable. These cases, for that reason, deserve a different treatment.

However, in the cases where the utility considered is that which is the most that can be attained by monetary expenditures, the rule, $u' = a$ constant at all states, still holds. One case is when the worker regards the utility of his/her family and dependents as almost a substitute for his or her utility.

Even when the above factors are not considered, i.e. when money is assumed to substitute (at least to an extent) for losses, the problem in the case of OSH insurance is complex. This is because the probability distribution of the states of health s is not only given by nature, but it depends crucially on the behavior of the firm. In other words, the return in a state s not only depends on the states of nature but also on the actions of the firm. As discussed above and in [52] the firm can be

seen to behave as an agent which is intermediate to the consumption of OSH for the worker, and whose actions affect the probability of state s to occur. We shall study this problem in the next section.

IV. MARKET IMPERFECTIONS

In the last section we examined what is the most that can be expected of markets, under the best conditions, in terms of efficiency of production and distribution of OSH. The behavior of risk bearing markets under perfect information was discussed. In this section we shall study in more detail some of the imperfections that stand in the way of efficient market behavior in order to detect areas where policy intervention may be needed.

In the first place we discuss imperfections in the insurance market for post-injury compensation by firms. Because of the inability of the insurer to monitor the firm's actions on behalf of improved OSH, the risk spreading of this market is not optimal. Alternative insurance schemes and their limitations are discussed.

Next we discuss the problem of imperfect information about the level of OSH of the firm from the worker's viewpoint. Possible asymmetry of information may create an 'adverse selection' problem where there is an incentive for firms to invest in a less than optimal way on OSH.

We then discuss the quasi public good problem of standards within the firms, wherein heterogeneous preferences among the workers and existence of infra-marginal workers may lead to inappropriate levels of OSH.

Finally we discuss OSH externalities and also the externalities that appear in the markets of production of OSH and of information about OSH.

Imperfect Information

At the end of Section III we discussed the role of insurance markets in shifting OSH risks. We shall now discuss more in detail the limitations or imperfections of OSH insurance markets for firms.

Insurance Markets for Post-Injury Compensation by Firms

In society as a whole the role of insurance markets to spread risks so as to protect risk averse individuals from suffering the full consequences of adverse outcomes about which there is uncertainty is quite limited. Ideally, such a market should offer to an individual the possibility of betting, at fixed odds, any amount he or she wishes on the occurrence of any event which will affect his or her welfare. The premium (or odds) should be determined as a price in any other market, by equating supply with demand. If all individuals have the same resources, identical probabilities about states (independent of their actions) and utilities, and if all returns are monetary, the results of the last section apply: optimal insurance is one where marginal utility is equalized across states. If the utilities are only dependent on income (or wealth), the optimal insurance would be the one that always gives his or her expected income.

However, the imperfect information on OSH hazards and the fact that the probabilities about states of health are dependent on the behavior or actions of the firms changes the nature of the problem.

Let us assume that all returns are monetary, and that utilities depend on wealth. In fact, this is close to what happens in the actual behavior of OSH insurance markets under Workmen's Compensation which

shifts the insurance problem to employers. Since the employer pays the insurance premium (and collects the payoff) in order to insure against post-injury compensation to employees, this case corresponds to the above assumption: for the firm all costs and returns are monetary.

We shall study here this problem, leaving aside for a moment the question of the worker's compensation, which is discussed in more detail later in this Section and also in Sections V and VI. Even if there was a perfect insurance market for employers, unless the compensations to the workers were more adequate than at present, the risk-bearing would be shifted to workers in a less than optimal way; see, for instance, the discussion in [55], Section II.

It is not difficult to see why the economic system has not developed a more complete market for OSH risk bearing. Insurance is limited in scope (many risks are classified uninsurable) and insurance is frequently limited as to amount. From the economic viewpoint these two limitations are due to the fact that the insurer must resort to direct controls over the insured, because the insurer cannot distinguish between the risks and the actions of the insured. An outcome is a mixture of unavoidable risk against which the insurer is willing to insure, and human decisions. If the insured has a reason to reduce losses through its actions, there is no problem. But if the existence of an insurance policy may lead to a motive to relax OSH precautions at the plant or costs (the so-called 'moral hazard' problem), the insurer or risk bearer will be bearing higher risks than agreed. Either the insurer will refrain from

insuring or else it will have to resort to direct inspection and control. This will restrict the amounts to be insured for, and the scope of the insurance so as to minimize losses.

In short, any insurance market for spreading OSH hazards in the form of returns to firms for post-injury compensations to workers will imply a need for standards and direct controls over the firms, even under ideal conditions of information and compensation for the workers that institute claims. If the government takes the role of controlling, for the sake of insurers, the OSH conditions in the firms, such forms of insurance would imply government action that would not differ very much in practical terms from any other form of government control for monitoring standards. The decentralized action of markets for risk bearing would not then yield net savings.

One way to take into consideration firms' actions on OSH that eliminates some of direct control costs is to rank firms by their past experiences of injury or illness of their workers. Such ranking is already in practice in existing insurance schemes. However, at present for the vast majority of firms, insurance premiums are not adequately tied to their injury experience. The relationship between premiums and injury experience rises with firm size. This may be due to the fact that in the group of smaller firms there may be a larger proportion of short-lived firms, and if firms are short-lived it is harder to use their experiences to rank the premiums.

Businesses with 10 or fewer employees are in fact exempt from most of the record keeping (see Ashford [7]). This is because small firms may face special difficulties in complying with OSH regulations; in fact the OSH Act includes a special provision for reduced penalties and loans to aid small businesses to comply with standards. Firms with less than 25 employees make up about 90% of all firms, and during 1975 only 55% of inspections were carried in those firms. See [67].

As reported in [52], at present even in firms with 1,000 employees a 10% rise in injuries would reduce premiums by only 3%; only for firms with more than 3,000 workers the premium becomes fully responsive to the injury rate. This was reported from L. Russell [44].

If workers were insured and compensated directly for injuries and/or illnesses by the insurer (or the firm) according, for instance, to a given fixed scale, this would eliminate some court costs. There could be, however, a problem of lack of incentives on the part of the workers. At present, the workmen's compensation requires the worker to incur certain costs to collect a compensation, and this acts as an incentive to prevent OSH losses. The costs associated with control described above, in the case of the workers would be smaller because, in principle, the incentive to prevent injuries or illness is still present for workers even when compensation is available. This, of course, is not true for many injuries or illnesses for which the 'moral hazard' problem for the worker still would exist, but would be true for major or irreversible

ones. At least, the incentive for workers to prevent OSH losses would be larger than for employers.

However, a related problem of incentive for controlling OSH levels by the firm would arise if it is the workers who pay the premiums, while it is the firm that sets the standards. This could be somewhat avoided in a system in which both workers and firms pay premiums and coinsurance. The coinsurance rates and premiums for workers could be set according to OSH odds at desired levels, while the premiums and the coinsurance rates for the firm could be determined so as to compensate the insurer for differential risks, according to the difference between the desired levels and the ones actually experienced by that firm.

This last specification would give the firms an incentive for setting better OSH levels, and, because of the existence of coinsurance, the workers' 'moral hazard' problem would be somewhat diminished.

However, such a solution would be at most a second best one. To achieve the appropriate incentives, the insurance plan must sacrifice some of its risk-spreading capabilities and this implies a loss of efficiency. This is discussed in more detail below. In addition, rating by past experience would not be as appropriate for smaller or shorter-lived firms which are difficult to rate for the past experiences of injuries/illness. Therefore, it becomes clear that a classification of policies by firm size as well as length of existence may be needed for studying what may be the most appropriate policies. For instance, for those firms that cannot be rated by experience, only coinsurance rates should be relied upon to create incentives.

The above reasoning can be formalized using the theory developed in [55]. We first study the case where the firms insure against post-injury compensation. As before, assume that all firms have identical resources, utility functions and probability distributions. Assume as before that utility depends on wealth only, and that each firm can take an action denoted as consisting, for instance, of OSH expenditures to expected post-injury compensation. At each state s , let $J(s,a)$ be the injuries compensation costs to the employer in state s with action a .

In order to compare outcomes we study the case where the insurer does know, for instance, the amount of injury compensation of the firm, denoted J , and also the cost of the action taken by the firm. The firm's wealth at each state s is

$$(1) \quad w = w_0 + J + p(J,a) - a$$

where w_0 is initial wealth and $p(J,a)$ is the payoff by the insurer to the firm. The firm chooses its OSH action (a) so that its expected utility, given by

$$(2) \quad \int u[w_0 + J(s,a) - p(J(s,a), a) - a]f(s)ds$$

is maximized.

A constraint for the insurer is that total expected payoff be equal to zero, i.e.

$$(3) \quad \int p(J(s,a), a)f(s)ds = 0.$$

for the a that maximizes (2) for the given payoff $p(J,a)$. By making the payoff $p(J,a)$ sufficiently negative if $a \neq \bar{a}$ where \bar{a} is a chosen action by the firm, the insurer has control in this particular case over the firm's action.

Therefore the insurer's problem is to choose an action a^* and a corresponding payoff $p(J, a^*)$ that maximizes (2) subject to (3). The optimal $p(J, a^*)$ would then be determined as in the case discussed in Section III by the condition that marginal utility be equal across states, i.e.

$$(4) u' = \lambda$$

Therefore the outcome is efficient. Note that (4) implies in this case that

$$(5) \frac{dp}{dJ}(J, a^*) = -1.$$

We shall discuss the loss of efficiency that occurs when the firm cannot be controlled directly in terms of the action it takes about OSH, but when the insurer can only deduce it through the injury compensation costs the firm incurs on J . The payoff function of the insurer is made then to depend on J only, i.e. $p \equiv p(J)$. The insurer then selects $p(J)$ to maximize the expected utility of the firm as in (2) above, subject to two constraints. One is that total expected payoffs be equal to zero, i.e. equation (3) above. The second is that a be selected so as to maximize (2) subject to the given $p(J)$.

This second constraint can be given by the derivative of (2) with respect to a equal to zero, i.e.

$$(6) \int \left[\frac{\partial J}{\partial a} + p' \left(\frac{\partial J}{\partial a} \right) - 1 \right] u' f(s) ds = 0$$

The marginal condition for the optimal payoff function for the insurer is

$$(7) \quad \lambda u'' + u' \left[1 + \lambda \frac{d}{ds} \left(\frac{\partial J}{\partial a} \frac{\partial J}{\partial s} \right) + \lambda \frac{\partial J}{\partial a} \frac{\partial J}{\partial s} \left(\frac{f'}{f} \right) \right] - \delta = 0$$

where λ and δ are the 'lagrangian multipliers' associated to the two constraints. In this case the payoff depends directly on the distribution function $f(s)$. Also, the marginal utility of wealth is not constant across states as before, since $\frac{\partial p}{\partial J} \neq -1$, which was the efficiency condition (5) derived before when the actions of the firm as well as J_1 were known by the insurer.

The question of incentives versus efficiency becomes now clear. It is not desirable to keep marginal utility (or wealth) constant across states. See [55], Case III. The payoff function $p(J)$ must be such that wealth at each state is an increasing function of the insurance payoff received. This is because, as the insurance payoff is positively related to the firm performance, the insured firm does not otherwise have an incentive to take a (positive cost) action towards better OSH performance. To achieve this incentive, the insurance plan violates the condition of efficiency (marginal utility constant across states) and risk spreading is not optimal.

