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**Alcohol consumption and workplace accidents: An examination
of workers' compensation claims rates**

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City University of New York, 1992

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**ALCOHOL CONSUMPTION AND WORKPLACE ACCIDENTS:
AN EXAMINATION OF WORKERS' COMPENSATION CLAIMS RATES**

by

David L. Durbin

A dissertation submitted to the Graduate Faculty in
Economics in partial fulfillment of the requirements for
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Abstract**ALCOHOL CONSUMPTION AND WORKPLACE ACCIDENTS:
AN EXAMINATION OF WORKERS' COMPENSATION CLAIMS RATES**

by

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The workers' compensation program has experienced enormous growth in costs over the past couple of decades. Workers' compensation now costs the United States economy in excess of \$60 billion per year, which exceeds unemployment insurance, social security disability insurance, AFDC or food stamps in total expenditures. Two themes have recurred throughout the history of the program. First, there have been debates over what constitutes a compensable injury, and second, debates have continued over the optimal level of benefits. From a public policy perspective, the focus is on the adequacy and equity of benefits for workers injured on the job without incorporating incentives to over-utilize the system. Currently, public officials are concerned that the high costs of the workers' compensation system may be hindering economic development and are concerned the system may be compensating claims that have not legitimately arisen "out of, or in the course of employment." In this study, I decompose workers' compensation costs into its two primary components and examine the role of worker behavior in the determination of

costs. Specifically, I investigate the role of alcohol consumption on workers' compensation costs as well as the impact of the benefit levels on workers' incentives. There has been only limited anecdotal evidence that alcohol contributes significantly to workers' compensation costs. I develop a two-stage model to explain both the determinants of alcohol consumption and the probability of a workplace accident. The data used in this analysis comprises one of the most extensive data sets constructed concerning workers' compensation costs. Data have been gathered for 27 states from 1964 through 1984. The analysis indicates that alcohol consumption indeed contributes significantly to the cost of workers' compensation, and that a 10 percent decrease in alcohol consumption would decrease workers' compensation costs by as much as \$2.4 billion per year.

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I. Introduction

a. Workers' Compensation Review

Workplace accidents cost the U.S. economy over \$45 billion in workers' compensation benefits to over 8 million injured and killed workers in 1989. This represented an 9 percent increase over 1988 benefits and is the latest in a series of escalating costs. Throughout the 1980s, the average annual growth rate in workers' compensation benefit costs was almost 11 percent. (For the period 1964 to 1984 which this study considers, the average annual growth rate was 13.0 percent.) Currently, workers' compensation (WC) programs, the social insurance responsible for compensating injured workers, are larger in terms of total expenditures than either unemployment insurance, social security disability insurance, AFDC or food stamps.¹

It is important to realize that benefit payments represent only the direct monetary costs of compensating injured workers for their lost earnings and their medical expenses. In addition, there are the unmeasurable psychological costs due to the pain and suffering of the injured workers as well as the hard to measure costs borne by industry for the lost productivity because of the need for rehabilitation and retraining.

If administrative expenses and insurance company profits and expenses are considered, the costs of workplace accidents approached \$60 billion in 1989. As a percent of payroll, WC

costs have more than doubled since 1970, far outpacing inflation and becoming a significant cost of business². Yet despite these expenditures, dissatisfaction with the WC system is widespread. Injured workers feel the system is too complex; employers feel costs are too high; insurers feel rates are inadequate and profitability elusive; and regulators and legislators are concerned with the impact of all these factors on the economic climate in their individual states.

The public policy issues facing workers' compensation in the 1990s are considerable. Among the most significant include: rapid escalation of costs as described above; increasing utilization of benefits; increasing litigiousness; worsening underwriting cycles impacting the profitability and viability of insurers, and consequently, the availability of insurance; emerging new claim types -- particularly occupational diseases that are stress-related; and, increasing fraud in the system including the avoidance of coverage by employers.³

Labor, industry, the insurance industry and government all have a significant interest in containing the rapidly escalating costs of workplace accidents and designing optimal and efficient social insurance programs. Significant cost containment reforms are being explored across the United States. Indeed, the costs of workplace accidents are currently undergoing significant legislative and regulatory scrutiny. A number of significant legislative reforms have

been enacted the past two years that attempt to address some of the problems with WC insurance. Major reforms have recently been enacted in California, Florida, Oregon, Maine and Texas⁴. Many other states have enacted more limited reforms, and a number of states have formed study commissions to investigate the efficacy of various reforms.