These results indicate deficiencies of OSH risk bearing markets. Since firms cannot be adequately provided with post-injury compensation insurance, they cannot afford to serve as a proper 'middleman' between the ultimate consumers of OSH (the workers) and the producers of it. Even if firms could be made to bear the full cost of OSH hazards, through a more comprehensive schedule of Workmen's Compensation, firms could not be well insured about such risks. They would, in those cases

have to bear risk in such unoptimal ways that it might impair their economic functioning--and perhaps these negative effects would be transferred to the workers also.

The difference between the insurance payoff that satisfies the condition of efficiency and the one that is given as a solution to (7) above is a measure of the inability to observe the OSH actions of the firm, or of the costs (administrative or informational) that may be involved in observing them.

The second best problem is to find the combination of incentives and of degree of efficiency that minimizes total expected losses. Two different premium schedules would have to be established for the firm and for the worker corresponding to the above analysis. For those injuries and accidents whose avoidance depend mostly on worker's precautions (e.g. wearing some equipment) the incentives (coinsurance rates) would have to be placed more on the worker than on the firm. The loss of efficiency would otherwise be larger for the worker as well. For those accidents or injuries that are mostly related to the firm's actions, the incentive would have to be placed more on the firm.

For those firms whose size is too small to have a statistically sound basis to observe J , other direct control means would be more adequate. The second best solution would be attained (at least for larger or longer lived firms) by minimizing the total sum of efficiency losses and losses due to lack of proper incentives.

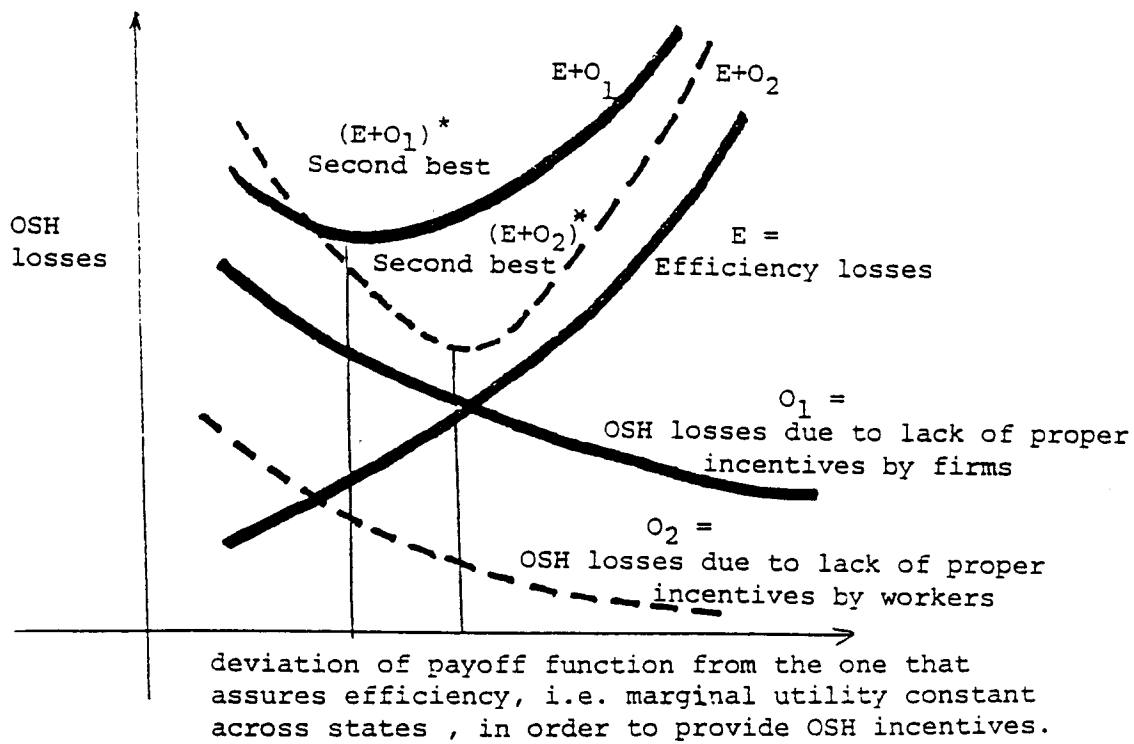


Figure 8

In Figure 8 there are two schedules of OSH losses due to the lack of proper incentives: one for the firm and another for the worker. It is assumed here that the types of losses considered are serious or irreversible enough that the 'moral hazard' problem of the worker is less important than the corresponding problem of lack of motivation of the firm. By segregating the premiums and coinsurance rates for these two groups as proposed, the second best can have a higher level of efficiency as well as a lower level of losses than otherwise. This fact points towards a possible policy recommendation. Whenever possible, in cases as those depicted in Figure 8, the introduction of new information and of preventive devices may be more efficient if they are of the type that relies more in decision making by the worker than by the firm. In Sections V and VI the possible role of the government in this area is discussed.

Note that in all the above the lack of information about probabilities $p(s)$ of occurrence of events was not considered directly--lack of information was mostly mentioned with respect to actions of the firms. However, by influencing the outcomes by their actions on behalf of OSH the fines can be seen as influencing the probabilities of these events. An analysis similar to the one given above could be carried out assuming that the probabilities $p(s)$ depend on actions $a(s)$, i.e. $p \equiv p(s,a)$.

The above cases must be distinguished from others in which there is a serious lack of information about $p(s)$ for all concerned. For instance, as mentioned above for many years the dangers of vinyl

chloride were unknown. This was in part related to the long 'latent periods' of the illnesses related to their substance, up to 20-35 years. Such cases indicate the need for another classification of OSH for policy purposes: by the general existing degree of information of the effects of a technique or substance. Since this information level relates to how new the substance is (or how long it has been in use) the classification should distinguish older from newly introduced techniques to establish which would be a more appropriate policy. This point is further developed in Section V.

An important problem in the above is the setting of the scale for compensation of injuries and/or illnesses. It is beyond this analysis to study whether legislation should be passed to aid the use of the court system in obtaining compensation, or whether compensation should be determined outside of the courts. However, some general comments are applicable.

When enough information is available with respect to exposure levels, substances or technique hazards, the costs of the injury and the firm which has caused the injury, a direct compensation would be preferable to compensation mediated by the courts. Smith [52] proposes a similar approach, calling it an 'injury tax' which could be made proportional to the cost of each case being remitted to the federal government, either directly or indirectly through the insurance companies. The employer could choose its action to avoid OSH losses, and workers and labor unions would serve the role that employers serve to the IRS in

providing verification of wages and salaries to the government. In Table B-2, Appendix B of [52], evidence is submitted to the effect that work injury rates are inversely proportional to the costs to employees of injuries. Employees are responsive to added costs to their firms because of injuries. This was computed by regressing the injury frequency rate A on the change in total injury costs M caused by a change in the number of injuries, I , the price of safety inputs P_s , a variable representing the level of inherent risk R , and a random error term, e . The parameters α , β and γ of the following equation were estimated

$$A = \alpha \left(\frac{dM}{dI} \right) + \beta R + \gamma P_s + e$$

The results were obtained by using data on thirty manufacturing industries. Based on those results Smith suggests a schedule of fines that would be required to reduce injury by certain rates, i.e. how responsive is the injury rate to such 'taxes'. For a fine of \$1,000.00 a low estimate of 4.4% to a high estimate of 6.2% is given; for a fine of \$2,000.00 a low estimate of 8.8% to a high of 12.5% is given; and for a fine of \$3,000.00 a low estimate of 17.6% to a high of 25.0% is given.

Most OSH injuries are temporary, involving more than 95% of all work injuries. As reported by Smith, in manufacturing a total cost of injury to the worker (including wages and medical expenses) were about \$525 in 1970. The figures on medical costs were obtained from the National Commission on State Workmen's Compensation Laws (Compendium) [30].

The typical work loss was of about 15 days according to the U.S. Department of Labor, Bureau of Labor Statistics [63].

Ideally the amounts of such forms of incentives and compensation should be determined by the rules discussed in Section II to improve overall safety in a cost-effective way for a given budget.

For many instances of occupational health, however, the conditions are less appropriate for such compensating procedures than they are for safety hazards. One problem is that the worker may have been employed by several firms and/or there may be a long latency period for an illness. In these cases it is difficult to detect the firm that has contributed to this event. In addition, when the illness is induced by a newly introduced substance and its total expected costs are unknown or where there is a large component of pain and suffering, a court procedure may be of help. From the point of view of prevention, the setting and monitoring of standards would probably be more appropriate in these cases.

Asymmetry of Information about OSH

A second problem of imperfect information arises if there is some asymmetry on the level of information on OSH from the point of view of the workers and of the firm. For instance, the worker may know less about the actual statistics of OSH hazards in each available job than each firm does. There is some empirical evidence that worker information about OSH levels is imperfect.

notorious) without knowing precisely what techniques or precautions each firm is offering. Workers may for instance grade jobs some statistic of the industry or sector. From the point of view of each firm there might be an incentive to reduce costs on OSH since the benefits of higher OSH costs (e.g. lower labor costs) cannot be obtained since they are not perceived by the worker. If the firm engages in providing information to prospective workers about the level of OSH that it offers, the costs of this information to the firm have to be deduced from the benefits in terms of lower labor costs. In short, there is a dampened incentive to improve OSH levels. If most firms follow this behavior, there would be a collective incentive to lower general OSH levels. This problem can be formalized as follows. Suppose that the supply of labor function of a worker is derived from constrained utility maximization. The utility of the worker u is a function

$$u \equiv u(l, w, m) .$$

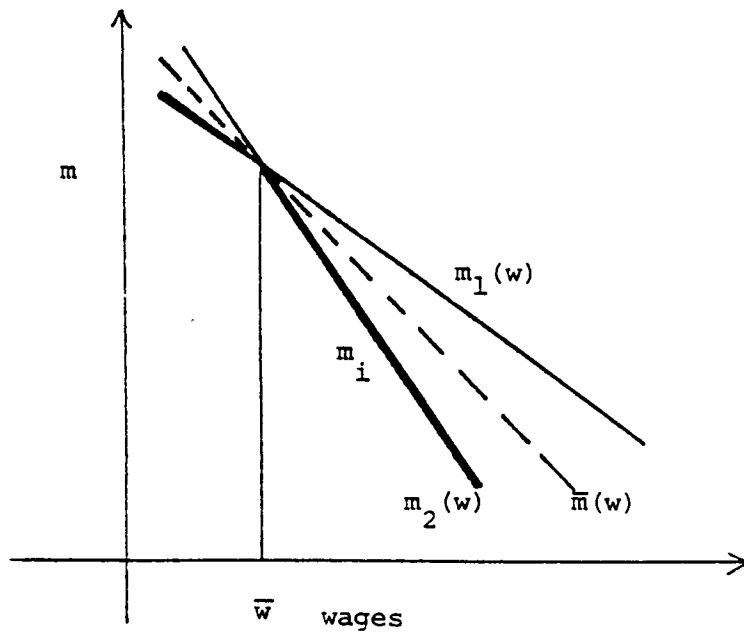
where l is leisure, w wages, and m represents expected (average) OSH level. The supply of labor will then be a function $S(w, m)$. Both the demand for labor by a firm and also the average OSH levels offered by the firm will depend upon wages, i.e.

$$D \equiv D(w) , \text{ and } m \equiv m(w) .$$

At an equilibrium in the labor market

$$S(w, m(w)) = D(w) .$$

Suppose there are two firms: one offers a schedule of average OSH wages represented by the curve $m_1(w)$ and the other by the curve $m_2(w)$ so that at wages higher than \bar{w} firm one offers more average OSH than firm two. (See Figure 9).