There is also a growing body of academic research which seeks to analyze and understand the incentives and behavior of firms, workers, and insurers. Labor economists have long been interested in how the existence (or absence) of compensating wage differentials affects labor markets, and have been interested in the implications of such differentials concerning the efficient allocation of resources, including incentives for promoting job safety. Recent research has sought to determine whether workers' compensation insurance benefits are an optimal means for compensating job risk and, also, whether (and the extent to which) there may be moral hazard considerations.

The response to these problems via research, legislative reforms, study commissions and task forces might in some sense be identified as the second reform era for workers' compensation. Some of the basic precepts of workers' compensation are being rethought, and changes to the system have been enacted in attempts to contain the rapid cost increases. It is this re-examination that provides the motivation for this study, especially current efforts to make workers more accountable for their own actions.

The purpose of this study is to consider one of recent attempts to make workers more accountable for their actions and estimate the impact on workers' compensation costs. There been some anecdotal evidence as well as media attention that alcohol consumption by workers leads to workplace accidents. Yet, there has been no systematic investigation of the role that alcohol consumption may play in total workers' compensation costs. Further, there has actually been some legislative action which would reduce or bar the ability of workers to collect workers' compensation benefits if drinking is deemed to be a causal factor in a workplace accident. The model and statistical results that are developed in this study will be used to develop estimates of the cost savings that may be generated by this type of legislation, and in some cases judicial, action.

b. Workers' Compensation Program History

It is useful to review some of the history of workers' compensation insurance to highlight institutional features of the system that condition the behavior of firms and workers. Beginning in 1911, workers' compensation insurance was the first compulsory social insurance program in the United States. The program remains the primary legal remedy for employees who are disabled by a work-related injury or illness. Workers' compensation laws arose out of a public policy desire to adequately and equitably compensate injured

workers instead of relying on expensive and uncertain tort and common law remedies. Although WC benefits might actually be less than those awarded by the courts, the benefits were viewed as a matter of right. These new state workmen's (sic) compensation systems were built on a quid pro quo, or exchange of the workers' tort remedy rights for the exclusive remedy of workers' compensation benefits.⁵ Employers accepted limited liability for workplace accidents rather than be subjected to the uncertainties and vagaries of unlimited court awards.

In addition, government intervention through a mandated workers' compensation system was rationalized on the basis of the failure of labor markets to provide the optimal levels of safety and income protection in the event of a workplace accident. That is, the prevailing social attitude was that employers were not providing a safe workplace. A significant reason for this market failure was (and continues to be) asymmetrical information -- workers consistently undervalue the risks they face on the job (either because they are uninformed or are unable to comprehend different risk levels). Consequently, wage differentials do not fully compensate workers for their risk of injury. Workers' compensation mitigates the market failure by insuring workers' incomes and providing incentives for employers to invest more resources in safety. Workers' compensation insurance pricing is designed to allocate the costs of workplace injuries to individual employers in proportion to

the costs they impose on the system, thereby encouraging employers to seek optimal safety/wage tradeoffs. Economic theory, particularly compensating wage differentials and hedonic wage equilibrium models⁶, provides some justification for this view.

The WC systems of the early 1900s were not without significant problems, however the public's attention was transferred away from the courts and toward the compensation system. The right to benefits was no longer an issue, but disagreements still arose over the degree of disability, whether the disability was permanent or temporary, and whether the cause of disability was work-related. Adequacy of WC benefits and the existence and extent of compensating wage differentials were (and continue to be) recurring themes.