Workers perceive the average OSH level of firms of one type,

$$\bar{m}(w) = m_1(w) + m_2(w)$$

m_i indicates the minimum between m_1 and m_2 . Because of the asymmetry in information, there will be a collective incentive for firms to lower their OSH levels to $m_i(w)$.

Figure 9

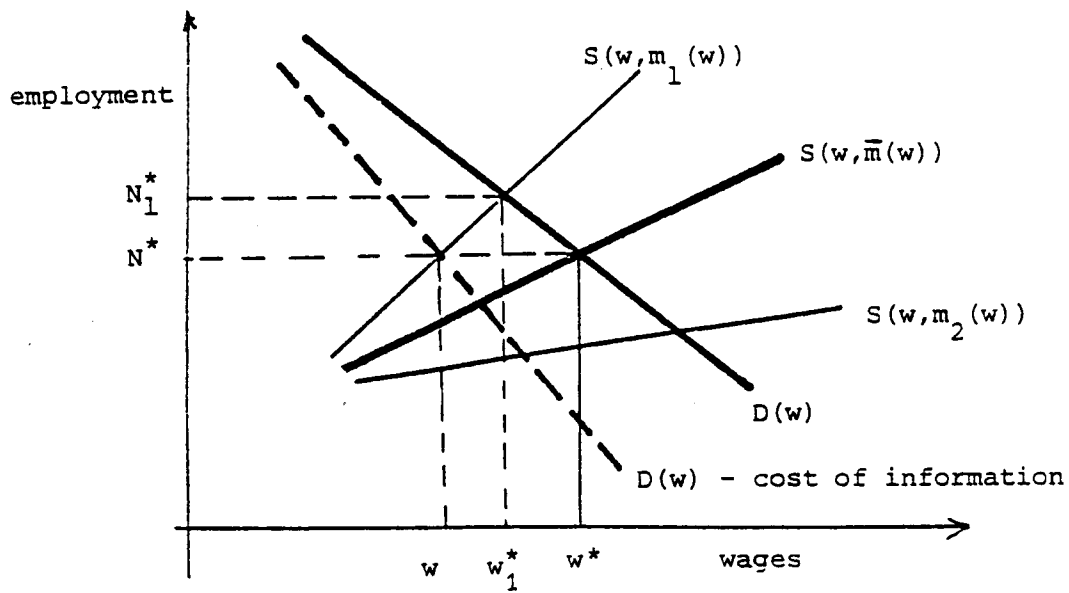


Figure 10

If workers perceive the average OSH level of firms one and two
i.e.

$$\bar{m}(w) = m_1(w) + m_2(w)$$

then they offer a supply of labor curve $S(w, \bar{m}(w))$, see Figure 10.

Equilibrium levels of wages and employment will be w^* and N^* respectively. Firm 1 should actually have an equilibrium with lower wages, w_1^* because it offers more average OSH. To obtain the benefits of its higher OSH level, it may engage in providing information at a cost Δ . If Δ is high enough, since information costs must be added to labor costs, it may shift $D(w)$ to $D(w) - \Delta$, undoing the benefits for the firm of the higher average OSH this firm offers. Therefore Firm 1 may have an incentive to offer $\bar{m}(w)$, so as to reduce costs and still obtain similar benefits. In that case the average OSH level of both firms decreases to a lower level. In this situation there is a collective incentive to overall decrease average OSH. The process does not end until the thick average safety line m_1 in Figure 9 is reached, yielding less than optimal levels of OSH as a whole.

A similar problem would arise if firms would purchase post-injury compensation insurance and the insurer would only be able to observe the statistic \bar{m} (as the workers in the example above). There would be a collective incentive to decrease overall \bar{m} , yielding less than optimal levels of OSH.

It would seem that when there is a problem of lack of information as in those cases discussed above, government action directed towards increasing the level of information may be helpful. In fact, there is

some evidence that both OSHA and the Consumer Product Safety Commission have considered placing a higher priority on the provision of information within their functions. See, for instance, Cornell, Noll and Weingast [19], Owen and Schultz (eds.) and U.S. Department of Labor RFD/A 76-10, [64]. As [19] and [72] report it, Congress has not supported these attempts, placing a higher priority on promulgation and enforcement of standards.

It is clear that for policy making purposes it would be useful to have a classification of cases that would detect where the most gains in efficiency can be obtained by providing information (such as in the cases discussed above).

Firms with Risky Technologies

There may be other cases with imperfect information where the government may have to intervene not only to provide information but also to provide efficient risk-spreading because insurance markets may not be able to do so.

A problem arises for insurance provision for firms with risky technologies to spread the risks of post-injury compensation costs. This is a so-called 'adverse selection' problem well known in the theory of insurance. It has some arguments in common with the 'moral hazard' problem and can be thought of as being an aspect of it.

The problem may be summarized as follows. It may not be possible for the insurer to provide insurance to the riskier firms at any premium. Because, the higher the premium levels are, the higher proportion of

risky firms (low average OSH, high post-injury compensations) would find the insurance attractive. If there is imperfect information about the OSH levels, the insurer may not be able to distinguish them. This can be seen as follows:

Let the supply of insurance be a function of premium and level of risk, $S(p, OSH)$. The demand of insurance depends on premiums $D(p)$, and the average OSH level is related to premiums $OSH(p)$. In equilibrium supply must equal demand, i.e.

$$S(p, OSH(p)) = D(p)$$

If, as premiums p increase, the average OSH decreases as explained above, it is possible that no equilibrium may exist. This means that no efficient risk spreading can be obtained from insurance markets for firms with very risky technologies (such as nuclear plants).

The government action may be needed to spread these risks. Otherwise, firms with risky technologies may not be able to operate efficiently since they would bear too high risks.²¹

However, even if the government intervenes on behalf of such firms, if workers cannot transfer to firms their costs in terms of OSH losses (due, for instance, to very limited workmen's compensation), then workers would be bearing these costs themselves. There is in such cases transfer of risk from the firms to the workers that is not only unequal, but also inefficient for society as a whole.

In the above we discussed several cases where the government role for pooling and disseminating information could be helpful in improving the functioning of markets, and general welfare.

²¹An example of government action of this sort is the Price-Anderson Act which limits the liability of nuclear power plants.

There are, however, several limitations to what can be accomplished if the role of the government is limited to gathering and disseminating information. These are discussed in more detail in Section V about the government role.

Even if relevant information about OSH was available, it would still be difficult for workers to make fully informed decisions as required for a competitive market equilibrium to obtain. One reason is that there is a limit as to the amount of information that can be pooled and disseminated, as well as to the amount of information that can be absorbed and classified by the workers. Also, the production and distribution of information may itself contain some public good aspects. This is discussed further in the part of this Section about externalities in the production of OSH information.

In addition, with respect to newer chemicals or processes, the information may be such that the worker must make decisions where very low probabilities are concerned. Empirical evidence shows that individuals rate poorly in making decisions when very low probability events are concerned. See for instance the work of Tversky and Kahneman [59]. It is possible that the higher quit rates observed empirically in Viscusi [68] are due in some cases more to an improvement of decision making with very low probabilities (when the demonstration effects on other workers are felt) than to an improvement of information.

For instance, a smoker that is aware of the probability of contracting lung cancer may change his behavior towards tobacco when a friend or a member of the family dies of lung cancer.

OSH as a Quasi Public Good

There are other imperfections in the labor market that may prevent the economy from attaining appropriate levels of OSH even in a world of perfect information. The existence of large firms (monopolists) that face an upward sloping labor supply curve may be one. If the value of wages and OSH levels are set in such markets, in equilibrium lower wage/OSH combinations will occur in this situation than if markets were competitive. This situation may also be related to the existence of fixed costs for worker's mobility, both geographic and across occupations.

Another added problem that would appear to be more associated with large firms relates to the setting of OSH levels. OSH levels in a firm are likely to be set simultaneously for all workers. Since they cannot be expected to be chosen on a worker-by-worker basis as implied in the discussion of the perfectly competitive markets, we may have a case for a market failure.

Having chosen a technique of production (certain substances, machinery, etc.) the firm will offer all of its workers, except for very minor variations, much the same levels of OSH, such as a plane of a certain type will offer all its passengers much the same level of safety. The assumption is that there are fixed costs that may prevent the adoption of more than one technique of production. The OSH level in the firm becomes then a (quasi) public good. If the determination

of the OSH level (associated to the technique of production) is an endogeneous variable for the firm, then there may be a competitive market failure since group returns and individual returns may differ, and marginal analysis may fail to yield optimality.

The source of the potential competitive market failure is similar to that of the analysis of Spence [56] for product quality setting by monopolies. It can be described as follows. If the firm is contemplating to improve by a small amount its OSH level, OSH costs will increase, say by an amount Δc . Wage premiums, in that case, may decrease. The increase in OSH level increases the benefit to the marginal worker who is just willing to be hired at the going wage by approximately $\Delta w(x)$, where x is the number of workers. Total wage costs for the firm then decrease by $x\Delta w(x)$. Therefore the increase is desirable for the firm if $x\Delta w(x) > \Delta c$.

However, $x\Delta w(x)$ is not an appropriate measure of the benefits of the increase in OSH for the workers at the firm as a whole. The OSH increase is socially desirable if the average benefit

$1/x \int_0^x \Delta w(n) dn$ exceeds the average cost $\Delta c/x$. The firm's problem would yield a gain in welfare if total benefits $\int_0^x \Delta w(n) dn$ would have exceeded the cost of the increase in OSH, Δc . The social benefits correspond to an increase in the revenues of the firm (a decrease in costs) only if the marginal consumer is average or representative, which corresponds to the case when

$$\frac{1}{x} \int_0^x \Delta w(n) dn = \Delta w(x).$$

However, there is no reason to assume that the marginal worker will be representative or average. In certain cases the marginal worker may have a valuation of safety which is below that of the average worker and the OSH standards set would be too low.

This may occur, for instance, because, as shown in [27], younger workers are more mobile. The firm faces a higher proportion of such workers than others. If the firm sets its standards for the marginal worker, and if younger and mobile workers put less emphasis on safety, this would produce a less than optimal choice of OSH levels by the firm.

There are models, such as that of Stafford and Cohen [57], that predict in some cases this type of divergence for wages, i.e. marginal wages lower than average wages. It would be of interest to see under what conditions, if worker's utilities depend on wages and OSH levels, similar results can show that marginal values of safety would be lower than average ones.

In the case described above the average value of safety becomes a difficult question--similar to that of the optimal level of a public good. It is also similar to the question of average valuation of quality of products by consumers in the market, and could be studied by similar methods [56]. In such cases there seems to be room for some form of government regulation. This is discussed in more detail in Section V.