The development of WC systems was left to the individual states. Consequently, there was a great deal of disparity in the benefit levels that injured workers could receive as well as in the overall system design, particularly in the administration of the system. For example, state provisions varied widely on the proportion of an injured workers' wages to be received as benefits. As recently as 1972, 20 states specified weekly benefit replacement rates of less than 50 percent, 12 states specified rates between 50 and 60 percent, 8 states specified rates between 60 and 66 percent, and 10 states specified benefit replacement rates greater than 66 percent.⁷ Differences in waiting periods and retroactive periods for receipt of benefits were also significant. More

sophisticated etiological techniques and emerging new diseases raised further questions over whether the cause of disability was work-related. (These may in fact be even more serious problems today.) States adopted different approaches to compensating so-called occupational diseases. The inconsistency, inadequacy and inequity of WC systems and benefits across states coupled with the growing awareness and concern over the extent and nature of disabling injuries prompted the first reform era for WC in the 1950s and 1960s.

Many observers felt that allowing individual states to administer their own WC system was not tenable and that the only way to have an equitable and adequate approach for compensating injured workers was to federalize the WC system. Others argued that federal involvement would be cumbersome and create unduly burdensome regulation. The controversy culminated in the passage in 1970 of the landmark Occupational Health and Safety Act (OSHA).

OSHA addressed a number of the criticisms of the existing WC system. In addition to the goal of ensuring the "highest degrees of health and safety protection for the employees"⁸, the act made provisions for the creation of the National Commission on State Workmens' Compensation Laws, whose charge was to determine the viability of a federal WC system. The National Commission recommended that, rather than adopting a federal WC system, the individual state systems should be preserved but with substantial reforms to ensure adequate and equitable benefit levels to reduce the

contention and litigation that permeated WC. The National Commission made 19 "essential" recommendations, along with a number of additional suggested reforms, to satisfy the five major objectives that were identified for a "modern workmen's compensation program". The five major objectives were that a WC system should provide: broad coverage of employees and of work-related injuries and diseases; substantial protection against interruption of income; provision of sufficient medical care and rehabilitative services; encouragement of safety; and, an effective system for delivery of the benefits and services.

The National Commission included specific benefit replacement rate recommendations, which have been adopted in part by virtually all the states. On average, compliance with the National Commission's 19 essential recommendations has increased from 6.9 out of 19 in 1972 to 12.2 in 1988 (i.e., states now comply with 12 of the recommendations). Two important recommendations were that benefits should replace two-thirds of a workers' pre-injury wage up to 200% of the statewide average weekly wage (SAWW). This latter recommendation was later revised to be 100% of the SAWW. Most states now have the two-thirds benefit replacement rate, and the average (across all states) maximum temporary total disability benefit as a percentage of the SAWW has increased from 56% in 1972 to 97% in 1988.⁹ As a result, most workers who experience a lost-time disabling injury or illness receive an indemnity benefit that is two-thirds of their pre-

injury weekly earnings, subject to a statewide maximum which is typically equal to the state average weekly wage. Thus injured workers can expect to receive two-thirds of their pre-injury earnings as long as weekly earnings are not more than 150 percent of the state average weekly wage.

The responses of individual states to the recommendations regarding lost wages is an important reason for the rapid increase in workers' compensation costs in the 1970s and 1980s. Indemnity benefit payments have increased over 700 percent since 1970, for an average annual growth rate of 13.7 percent. In terms of the cost per covered worker, paid indemnity benefits increased from \$11 per covered worker in 1950, to \$33 in 1970, and \$197 in 1987¹⁰.

Although statutory benefit increases have been a major reason for the increase in the cost of indemnity benefits, a contributing factor has been the increased utilization of workers' compensation benefit programs. Several recent studies of this so-called "benefit utilization" phenomenon have found that increases in benefit provisions tend to increase both the incidence and average duration of workers' compensation claims. Gardner, in a recent survey of the literature¹¹, develops a consensus estimate that a 20 percent increase in indemnity benefits causes not only a direct 20 percent increase in costs, but also increases the incidence of claim filing by approximately 7 percent and the average duration of claims by 2-4 percent. Thus, a 20 percent increase in indemnity benefits would give rise to

approximately a 30 percent total rise in indemnity costs.