Institutional Rigidities

There are several institutional rigidities that may prevent market forces from bringing about a competitive market equilibrium outcome, with the corresponding OSH losses. One of these, which is well understood is the limitation of worker's mobility. Workers, in such cases, cannot have the choices available that would give the incentive to the employer to improve OSH. Even after a workplace or a substance used by a firm is known to be damaging to the health of a worker, that worker may be 'locked' into the job.

Wage rigidities are sometimes blamed for existence of unemployment. In such situations, less than optimal OSH outcomes are likely to occur. Minimum wage legislation could also have similar effects. These issues were discussed in Section II above.

Other rigidities relate to the existence of large firms which cannot adjust OSH levels on a worker-by-worker basis. This was discussed above in this section. The role of unions may also have similar effects. In a bargaining process, the infra-marginal worker may not be represented in a way that would assure an optimal OSH outcome. Related problems are discussed further in Section VI.

Institutional rigidities leave room for improvement of OSH levels by government action: this action may take the form of attempting to eliminate the rigidities as well as, or instead of, direct regulation of OSH.

OSH Externalities

As discussed already, the costs of the illness, injury (or death of a worker) accrue not only to the worker, but to his/her family in the first place, and also to society as a whole. This may give rise to externalities.

For instance, the utility of being employed is shared by the whole family of the worker. However, as in cases of illnesses with long latent periods, the health risk associated to that employment may be borne mostly by the individual (or his/her couple) rather than by the children, who might have left the household by the time the worker is ill or deceased. The returns of the wages and OSH obtained from employment accrue to a group (the family) and may differ from the individual return. The worker would take into account the expected OSH damage as well as the wage level-- while the family returns may be higher for higher wages even with lower OSH. When individual and group returns differ, there is a loss of Pareto optimality at the market equilibrium. In such cases, when private and social returns differ, governmental intervention may increase the welfare of all parties. Or, alternatively, private institutions may arise to take advantage of the potential increases in welfare to all parties. To the extent that such institutions may be large and tend to concentrate power, other negative consequences may develop.

Another OSH externality is purely financial and is derived in part from the existing income security programs. This was discussed in some detail in Section II. Health care expenses and the expenses of

supporting families whose main wage earner has been incapacitated, ill or deceased, are translated through social security, welfare payments and disability insurance (and through taxes) to society as a whole.

If a firm is imposing unhealthy or dangerous conditions on its workers, it might be obtaining effectively a transfer from the rest of society to itself, to defray its reduced OSH costs. This is because the firm does not pay a higher contribution to these income security programs (social security taxes or employer's health insurance contributions) if its OSH risks are higher.

The above described externalities imply that the competitive market mechanism may not operate adequately. Neither the worker, nor the firm are likely to fully take into account the costs of OSH risks to the worker. In the first case, even if the family losses are internalized (for instance, if the family internalizes the OSH damages to the wage earner), the losses that accrue to society (via income transfers) are not likely to be fully computed. Similarly, the firm may not have appropriate incentives to reduce OSH losses since it does not perceive its costs fully; they are transferred to society. In such cases the role of the government is to impose measures that would internalize these costs for efficient decentralized decision making (for instance, fining firms for the OSH costs to others that the employer does not compute as part of his/her costs). Alternatively the government could impose and monitor OSH standards that are computed as efficient outcomes.

Unlike several other developed countries the United States does not have a government operated national health insurance or national health service covering the entire population. Medicare and other programs provide health services to the poor. The majority of the population, however, depends largely on private hospital and/or surgical insurance to finance large medical expenditures [17]. If a form of national health insurance is adopted in the U.S., the government would have a further incentive to intervene in order to promote OSH.

In the computation of the magnitude of an externality, certain problems arise. For instance, the cases where information is more difficult to collect and disseminate are less likely to be identified as for costs, and these costs are likely to end up being undervalued. In addition, pain and suffering due, for instance, to a long illness for which not much medical expenditures are necessary may be undervalued also. In those cases, the worker and his/her family may bear most of the costs. The existence of these externalities indicates the need of adequate government intervention to promote OSH.

Externalities in the Production of OSH and of Information about OSH

There are several reasons for the possible failure of perfect market competition to achieve optimality in the allocations for the production of OSH (safer equipment, safer substances, etc.) or of information about OSH (more information about equipment/substances whose OSH effects are unknown).

Some correspond roughly to classical reasons for market failure such as indivisibilities and inappropriability. These problems have been much studied in the literature: under the heading of marginal-cost pricing and under that of divergence of social and private benefits or costs. The latter problem refers to the OSH production analog of the OSH externalities discussed above. For instance, in general, the social benefits of increasing OSH information may exceed those benefits to the firm or individual that produces it. Therefore, no individual would have the incentive to gather and analyze the data him or herself. It would also not be efficient for private business to do so. In both cases the costs may more than compensate the social benefits, but the individual or the firm may not be able to recuperate the costs. This is because it may be costly in some cases to withhold information. Furthermore to do so would be inefficient; in social terms once the information

is available provided the marginal cost of dissemination is smaller than the benefits of the information, the wider it is used the better. As opposed to other public goods, information does not necessarily get 'used up' or 'crowded' (such as other public goods, for instance, public transportation, or recreation sites). It is only when dissemination costs are large that there are economic limits to sharing information.

In the cases of production of OSH and of information about OSH there is an additional source of market failure induced by uncertainty. Since they are both risky activities with unknown probabilities of returns, unless proper risk-sharing is provided, there is bound to be some discrimination against such research activities. If, as studied in Arrow [3] in the private sector it is the large firms that are better suited to create incentives to research in this area (if only because of large fixed cost to research or because the appropriability of the produce may be greater under monopoly than under competition) the problem still remains that these benefits may be offset by the disincentive created by the monopolistic wage levels.

If the government and other non-profit institutions are to compensate for the less than optimal allocation of private resources to production of OSH and of information about OSH, how shall the government allocation of resources be determined and how shall the government produce incentives to encourage efficient use of resources? Some of these problems have been widely studied in more general terms in the literature. For some classic examples see R.R. Nelson "The Simple Economics of Basic Scientific Research" [33]; C.J. Hitch "The Character of Research and

Development in a Competitive Economy" [21]; for more recent theoretical and empirical work especially dedicated to OSH problems, see for instance the work of T.C. Sinclair, P. Mastrand and P. Newick "Human Life and Safety in Relation to Technical Change" [47]. A further discussion of possible government role in promoting production of OSH and of information about OSH is contained in Section V.

V. THE ROLE OF GOVERNMENT

Objectives of OSH Policy

Government intervention in the OSH area has several (interrelated) objectives. One is to contribute to increase OSH levels where there is reason to believe that market imperfections are bringing about OSH levels which are less than optimal. Particular cases where competitive market failures may occur in the OSH area were discussed in Section IV.

A second objective is to help determine possible tradeoffs between more OSH and other social goals, as discussed in Section II, and, implicitly, socially desirable overall OSH levels.

A third objective is to help bring about socially desirable distribution of OSH risk. This third objective relates to the first because it is concerned with Pareto optimal distributions; however, this objective includes also considerations of equity. This was discussed in Section III.

A fourth objective is to assure that the allocation of government expenditures (taxpayers contributions), while in accordance with the above goals, is done efficiently, as discussed in Section II.

The difficulty of analysing government roles is that these different objectives are interrelated to the extent that a policy addressed to each one is likely to affect also the others. Therefore, for analytical purposes, they have to be studied together even though the effect of policy on each should be analyzed separately.

Another difficulty is that there may be tradeoffs between the government objectives, and the ranking among them may not always be understood or well determined. Since government is not a monolithic unit, perhaps this is the way it should be.

Analysis of a policy should therefore contain whenever possible the tradeoffs between these goals in order to clarify possible choices to be made. If this is not explicitly done, an implicit value judgement may have been made that could bias the discussion, for example, by preferring a policy which implies a more efficient use of resources to another which may be less efficient in the short run but prevent high irreversible OSH losses in a more immediate way. A certain amount of subjective judgement cannot be avoided, but it may be preferable to make it as explicit as possible.

Until the OSH Act of 1970, occupational safety and health regulation was mostly the responsibility of the states;²⁴ at present OSH regulation is primarily the responsibility of OSHA. The states can submit plans to OSHA to run their programs, and OSHA is required to approve them if they are as stringent as federal programs. On the other hand states receive only 50% federal financing and OSHA 100%, which gives an incentive for more centralized federal action. Even though there are reasons why states regulation could be preferable,

²⁴There were some exceptions, such as the Longshoremen's and Harbor Workers' Act of 1927 that assigned federal regulatory powers for longshoremment job safety, to the Bureau of Labor Standards of the U.S. Department of Labor--now in charge of OSHA, see [19].

for instance, the standards could be set in a more decentralized manner and thus would reflect local conditions and needs more precisely and economically, Congress intended that OSH control be a federal activity. See for instance the report in [19].

One reason why federal regulation may be preferable is because it may avoid possible competition by states for investment and location of industries at the cost of OSH. For instance, a state may have an incentive to offer lowered costs of OSH in order to attract new plants especially to the areas in which there are higher unemployment rates or lower growth rates. If there are reasons to suspect that in those cases is where market failures (say, lack of mobility of workers, or other institutional rigidities) may exist, then a federal role may be preferable.

In the following analysis, then, we assume that the government role is carried through federal controls. We discuss the following instruments: incentives, which include liability laws and taxes, standards; and provision of information. To the extent that these instruments are complementary in helping to promote OSH for efficient administration of OSH control, it is of importance to detect in which cases each may be most useful with respect to the alternatives. The best form of use of each instrument, or the best achievement of control by use of a combination of these different instruments can then be studied. Since we proposed four complementary objectives for

government intervention in OSH, the contribution to each of these goals should also be clarified. The material of this section is then to be used to prepare the ground for the classification of OSH risks for the determination of appropriate government roles given in Section VII.

INSTRUMENTS

Incentives

Incentives can be viewed as financial penalties that are imposed on employers when OSH damages (i.e. injuries, illnesses, loss of life) occur.

Workmen's Compensation

Workmen's compensation laws can be a form of incentive to increase OSH--since, for instance, the firm experiences higher costs if its total bill for post-injury compensations increases. This incentive role is one of the objectives listed by the National Commission on State Workmen's Compensation Laws for a Workman's Compensation Program ([30], [31]). However, at present, the incentive role of workmen compensation laws is questionable due to the quite strong limitations existing on compensations and to the fact that most firms purchase insurance against the event of workers compensation. Nevertheless, workmen's compensation should be regarded as a major component of a government strategy for dealing with OSH, since related laws are in force at both state and federal level and several recent legislative proposals for extension of its functions, coverage and compensation limit, are being contemplated.

Other goals of the Workmen Compensation Act as viewed by the National Commission of State Workmen's Compensation Laws are income security and provision of sufficient medical care and rehabilitation services, and broad coverage of employees for OSH losses .

This covers two of the objectives for government intervention in

in the OSH area stated at the beginning of this section, and leaves aside questions of efficiency and of determination of tradeoffs with social goals other than OSH. These two latter questions, however, are seldom considered explicitly as government roles in each form of control endorsed but need to be discussed when the policy and its best uses are considered. The possible role of workmen's compensation law as distributing risks through an insurance mechanism is also not explicitly mentioned in [31] (it is implicitly considered in the clause about income security) and needs particular consideration.