The current or second reform era in WC is more concerned with containing the rapidly escalating costs than promoting consistency and adequacy of benefits. Several states are in fact even scaling back on benefits, particularly for permanent injuries. Closer scrutiny is also being given to the actual impact of the injury on the wage-earning capacity of the worker. Moreover, there may also be retrenchment on the quid pro quo in that individual worker behavior is being scrutinized much more closely. For example, several states¹² have enacted legislation whereby employers who establish drug and alcohol free workplace programs may be eligible for insurance premium credits and that, in addition, an employee of such a workplace testing positive for alcohol or drugs after an accident may lose his or her right to benefits on the presumption that the proximate cause of the accident is intoxication. Other states are considering blood alcohol standards not unlike those used for driving while intoxicated. Still other states have let the courts decide the compensability of claims in alcohol-related accidents.¹³ While there is a growing literature which examines a number of issues germane to WC, there remain many unanswered questions. Specifically, the direct role of worker behavior remains under-researched.

c. Literature Antecedents: Issues and Breadth of Analysis

In recent years while claims frequencies in workers' compensation have risen dramatically, policymakers and practitioners have consistently underestimated the cost consequences of liberalized benefits. Recent research has shown the costs of workplace accidents to be dependent on a complex set of factors that encompass work site safety features and technology, along with the behavior of workers, firms, insurance companies and government. This research has considered the role of industrial activity, the shift from a manufacturing to a service economy, the age distribution of the workforce, and the structure of the workers' compensation programs in the overall determination of workplace accident costs.¹⁴ However, there is no consistent evaluation of the effect of changing economic and demographic conditions on workplace accidents and their associated costs. Further, there has been no significant research which distinguishes the impact of economic and demographic factors on the incidence or frequency of workplace accidents versus the impact on the duration or severity of those accidents.

In addition to investigating the relationship between alcohol consumption and workers' compensation costs, my research will also provide a more comprehensive analysis of the role of economic and demographic factors on workers' compensation costs than previously considered in the

literature. Further, unlike the existing literature (with the exception of an unpublished paper by Butler (1989)) which typically focuses on either the frequency or severity of workers' compensation claims, my analysis will also distinguish between the effects on frequency and severity.

To fully analyze the relationship between economic conditions, worker behavior, the workers' compensation system, and system costs it is necessary to consider both the frequency and severity of workers' compensation claims. There is a basic accounting identity that captures the relationship between the frequency and severity of claims and total costs. This identity forms the basic context of the analysis presented in this paper. Costs per worker can be decomposed in a natural way as follows:

$$\begin{aligned} (1) \quad (\text{costs/employee}) &= (\text{claims/employee}) \times \\ &\quad (\text{costs/claim}) \\ &= \text{frequency} \times \text{severity} \end{aligned}$$

By taking the natural logarithm of the terms on both sides of the equation we get:

$$(2) \quad \ln \text{ costs} = \ln \text{ frequency} + \ln \text{ severity}$$

This formulation allows an analysis of the increasing average cost per employee by separately considering the

frequency and severity components. As mentioned above, only Butler (1989) considers these two phenomena simultaneously. However, Butler concentrates on the relative changes over time in frequency versus severity and the resulting implications for actuarial ratemaking techniques. In my analysis, the effects of alcohol consumption and the economic and demographic factors on both the frequency and severity of workers' compensation claims will be investigated.

In most states, WC is subject to prior approval rate regulation. Thus benefit and system reforms, such as disallowing WC claims if a worker has been drinking, need ex ante evaluation. This study will provide evidence which may be useful in efforts to price potential reforms. In addition, much of the extant research on WC has been much more narrowly focused considering only the experience in a single state (perhaps over a period of time) or for a number of states over a small time period. The data constructed for this study comprise 27 states from 1964 to 1984 which is the most comprehensive data set yet analyzed.¹⁵

While much of the existing economic research uses a state dependent utility approach, there has been little examination of the direct role of workers' behavior on workplace accident costs. Some previous studies have included a measure of an individual's likelihood of being accident prone as an argument in the utility function; this study seeks to parameterize that propensity by considering behavior like alcohol consumption that is likely to give rise to an

increase in the probability of having an accident. My results will also provide useful information in the debate over the total costs to society of drug and alcohol consumption.