Workmen's compensation laws were intended to avoid the costs and other disadvantages to workers (such as strong 'burden of proof' requirements) and other significant difficulties of implementation of the laws that have as an only claim for liability the negligence of the employer. These latter laws, the so-called 'tort laws', were almost solely the ones in practice until the beginning of this century. In theory tort laws could provide better incentives than workmen's fines to prevent OSH losses. In fact, in [72] Zeckhauser and Nichols mention that the legal duties and threat of liabilities implied by such laws are very close to the responsibilities that motivate OSHA and what might be regarded as the proper incentives for the firm. However, the existence of compulsory workmen's compensation conflicts legally with the use of tort laws since legally the first one then

becomes the exclusive resource of the worker [7].

Workmens' statutory compensation is easier to obtain, since it is of the form of 'no fault' insurance and thus requires much less informational and legal costs to be undertaken by the worker. However, the settlements are smaller (low maximum payments) and in fact, quite restrictive. In 1976 it is reported that the actual rate of replacement of foregone earnings was between 10 and 40 percent. The National Commission on State Workmen's Compensation Laws estimates that overall in 1972 the median percentage average of wage loss replacement was 40-44%. In addition, as reported in Ashford [7], the estimates of worker earnings are understated. Other limitations also exist. The benefits for permanently disabled workers are often limited in duration or amount of money, also no consideration is taken for inflation which (at 10% price rises per year) could erode rapidly the compensation of long term disabilities.

There are also examples of the limitations of liability under common law with respect to a prticular hazard. The Price-Anderson act, for example, limits the liability of power companies with respect to the damages arising from an accident at a nuclear power facility.

The tradeoff between tort laws and workmen's compensation combines elements of distribution of income and risk. This is because of two reasons. One is that statutory compensation involves lesser but surer settlement; common law has an uncertain chance of a larger

compensation. The other is that the ability of low income groups to use successfully the more complex legal procedures is smaller. See, for instance, the evidence in the work of J. Auerbach [8]. However, for efficiency reasons this tradeoff should be left to the worker who is better able to assess the probabilities and returns involved--while under present laws, workmen's compensation is sometimes compulsory and prevents the use of common law liability.

To the extent that workmen's compensation can be extended to better fulfill its objective of income security for OSH losses, it could have an important role as spreading risks as well as to equalize income of workers. However, as noticed above, in the present forms, such function is quite limited because of the inadequate limitations on compensation. This could in principle be corrected if these limitations were less severe; this, in fact, is the nature of several recent legislative proposals.

Interestingly, representatives on the insurers business community, such as the American Insurance Association, and Mutual Insurance Alliance are opposed to the relaxation of such limitations, see [7], chapter 8. This would seem at first sight to go against the insurance industry interest in increasing its revenues, selling more insurance, or at higher premiums.

It is of interest to discuss this point because it links with the arguments about imperfections in insurance markets made in Section IV,

and also exposes a connection between two instruments of government control, the provision of information and of incentives in relation to workmen's compensation.

The argument is as follows: As presently existing, the legal limitations on workers compensation diminishes the cost of insurers to control for OSH preventive actions by the fines. The lack of control of firms' actions by insurers was shown in Section IV to lead to two major (related) problems in insurance markets: moral hazard and adverse selection. As we showed, the market imperfections were significant enough that under sufficient risk and lack of information conditions, no market equilibrium would exist with positive values of exchange. For the insurance industry, this may mean no business for certain high risk/low information categories. Therefore, if the firms liabilities are constrained by law, the market for insurance may be quite enlarged, with the accompanying benefits to the insurance industry. The alternative way in which those markets could be secured by the insurers would be to incur in large informational costs about the firms' actions. Therefore, the restrictions on workmens compensation save informational costs that the insurers would have to undertake in order to keep the market for insurance in OSH compensation which now exists.

Similarly, from the point of view of the fines, the severe limitations on workmens compensation has an important role in spreading and

reducing their risk. Not only the employee's loss of his/her common law right limits risks to the employer, but also insurance is available in these conditions that would not exist otherwise.

An added negative factor of this situation is that because of those limitations, employers may now be overinsured and this, as shown by the discussion in Section IV, may lead to a negative effect on OSH expenditures due to a loss of incentive.

As seen by Ashford, for instance, this spreading reduction on risk for firms may be the single most effective achievement of workmen's compensation [7]. It should be noticed however that this reduction of the firm's risks may not only have negative effects such as transfers of costs away from firms and insurers and to the rest of the population (through higher OSH costs, higher medical costs, social welfare transfers and the corresponding taxes) but also some positive effects such as increased production. For instance as in the price-Anderson act that limits liability of nuclear plants, reduction of uncertainty and risk costs for fines is a form of financial encouragement to these firms through decreased costs and increased revenues. However, such financial incentives have allocation effects that may decrease Pareto efficiency in a competitive market system. For example, it encourages more those firms with higher OSH risks. To the extent that such policies are made with an overall welfare gain in mind (welfare, for instance, being measured by consumer surplus plus fines revenues) they may have

positive effects. Some risky technologies may be more productive. However, without a full disclosure of the effects of such policy, social choices, biased tradeoffs with other goals, and efficiency consideration are not optimally made. For instance it may be preferable to give the same financial incentives to firms that are risky but whose risk may be less costly in terms of OSH damage. Firms engaged in the production and dissemination of information about OSH hazards and of productivity increasing techniques that improve OSH would be of that type, since research and development is usually risky.

At any rate, the role of government in improving information about OSH and monitoring firms could decrease the extent to which the increase of risk spreading ability of workmens' compensation (e.g. higher fines, less limitations on compensation) is a zero sum game between workers on one side and firms (and insurers) on the other.

In sum, a coordination of the informational role of government (about OSH and about firms' actions) with the legislative role of government, may increase the effectiveness of both roles. As in the above discussed case, the expenditures used by the government in the role of a provider of information should not necessarily be regarded as being taken away from costs allocated to other government roles, such as spreading risks and providing income security. Because in some cases higher costs on information activities will lower the costs of others. In the name of efficiency such cost externalities across policies should be taken into consideration.

As we shall discuss later, a similar crossed cost effect may exist with respect to other financial incentives (such as taxes) and standards. The above arguments are not as valid in the case of small firms. For instance, for those firms, the adequate collection of information about firms' actions by the government or other agents, especially as related to experience rating, is not feasible in general. Also, because of the relative advantage of increasing returns, large firms are in a much better condition to absorb OSH costs than smaller ones. In fact, the possible negative effects of OSH regulations on small firms (and related negative effects on income distribution) has been taken into account in OSH Act, as discussed in Section IV. In order not to diminish incentives to improve OSH levels for those firms, however, a carefully chosen co-insurance system for small firms could be established. The problem is a second-best exercise, as discussed in Section IV.

Even if a more comprehensive system of compensation was legislated there are certain intrinsic limitations of the workmen's compensation system that make other forms of regulation preferable. One is derived from the fact that in order to insure efficiency for its goals, the level of compensation required may be different. For instance, for the goal of achieving proper incentives, the statistical frequency of the damage is the relevant information. For the role of achieving income security or financial risk spreading, the severity of the financial loss is the relevant information--these two criteria may not mix well in certain cases. For example, see the discussion in [19].

Another limitation is that there may be tradeoffs between the positive distributional effects on financial risks obtained by workmen's compensation and other market forces of risk distribution, such as that of wage differentials. Higher compensations may lead to a lowering of risks premiums in the labor market.

Finally, workmen's compensation is not as appropriate when there are health damages as with safety losses. In particular, the prevention value of workmen's compensation may be greatly decreased, for instance, for illnesses with long latent periods of so-called multiple etiologies.

The causes of accidents are often relatively easier to ascertain than the causes of loss of health--and also easier to relate to a particular firm. But diseases may be caused by many different conditions, or, cumulatively, at several different workplaces. This has the effect of making workmen's compensation (or taxation) less preferable to other forms of prevention, such as standards. In some cases, it would make it less preferable to common law liability also. In those cases, the above described government role in providing information about firms' actions may be less useful than the role of government in providing incentives for more research to be used in the setting and monitoring of standards.

There is another reason for which, in the case of health, workmen's compensation (and also taxation) may be less preferable than the promulgation and monitoring of standards. It arises from timing

considerations. Health losses usually take a longer period to become apparent. Some of these losses can take up to twenty years or so, as in the case of vinyl chloride. Even if the fines for compensation or taxation would be very high, the present managers of the firm may have very high discount rates which would diminish the impact of those costs as incentives for prevention. This may happen for instance if the life of the firm is not expected to be that long, or if the firm does not plan with a 20 year horizon. Another, perhaps more immediate, reason, but related to the above, is that the manager him or herself may not expect to be with the firm for the period of time that it takes for the health loss to be found.

Government action is not likely to alter such discount rates. For the above reasons, it would seem that for decreasing health damages regulation in the form of standards and monitoring may be preferable.

Taxation

Taxation schemes are another incentive for the firm to reduce OSH losses. The incentive given is efficient when the taxes force firms to internalize the costs which are borne by society as a whole and not perceived by the firm, such as those externalities discussed in Section IV.

Taxation, however, differs from the workmen's compensation in that the transfers are made to the government rather than to the workers. Thus, the efficiency of this method depends in part on the use of the government funds thereafter--while in the case of workmen's compensation the worker decides his or her optimal allocation of the compensation.

In the control of other forms of negative externalities produced by firms, such as pollution, taxes have been studied and are usually referred to as effluent charges. The problem of taxation for the internalization of externalities has been studied quite extensively in economics. See, for instance, Baumol [9], Baumol and Oates [10], [11], Coase [18].

A tax to fines proportional to the OSH losses it causes has been suggested in [52] and has several advantages. We have discussed this in some detail in Section IV.

About the possible disadvantages of taxes, they have several elements in common with respect to workmen's compensation; we refer to the discussion of above. While the questions of insurance and information arising with

workmen's compensation do not appear here for taxation, the restrictions on the efficiency and distributional characteristics of taxation to health losses (as opposed to safety losses) are all pertinent. Also, with respect to small firms, analogous problems arise with taxation as with the case of workmen's compensation.

Taxes could be very efficient if enough information is available. For example, for frequent safety losses, or losses whose probability of incidence may be small but are well understood, and where the effect of the firm on the worker's OSH loss is relatively easy to establish, taxes seem preferable to workmen's compensation, since they produce less transaction costs than going through a court system.

However for more 'unusual' cases, for which there is less information or else the evidence is more difficult to establish workmen's compensation or common law seem preferable.

To the extent that the government can provide more information, there would be less cases in which workmen's compensation or common law may be needed, and taxation could be used, with the corresponding savings in transaction costs. This would be another instance where the government role as a provider of information may decrease costs of other government enforcement activity, and shift the level of efficient utilization of different policies.

The use of taxes and other forms of incentives require more study. Also, there is some resistance among policy makers about their use.

Because of the above discussion about the cases in which taxation or workmen's compensation may not be a good policy instrument, much of that resistance, especially for health damages, seems justified. In addition, there are other cases when standards seem preferable to incentives. We discuss in more detail appropriate combinations of incentive/standard combinations in the following section.

Standards

Standards are likely to be preferable to other forms of regulation in some cases. For instance, if there is a high degree of uncertainty, standards may be a way to attempt to avoid catastrophic mistakes while gathering more information to reduce the amount of uncertainty. Postponing decisions, or else avoiding making irreversible or extremely costly decisions is a rational way to proceed when information is very bad. For the same reason, standards are also a better way to deal with actions that have a large irreversible component, even if the probabilities are known and uncertainty is not very high. For example, in cases of serious illness or death of workers. Incentives which produce a cost to the firm after the fact are more interchangeable with strong measures of prevention, the smaller the costs and the larger is the reversibility of the event, for instance, if monetary compensation can undo the damage to an extent.

This point has been recently put forth by the present Assistant Secretary of Labor for Occupational Safety and Health, Dr. Evla Bingham [46] in an answer to the position of C. Schultze, the Chairman of the Council of Economic Advisers. Schultze would prefer incentives over standards. In Dr. Bingham's words: "the idea of using worker's bodies to drive the wheel is a philosophy untenable to me. I am in the business of preventing sickness and injury, not using bodies to drive up the

cost so that business will find it more profitable to comply."

This point can actually be formalized in a manner similar to the study of other problems of regulation when costs and benefits are uncertain. Rules that apply to very uncertain situations as explained above will also be applicable for very irreversible situations.

In economic terms an incentive such as a tax can be thought of as 'price' reward (or punishment) schedule. Standards are quantity controls. Problems of optimal rewards, i.e. the rewards that the regulator transmits to a firm to elicit an optimal response, have been studied quite extensively. The arguments in favor of price regulation (taxation) used to be more favored by economists. At present, problems of optimal reward or regulations under uncertainty are studied, there are many arguments in favor of quantity regulations (standards). More recent work such as [69] and [70] sponsor price/quantity regulation. The degree of uncertainty influences the optimal combination of price rewards (taxation) and quantity controls (standards).

While the benefits obtained by the rewards schedule depend on the output of all the firms, the reward function must influence the action of the individual firm. 'Price' rewards are taken to be linear functions of output. 'Quantities' controls are penalty functions of deviation from targets, for instance, quadratic loss functions. The analysis of what are optimal taxation/standard combinations can be done following the work of Weitzman [69].

Let there be n commodities, and denote by x_i the units of commodity i produced by the i -th firm. $x = (x_1, \dots, x_n)$ either represents different goods (i.e. each firm produces a different good, or the same item produced by different production units). OSH production would be one of these commodities--its negative would represent OSH losses. The cost function of firm i is written as

$$c_i(x_i, \varepsilon_i)$$

where ε_i is a disturbance term, a stochastic element representing the uncertainty about the events (including OSH losses) in different states of the world. As viewed by the regulator, OSH events have a prior distribution, and this is the distribution of the random variable ε_i . The benefit function depends also on an uncertain random variable δ , whose probability distribution is estimated also by the regulator as a prior, i.e.

$$B \equiv B(x, \delta).$$

C_i is assumed to be strictly convex in x_i for each ε_i , and B strictly convex in x for each δ . A response function relates the amount of output produced x_i to the state ε_i , i.e. it is a function $g_i(\varepsilon_i)$

The expected social return over all response functions $\{g_i(\cdot)\}$ is

$$\Psi(\{g_i(\cdot)\}) \equiv E_{\{\varepsilon_i\}, \delta} [B(\{g_i(\varepsilon_i)\}; \delta) - \sum_{i=1}^n c_i(g_i(\varepsilon_i); \varepsilon_i)]$$

A reward or regulatory function $R_i(x_i)$ is a schedule of monetary payments received by firm i as a function of its output (for instance its OSH output). If the regulatory function is in a form of taxation incentive that yields a price p_i to be paid for the output of firm i , the regulation function is:

$$R_i(x_i) - p_i x_i$$

If \hat{x}_i is a standard or quota on the amount to be produced

$$R_i(x_i) = -\frac{q_i}{2} (x_i - \hat{x}_i)^2$$

By the process of profit maximization each regulatory function generates an output response. For a given $R_i(\cdot)$ and ϵ_i the firm i will attempt to solve the problem

$$\max_{x_i \geq 0} R_i(x_i) - c_i(x_i; \epsilon_i)$$

The solution is some response function

$$g_i(\epsilon_i) = G_i(R_i(\cdot), \epsilon_i)$$

satisfying for all ϵ_i the condition

$$R_i(G_i(R_i(\cdot), \epsilon_i)) - c_i(G_i(R_i(\cdot), \epsilon_i); \epsilon_i) = \max_{x_i \geq 0} R_i(x_i) - c_i(x_i; \epsilon_i)$$

Through the output function they induce, regulatory functions yield an expected value of the difference between benefits and costs

$$(1) \quad \phi(\{R_i(\cdot)\}) \equiv \psi(\{G_i(R_i(\cdot), \cdot)\}).$$

where the $\{q_i\}$ satisfy

$$(3) \sum_{j=1}^n \frac{\beta_{ji} \theta_{ji}}{q_j + \gamma_j} + \eta_i = \frac{1 - \gamma_i}{q_i + \gamma_i} \quad i = 1, \dots, n$$

In the above expression (3) θ_{ij} is a parameter defined by the conditional expectation of ε_j given ε_i , and the η_i by the expected value of δ_i conditional on ε_i . The β_{ij} are derived from the marginal benefit of commodity i , which is assumed to be of the form:

$$B^i(x, \delta) = p_i - \sum_{j=1}^n \beta_{ji} (x_j - \hat{x}_j) + \delta_i \quad i=1, \dots, n$$

Finally, the δ_i are derived from the marginal cost function of the i -th producer which is assumed to be of the form

$$C'_i(x_i; \varepsilon_i) = p_i + \gamma_i (x_i - \hat{x}_i) + \varepsilon_i, \quad i=1, \dots, n$$

An optimal regulation $\{R_i^*(\cdot)\}$ is a function that maximizes (1), i.e. that satisfies

$$\phi(\{R_i^*(\cdot)\}) = \max_{\{R_i(\cdot)\}} \phi(\{R_i(\cdot)\})$$

In Weitzman [] it is proven that under certain regularity assumptions and assumptions on the conditional probabilities, optimal regulation can be expressed in the form

$$(2) \quad R_i^*(x_i) = p_i x_i - \frac{q_i}{2} (x_i - \hat{x}_i)^2 + \text{constant}$$

To firm i , this regulatory function means: if output \hat{x}_i is produced the firm receive p_i dollars per unit of output, aside from the arbitrary constant. For each units more or less²⁵

²⁵Of course, the penalty functions need not be symmetric functions of the deviation from the target. Undershooting the target (OSH level) would have much higher penalties than overshooting it.

produced, the payment per unit goes down by $q_i/2$ dollars. The properties of an optimal regulation can be derived from equation (2) which is the analytical expression for the optimal regulation. The first term of (2)

$$(4) \quad p_i x_i$$

is the price regulation (e.g. taxation). If p_i would represent accurately the marginal benefit of commodity i , using (4) as a regulation (i.e. taxation) would induce the firm i to produce that amount of OSH where marginal benefit equals marginal cost. This idea is what makes taxation so attractive to many economists. However, as Weitzman points out, the marginal benefit of commodity i cannot be reduced to a single number p_i that is known in advance. The term in the second part of expression (2)

$$(5) \quad -\frac{q_i}{2} (x_i - \hat{x}_i)^2$$

is a quadratic penalty for deviation from the target value \hat{x}_i (the standard). If \hat{x}_i would be the socially optimum output (say, of OSH), and if the government would have (5) as a regulatory function, it would apparently be able to direct the firm to produce the social optimum amount of OSH. However, rarely it is known which is the optimum social level \hat{x}_i in advance.

The optimal regulatory function in (2) contains both a taxation and a standard. According to these results, one can find out in what cases it is preferable to emphasize standards.

If marginal benefits decrease rapidly around the optimal quota there is a high degree of risk aversion and the regulatory authority cannot afford being even slightly off the mark, relying on prices is too risky; a miscalculation will have detrimental circumstances. In such a situation, the weight of the quantity (or standard) term (5) becomes higher in (2), the q_i 's are larger. For a proof, see [69]. In such situations one should put more emphasis on the standard as the regulatory force; it provides a rigid output controllability which is preferable under the conditions. Examples of such OSH hazards where standards are preferable would be those with very high costs (deaths), or very high uncertainty and relatively high costs (unknown health effects that could be very serious). However, the weight of the second term (5) in (2), (derived from the values of the q_i 's) is lessened when benefits are close to being linear. In such cases, when the uncertainties are not very large, and the costs of deviating from the target relatively smaller, expected marginal social benefit is approximately constant over some range, then the superior policy is the one where the price term (4) (taxation) dominates, for instance, those OSH hazards which have relatively little uncertainty and whose social costs are relatively lower (e.g. stair cases, bathroom regulations).

Provision of Information

The importance of the government role in providing information to all agents making OSH decisions has been underlined many times in the above discussions.

The problem can be divided into two categories: the generation or production of information, and the dissemination or distribution of information.

Since this study does not attempt to deal with the regulatory problem in operational terms, but rather to raise analytical issues that may be of use for regulatory strategy, we shall not offer here specific policy guidelines.

One point that was stressed in several parts in this work was that the production and dissemination of information may in many cases be complementary rather than competitive with other policies in terms of use of resources because expenditures allocated to informational activities could decrease the costs (or improve the outcome) of other regulatory activities. In this section, for instance, we discussed the possible government role to provide information to insurers in order to make feasible the extension of workmen's compensation beyond the present restrictive limits. This information consisted not only, for instance, of knowledge about effects of new chemicals or techniques but also in better knowledge about firms' actions, such as experience of injuries, or present OSH cost for prevention. In that second sense, the gathering of information may help to decentralize in

some cases the gathering of information (by relying on workers' monitoring, for instance). In other cases, the role of distribution of risk can be decentralized in more efficient ways across society (through private insurers) while allowing for adequate forms of compensation for workers. This was discussed in detail in the last part of Section III, in Section IV in the part on markets with imperfect information, and in this Section in the part on workmen's compensation.

A similar informational role could be played by the government to help to substitute more costly court action by standardized injury-taxes (or in general OSH taxes). This was discussed in this Section both in the part about workmen's compensation and also in the part about taxation. Finally, the discussion on OSH externalities and externalities on the production of information about OSH in Section IV underlines the crucial role of government in this issue. As with other forms of research and development, the government has an important role: to share the uncertainties of such forms of production so that socially optimal levels of production take place. The U.S. government's role as a provider of incentives to decrease uncertainties and increase production is clear in cases such as the Price-Anderson act, that diminishes the (liability) risks to nuclear power plants. A similar but more OSH oriented government attitude is called for in the production of OSH and of information about OSH. There is also a government role for encouraging more decentralized work in the area of production of OSH information--for instance, by encouraging private foundations.

Of course, the provision of OSH information to workers and to labor unions may also help to obtain further decentralization in decision making. This is discussed in more detail in the next Section.

VI. THE ROLE OF LABOR UNIONS

Labor unions are one of the main institutions for conveying workers' preferences and demands to management.