To summarize, the goal of this study is twofold. First, a model and statistical estimates are developed that more comprehensively examine the relationship between alcohol consumption and workplace accidents than has previously been the case in the literature. The analysis will attempt to quantify the relationship between alcohol consumption and both the frequency and average cost of workplace accidents.

Second, the decomposition of worker' compensation costs into the frequency and severity components will be more fully developed than previous workers' compensation studies. With one exception (Butler 198), the existing research has only considered either the frequency or average costs (severity) of workplace accidents. Further, the analysis here is unique in that the data used in this study is more extensive than in the literature; workplace accident information has been combined with economic, demographic and workers' compensation administration information, and then with alcohol consumption information. This has been done for 27 states for 21 years (1964-1984). This will allow an examination of both intertemporal and cross state variations in drinking and workplace accident patterns while controlling for other significant economic and cultural forces thus allowing measurement of the marginal impact of alcohol consumption on workplace accident costs.

The remainder of the study will proceed as follows: Chapter II provides a discussion of the salient features of WC programs and discusses in more detail the accounting framework which decomposes WC costs into frequency and severity components. Chapter II also provides a review of the workplace accident literature. There are two sections to the literature review. The first is a review of the role of alcohol use in industrial accidents, and the second is a review of the recent developments to isolate the effect of workers' compensation on the incidence and costs of workplace accidents, i.e., the so-called benefit utilization phenomenon. Part of this later discussion will consider whether workers' compensation affects the risk-bearing activities of workers, their willingness to file insurance claims, or both.

Chapter III formally develops the notion that workers' level of safety effort (or degree to which they may be accident prone) may be affected by alcohol consumption. A theoretical model is developed which is drawn in part from the existing WC literature and in part from the literature on drinking and driving. The model considers the determination of both per capita alcohol consumption and workplace accidents and their average costs after controlling for other economic and demographic characteristics. In addition, the association between economic activity and alcohol consumption will be explored controlling for differences in state laws, prices and attitudes. Examples will be drawn from the

literature on alcohol consumption and automobile accidents.

Chapter IV will describe the data, discuss the econometric specification of the model, and report the empirical results. Chapter V concludes with a discussion of the empirical findings.

II. Institutional Framework and Literature Review

A. Institutional Features

Since the workers' legal remedy for workplace injuries is almost exclusively workers' compensation insurance, understanding the structure of the program is important. Indeed, much of the recent research into the determination of workplace accidents as well as refinements in estimating compensating wage differentials explicitly make use of variables which control for workers' compensation benefits (for examples see Butler and Worrall 1983, Viscusi and Moore 1987, Worrall et.al. 1988, Meyer, Viscusi and Durbin 1990, Durbin 1989, Krueger 1989).

Workers' compensation (WC) is a no-fault social insurance system responsible for compensating injured workers. WC provides full medical coverage and partial wage replacement for injury or illness that arises "out of, or in the course of" employment. Each state has its own workers' compensation program, and there are several federal programs as well. The insurance is compulsory in 47 states; coverage is generally provided in the other three. As a result most wage and salary employees (approximately 100 million in 1990) are covered by a job injury law (Nelson 1991).

In addition, under the terms of the federal legislation overseeing the broad operation of the insurance industry (the McCarran-Fergusson Act), there is direct regulation of workers' compensation in every state.¹⁶ Additional legislation charges the regulatory apparatus in each state

with assuring that insurance companies remain solvent, while at the same time administering prices that are "neither excessive, inadequate nor unfairly discriminatory". The specific prices charged by insurance carriers are generally subject to some sort of prior approval regulation in most states. The level of benefits, duration of payments, provisions for awards, rehabilitation, medical service delivery, and the method of adjudicating disputes are left to the individual states and are usually spelled out in each individual state's insurance laws. Thus each state's workers' compensation program is comprised of a variety of parameters and factors which will affect the incentives of both injured workers and employers. In effect each state is a separate market; the different state markets will provide an important source for the variation in workplace accidents and their associated costs.