Even though empirical results (e.g. Thaler and Rosen [58] and Viscusi [68]) suggest that workers in risky occupations are able to command higher wage premiums for risks if they are unionized, historically, labor unions have not fared very well in the OSH area. In the following we discuss a possible rationale for the behavior of labor unions of not emphasizing health and safety in collective bargaining.

It should be noted, however, that unionized workers represent less than 25% of all workers in the U.S. Better conditions for unionized workers may in some cases improve the conditions of non-unionized workers as well, by improving their bargaining position with respect to OSH, as higher salaries of unionized workers may improve those of non-unionized workers in some cases. However, in other cases, the effect may be just the opposite. This requires careful case by case empirical examination. The role of government to improve the OSH levels of non-unionized workers may be in those latter cases, most important.

There are some difficulties involved in collective bargaining when there is more than one item on the agenda. This is because in these cases problems arise for adequately representing different individual preferences by collective ones. For example, if the individual utility functions of workers

depend, for each level of leisure, only on wages, i.e. $u \equiv u(w)$, since all utilities are increasing in wages, any increasing function of w , $W(w)$ would be an adequate collective welfare function for workers to be used by their representative in the bargaining process. When individuals have different preferences and there are more than two items in the agenda, the problem becomes more difficult. Such aggregation of preferences when more than one item is on the agenda are especially difficult when one of the items may be related to the other, and in an opposite direction in some cases. For instance, the desirability of higher wages is derived from the utility of income. To the extent that more OSH may increase labor costs, decrease demand for labor and thereby decrease income (as discussed in Sections II and IV), more OSH may imply less income. Therefore, wages and OSH may, in those cases be related, and affect the utility of workers in opposite directions.

More formally, assume that the following principles or axioms are to be satisfied by the aggregation of individual into collective preferences or welfare functions.

- (1) Anonymity: the order in which individuals are considered (i.e. the order of voting if the aggregation is determined by a voting procedure) should not change the outcome. This can also be understood as a basic rule of equality of representation.
- (2) Pareto condition: if all prefer outcome a to b , the collective welfare function does too, i.e. $W(a) > W(b)$

(3) Reliability on some polling processes, i.e. that if there is imperfect information, after a certain amount of information is collected, say, by a poll, the outcome can be relied on to be approximately accurate.

This condition can be seen to be, at a technical level, one of continuity of the map that aggregates individual preferences into collective ones:

$$(u_1, \dots, u_n) \rightarrow W$$

where there are n workers. Then, for instance, if $W = u_1 + \dots + u_n$ then $W(w)$ satisfies properties (1) (2) and (3) if all individual utilities are increasing functions of one variable, wages.

However, when there are more than two items on the agenda, for instance, when the utilities of workers depend on wages and OSH levels, and, in addition, when there is imperfect information about OSH preferences, (so that for instance intensities of preferences between any two alternatives may not be known) there may be no rule of aggregation of workers' preferences into collective ones satisfying the conditions (1) (2) and (3). This was proven in Chichilnisky [16]. Problems of impossibility of aggregation into collective rules have been studied extensively since the classical work of Arrow [4] and Black.

This then represents an obstacle for labor union representatives in satisfactorily representing the membership preferences when wages and safety are both on the agenda. To avoid these problems, a simpler agenda with just one item, wages, may be preferred in many cases by the representative, since these are less informational problems about preferences on wages than on OSH.

There are other reasons why, even if a dual agenda (on wages and OSH) is chosen, union representatives may lean towards seeking (bargaining for) higher wages and deemphasize OSH. They also relate to information problems. (1) The lack of information or uncertainty about health hazards by the workers, and thus their possible lower average valuation of OSH improvements obtained by the union may undermine the value of bargaining for them in the eyes of the representative. This is associated to (2) the costs and difficulties for the union representatives to obtain information about health hazards in the industry--and to disseminate it to the membership--versus no costs with respect to wages. Therefore a wage gain by the representative requires less costs to be appreciated by the membership than an OSH gain.

Many of the arguments presented above are derived from the lack of availability of information about OSH and about firms' actions about OSH, and from the costs of obtaining information.

More recently, as of 1966, the National Labor Relations Board has established the principle that OSH be mandatory items in the bargaining agenda.

In Ashford [7], Chapter 10, it is reported that the present trend is towards contract bargaining as the union mechanism for improving OSH conditions. This may be related to the current awareness and increased information about OSH problems referred to above. This was reported from the Proceedings of

the Conference on Occupational Health and Safety at the Jack Tar Hotel, San Francisco, California, November 1973 sponsored by the California Labor Federation, AFL-CIO and the Center of Labor Research and Education, University of California, Berkeley. The unions are working to adopt OSH clauses in the collective bargaining agreements in the following areas: funding for production of OSH information on a country wide basis, expanded protection, methods to expedite arbitration, union inspection rights, use of impartial experts, training of union OSH stewards to control enforcement of standards, screening tests for employees to identify health hazards, OSH committees to conduct inspections and to set policy. Many of those items are still to be incorporated in the bargaining agenda. If adopted they would improve greatly the efficiency of unions in bargaining for better wages and OSH conditions. Some of the problems presented above for union bargaining about OSH would then be resolved.

As seen from the above, the role of government could be extremely important, especially in the provision of the information implicit in the above areas. Such policies of the government would help to bring about more efficiency in the setting of OSH levels by collective bargaining processes, at least for unionized workers. Some of the costs of monitoring OSH and disseminating information could be undertaken by the unions, in a more decentralized way, as suggested by the above

clauses. This would be another way that the provision of information by the government may be complementary to other regulatory activities, and also decrease other regulatory costs.

VII. CONCLUDING REMARKS

This paper analyzed some problems of labor market adjustments to OSH hazards, and presented some analytical models for the eventual measurement and empirical analysis of factors affecting the levels of OSH. The work has not attempted to deal with regulatory problems in operational terms: the purpose was to raise conceptual issues that may be relevant for regulatory strategy.

The question of appropriate OSH levels was seen to relate with issues of efficiency and social equity in the distribution of risks, and also with tradeoffs with other possibly competing objectives (such as employment and other government programs). In order to clarify alternatives and to help make policy choices, a cost-efficiency criterion was proposed as useful to analyze, in particular, choices among expenditures in different standards, and across activities and classes of workers. Efficiency was also seen to be an important mediating factor in deciding the severity of tradeoffs and thereby the feasibility of policies addressed to improving risk distributions in society (without hindering distribution of income and of other goods).

Market imperfections in the decentralized determination of OSH levels and risk premiums were analyzed. Problems of lack of information or of asymmetric information about OSH and about firms' actions about OSH were studied, as well as OSH externalities and also externalities in the production of OSH and information about OSH.

The role of the government was discussed in the light of objective and alternative instruments of policy.

The role of labor unions was analyzed, both with respect to the historical characteristic of not emphasizing OSH, and with respect to the more recent trend to bring OSH issues as part of contract bargaining.

In the light of this analysis, the diverse characteristics of OSH problems were shown to call for a variety of policies. A classification of OSH cases and of corresponding adequate policies appeared as an important component of a cost efficient policy for the improvement of OSH levels and their distribution. The brief discussion that follows is not to be viewed as policy recommendations, but rather as an aid in clarifying some of the conceptual issues involved, and analyzing regulatory strategy.

A common component of many OSH hazards is that the OSH losses (death, injuries, illnesses) are experienced by one group (the workers, their families and communities) while many decisions about OSH (and accompanying costs) such as prevention, development of safer techniques or substances, production and dissemination of information about OSH, are made by firms. This characteristic is, for instance, is what Smith [52] refers to when he calls firms the 'middlemen' between production and consumption of OSH.

In economic terms, the firms in those cases are agents for the workers much the same way that medical doctors and hospitals have the

role of agents to decide the patient's health care of medical expenditures. The problem of OSH is complex because the agent's utilities (firms' OSH costs) may be in contradiction with the workers' utilities (decreased OSH losses). Because of the existence of this agent relations among other reasons, insurance markets that in general operate to spread risks do not function appropriately. OSH losses insurance for workers (adjusted so that premiums would not discriminate against low income groups, and with coinsurance rates to provide incentives) could not be expected to solve the optimal risk distribution problem. One rule is to have the firms internalize the worker's OSH losses and to provide insurance to firms. Tort laws, workmen's compensation, have this role of internalizing OSH costs. However it is widely agreed that at present the fines and compensation to workers are not sufficient to spread risks adequately, or to provide adequate incentives for firms to prevent OSH losses. These questions were discussed in some detail in Sections III, IV and V.

To the extent that certain hazards are well understood, are not so irreversible and of such a nature that money compensation is appropriate, a system of incentives in the form of taxation to firms seems preferable to workmen's compensation and tort laws to force fines to internalize OSH losses for reasons of efficiency. The OSH losses in this case should have relatively known risks (probability distributions of occurrence), the consequences should be more or less well established, and in addition the association of the losses with a particular firm

should be relatively easy to establish. Examples are safety hazards (such as injuries) or some health hazards (such as 'black lung' in some cases). When there are some informational problems such as to establish whether the worker has suffered an injury or an illness, or the firm's (or firms') identity, workmen's compensation or liability legislation may be more adequate. Under these conditions, the premiums that the insurer should demand from the firms should depend on the characteristics of the firm as well as on the firm's actions. For large, longer lived firms comprehensive experience records should be kept to help in determining the firm's actions by past experiences of OSH losses. Here the informational and monitoring roles of the government may overlap. The government could help the availability of adequate OSH insurance coverage to firms in several ways. One would be to monitor firm's actions effectively, conveying to the insurance information about firm's actions (see the discussion of Sections IV and V). Another way would be to legislate that comprehensive records about OSH be filed each year by firms, much the same way that records on income are filed and with similar penalties for misrepresentation of facts. Another way still would be to engage workers and labor unions in helping to decrease government monitoring costs by encouraging by better reporting of OSH losses and of firm's actions, much the same way that employers report on workers' income. This could also serve the function of gathering and disseminating information to workers and unions about OSH and OSH actions by firms.

For small firms, where experience rating cannot be used to produce incentives more reliance would be placed on coinsurance rates. These issues were discussed in Sections V and VI.

In contrast to the above cases, when OSH losses are irreversible or very costly and not adequately compensated by incurring expenses, or where uncertainty and social risk aversion is very high, standards seem preferable to incentives. This type of OSH problem is associated with life loss, and also with health hazards with high uncertainty and social risk aversion, or hazards where there may be long periods of pain and suffering that cannot be alleviated by incurring health expenditures. This was discussed in Section VI. It should be noticed that for standards to be effective more emphasis should be put on the targets (lives saved, illnesses prevented) than on the method for reaching the target. For efficiency's sake the firms should be able to choose methods that minimize cost whenever possible. Adequate fines for non-compliance and adequate inspection are very important: a good incentive system may be preferable to a bad system of setting and monitoring standards, even in the cases of these types of OSH losses. Again, in order to diminish costs, workers and labor unions should be engaged in reporting firm's actions whenever possible. See Section VI.

The role of the government in providing information was seen to be complementary to the role of establishing incentives and/or standards. There may be some cost savings for both incentives and standards

policies when there is better information. For example, with better information some legal costs can be saved since taxation may become preferable to workmen's compensation or liability laws. Also, the insurers may be able to provide wider coverage to firms if there is more OSH information and also information about firms' actions. In the case of standards, more adequate goals and better compliance rates may be feasible at lower costs if more is known about certain OSH losses. For efficiency, the role of producing and disseminating information about OSH should utilize whenever possible, nongovernment groups and organizations. For example, labor unions could be effective in disseminating information and to provide in some cases 'on the site' OSH monitoring offices; workers could be of help in producing and monitoring information about firm's actions. The degree of unionization of an industry or sector should be taken into account to disclose the needs of OSH regulation for non-unionized workers. Provision of economic incentives to OSH research and development could be a more decentralized government role in production of OSH information. Data on the possible spillover effects of OSH losses on the worker's family and communities, and on the population as a whole (through income security and medical programs) would also be an area of OSH information to be further developed.

BIBLIOGRAPHY

1. Akerlof, G. "The Market for Lemmons: Quality Uncertainty and the Market Mechanism," Quarterly Journal of Economics, 1972.
2. Arrow, K.J. "Alternative Approaches to the Study of Choice in Risk-Taking Situations," Econometrica, Oct. 1951, 404-37.
3. _____. Essays in the Theory of Risk Bearing, Markham Publishing Co., 1971.
4. _____. Social Choice and Individual Values, Second Edition. Yale University Press, 1955.
5. _____. "Uncertainty and the Welfare Economics of Medical Care," American Economic Review, Dec. 1963, 941-73.
6. _____. "Welfare Analysis of Changes in Health Coinsurance Rates" in The Role of Health Insurance in the Health Services Sector, (Richard N. Rosett, Ed.). National Bureau of Economic Research, New York, 1976.
7. Ashford, N.A. Crisis in the Workplace. MIT Press, Cambridge, Mass., 1976.
8. Auerbach, J. Unequal Justice: Lawyers and Social Change in Modern America. Oxford University Press, 1977.
9. Baumol, W.J. "On Taxation and the Control of Externalities," American Economic Review, June 1972, 307-22.
10. _____ and W.E. Oates, "The Use of Standards and Prices for Protection of the Environment," Swedish Journal of Economics, March 1971, 42-54.
11. _____. The Theory of Environmental Policy. Englewood Cliffs, N.J.: Prentice Hall, 1975.
12. Bureau of National Affairs. The Job Safety and Health Act of 1970. Bureau of National Affairs, Washington, D.C., 1971.
13. _____. OSHA and the Unions: Bargaining on Job safety and Health. Bureau of National Affairs, Washington, D.C., 1973.
14. Calabresi, G. The Cost of Accidents: A Legal and Economic Analysis. Yale University Press, New Haven, 1970.

15. Chelius, J.R. "The Control of Industrial Accidents: Economic Theory and Empirical Evidence," Law and Contemporary Problems, 38 (1974), 700-729.
16. Chichilnisky, G. "Social Choice and the Topology of Spaces of Preferences," forthcoming. Advances in Mathematics.
17. Chiswick, B. and J.A. O'Neil (eds.) Human Resources and Income Distribution. W.W. Norton & Co., Inc., New York, 1977.
18. Coase, R.H. "The Problem of Social Cost," Journal of Law and Economics 3 (1960), 1-44.
19. Cornell, N., R. Noll and B. Weingast, "Safety Regulation" in H. Owen and C.E. Schultze (eds.), Setting National Priorities, Brookings Inst. 1976.
20. DiPietro, A. "An Analysis of the OSH Inspection Program in Manufacturing Industries 1972-73," Draft Technical Analysis Paper, Office of the Assistant Secretary for Policy, Evaluation, and Research, U.S. Department of Labor, 1976.
21. Hitch, C.J. The Character of Research and Development in a Competitive Economy. The Rand Corporation, 1958.
22. Kunreuther, H. "Limited Knowledge and Insurance Protection," Public Policy, 1976.
23. Lowrance, W.W. Of Acceptable Risk: Science and the Determination of Safety. Los Altos, California: William Kaufmann, 1976.
24. Lucas, R.E.B. Working Conditions, Wage Rates and Human Capital. Ph.D. Dissertation, M.I.T. 1973.
25. MacKerron, G.S. Human Life and Safety in Relation to Technical Change: An Analytical Summary. Science Policy Research Unit, University of Sussex, 1975.
26. Mendeloff, John. An Evaluation of the OSHA Program's Effect on Workplace Injury Rates: Evidence from California through 1974. Report prepared for the Office of the Assistant Secretary for Policy, Evaluation and Research, U.S. Department of Labor, 1976.
27. Michigan Quality of Work Survey. Institute for Social Research, University of Michigan, 1969-70.
28. Miller, G.A. "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," The Psychological Review, March 1956, 81-97.

29. National Academy of Sciences (USA), National Research Council, Assembly of Life Sciences, Committee on Public Information in the Prevention of Occupational Cancer, February 1976, Washington, D.C.
30. National Commission on State Workmen's Compensation Laws. Compendium on Workmen's Compensation. Washington, D.C. 1972
31. _____ Report on the National Commission on State Workmen's Compensation Laws. Washington, D.C., July 1972.
32. _____ Supplemental Studies for the National Commission on State Workmen's Compensation Laws. Vols. I-III, Washington, D.C., 1973.
33. Nelson, R.P. "The Simple Economics of Basic Scientific Research," Journal of Political Economy, 1959.
34. The New York Academy of Sciences, Conference Proceedings of the Bicentennial Conference on Occupational Carcinogenesis, 1976.
35. The New York Academy of Sciences, Occupational Monitoring for Genetic Hazards (Workshop), 1976.
36. NIOSH. Criteria for a Recommended Standard - Occupational Exposure to Asbestos, National Institute for Occupational Safety and Health, Washington, D.C., 1972.
37. _____ The Toxic Substances List. 1973 Edition, HEW, June 1973.
38. Oi, W.Y. "The Economics of Product Safety," The Bell Journal of Economics and Management Science, Spring 1973.
39. _____ "An Essay on Workmen's Compensation and Industrial Safety," in Supplemental Studies for the NCSWCL, Vol I, 41-106.
40. _____ "On the Economics of Industrial Safety," Law and Contemporary Problems, 1974.
41. _____ "On Evaluating the Effectiveness of the OSHA Inspection Program," Paper presented at the Department of Labor Conference on Evaluating OSHA, Annapolis, Maryland, March 18, 1975.
42. Parsons, D.O. "Specific Human Capital: An Application to Quit Rates and Layoff Rates," Journal of Political Economy, 1972.
43. Roberts, M. and M. Spence, "Effluent Charges and Licences under Uncertainty," Working Paper, Stanford University, 1975.

44. Rusell, L. "Pricing Industrial Accidents," Supplemental Studies for the National Commission on the State Workmen's Compensation Laws, Washington, D.C. 1973.
45. Ryder, H. F. Stafford and P. Stephan. "Labor, Leisure and Training over the Life Cycle," International Economic Review, October 1976.
46. Shabecoff, P. "The Woman Who Turned OSHA Around," The New York Times, February 1978.
47. Sinclair, T.C., P. Mastrand and P. Newick. Human Life and Safety in Relation to Technical Change. Science Policy Research Unit, University of Sussex, 1972.
48. Smith, Robert S. "Compensating Wage Differentials and Hazardous Work," Technical Analysis Paper No. 5, Office of Evaluation, Dept. of Labor, August 1973.
49. _____ "The Estimated Impact on Injuries of OSHA's Target Industry Program," Cornell University, undated.
50. _____ "Evaluating the Impact of OSHA on Occupational Safety and Health," Office of the Assistant Secretary for Policy, Evaluation, Research, U.S. Department of Labor, April 1975.
51. _____ "The Feasibility of an 'Injury Tax' Approach to Occupational Safety," Law and Contemporary Problems 38 (1974) 730-744.
52. _____ The Occupational Safety and Health Act: Its Goals and Achievements, American Enterprise Inst. for Public Policy Research, Washington D.C., 1976.
53. Settle, R. and B. Weisbrod. "Government-Imposed Standards: Some Normative and Positive Aspects," Working Paper, Undated.
54. Spence, M. "Consumer Misperceptions, Product Failure and Producer Liability," Department of Economics, Harvard University (Mimeo), 1977.
55. Spence, M. and R. Zeckhauser. "Insurance, Information and Individual Action," The American Economic Review, May 1971.
56. Spence, A. M. "Monopoly Quality and Regulation," The Bell Journal of Economics, 1976.

57. Stafford, F.P. and M.S. Cohen. "A Model of Work Effort and Productive Consumption," Journal of Economic Theory, 1974.
58. Thaler, R. and S. Rosen. "Estimating the Value of Saving a Life: Evidence from the Labor Market," Paper presented at NBER Conference on Income and Wealth, Household Production and Consumption, Washington, D.C. November 3, 1973.
59. Tversky, A. and Kahneman, D. "Judgment under Uncertainty: Heuristics and Biases," Science 185 (1974), 1124-1131.
60. U.S. Bureau of Labor Statistics. Major Collective Bargaining Agreements in Selected Industries: Safety and Health Provisions before and after the Occupational Safety and Health Act of 1970. Report prepared by the Office of Wages and Industrial Relations for the Office of Occupational Health Statistics, Bureau of Labor Statistics Washington, D.C., February 1975.
61. U.S. Congress, House of Representatives, Committee on Education and Labor, Select Subcommittee on Labor, Occupational Safety and Health Act of 1970 (Oversight and Proposed Amendments). Hearings (93rd Congress, 2nd Session), Washington, D.C.
62. U.S. Congress, House of Representatives, Permanent Select Committee on Small Business, Subcommittee on Environmental Problems affecting Small Business, The Effects of the Administration of the OSH Act on Small Business. Hearings (93rd Congress, 2nd Session), Washington, D.C. 1974.
63. U.S. Department of Labor, Bureau of Labor Statistics, "Occupational Illnesses by Industry, 1972," Washington, D.C. 1974.
64. U.S. Department of Labor RFD/A 65-10, October 1975.
65. U.S. Department of Labor. Inflationary Impact Statement: Coke Oven Emissions. Occupational Safety and Health Administration, Washington, D.C., February 27, 1976.
66. U.S. Department of Labor. Inflationary Impact Statement: Inorganic Arsenic. Occupational Safety and Health Administration, Washington D.C., undated.
67. U.S. Department of Labor. Occupational Safety and Health Administration's Impact on Small Business. Occupational Safety and Health Administration, Washington, D.C., undated.
68. Viscusi, K.W. "Quit Rates, Compensating Wage Differentials and the Job Hazards: an Empirical Analysis of Adaptive Worker Behavior," Ph.D. Dissertation, Harvard University, 1976.

69. Weitzman, M. "Optimal Rewards for Regulating Economic Activities,"
Forthcoming American Economic Review.
70. _____ "Prices versus Quantities," Review of Economic Studies,
October 1974, 477-92.
71. Zeckhauser, R. "Procedures for Valuing Lives," Public Policy, 1975.
72. _____ and A. Nichols. "The Occupational Safety and Health
Administration," An Overview Prepared for the Senate Committee
on Government Operations, 1976.
73. Zubkoff, M. (ed.) Health: A Victim or Cause of Inflation? Published
for the Milbank Memorial Fund by Prodist, New York, 1976.