There are two basic benefits provided by workers' compensation insurance. Unlimited medical benefits are typically provided for all workplace accidents subject to a maximum amount or time limit in some states. In general though, all medical expenses are covered. Indemnity benefits are provided for lost wages for those accidents serious enough to result in lost worktime. Unlike medical benefits, indemnity benefits only partially replace lost wages. Individual states establish minimum and maximum benefit levels, as well as a benefit replacement rate. There are also waiting and retroactive periods for indemnity benefits. The

waiting period is the period of time - between 3 and 7 days - that a worker must wait before filing for indemnity benefits. The retroactive period is the period of time after injury and during which the worker is out of work after which the worker may recover indemnity benefits for the waiting period. Retroactive periods typically vary from between 7 and 21 days.

Indemnity benefits also depend on the nature of the injury. The most common are known as "temporary total" and are usually paid for the period of time just subsequent to injury when the worker is not able to work at all and up to the time when the injured worker has recovered to the extent possible (i.e., prior to the time of "maximum medical improvement" or the return to work). As discussed earlier, indemnity benefits are usually set as a proportion of the pre-tax, pre-injury weekly wage. After a convalescence period, which may be statutorily set or be established by a treating physician, if a worker is unable to work at all, "permanent total" benefits will be paid. If a worker is able to return to work in some limited capacity at a diminished earnings capacity, "permanent partial" benefits will be paid. Depending on the state, permanent partial benefits may be determined according to a schedule that depends on the type of injury (e.g., amputation of the arm, loss of eye, etc.), or may be determined by a formula relating to some proportion of the workers' actual wage loss. In injuries where a worker is killed, death benefits, which are often set as a number of

weeks of benefits, are paid to the surviving family. Benefits are generally not taxable, although a few states set benefits as a proportion of spendable (post-tax) earnings.

The fact that indemnity benefits do not completely replace lost earnings is a recognition that if they did, incentives to return to work would be severely reduced. This same problem is faced by other social insurance programs such as unemployment insurance.

Even though the concept of workers' compensation is fairly straightforward, the determination of insurance rates (prices) is a technical and often difficult and imprecise matter. Since insurance policies are written for individual employers, and since there is a wide variety of businesses in each state, different firms have different risks of injury and illness and hence different expected costs. Insurance rates will differ by type of business in order to satisfy the typical statutory requirement that rates not be unfairly discriminatory, i.e., that there be no price subsidies for any particular industry. In addition, the final price a firm pays for its workers' compensation insurance will reflect pricing adjustments due to firm size, past safety experience and safety technology.¹⁷ In addition, because the workers' compensation insurance market is different in each state, similar businesses with essentially the same underlying job risk may have different insurance costs in different states.

The rate setting and benefit determination process in each state is undertaken ex ante and is largely based on

expectations of dollar loss amounts. WC is also experience rated based on a weighted average of a firm's own experience and the average experience of the industry the firm is engaged in; the weight given to a firm's experience is a function of firm size (in terms of the amount of WC premium that is generated, which will equal price times payroll). As a result, WC also affects employer incentives, especially in the provision of workplace safety.

B. Relevant Research: The Role of Alcohol In Workplace Accidents

Even though there is a growing and significant literature on the effects of alcohol consumption on automobile accidents (Asch and Levy 1988; Cook 1989; Coate and Grossman 1988; Phelps 1989; Safer and Grossman 1987; Wilkinson 1987), most information on the role of alcohol consumption on industrial accidents is highly anecdotal or based on small specialized samples. In a 1985 review of the literature, Hingson, Lederman, and Chapman-Walsh (HLC) found only three studies in the 30 years prior to 1982 which even attempted to analyze the relationship between drinking alcohol and the relative risk of workplace accidents. The results surveyed by HLC were inconclusive; no consistent relationship between alcohol consumption and workplace accidents was established.

One of the early studies on which HLC report (Baker, Sankoff, Fisher and Van Buren 1982) analyzed data on only 148

deaths from work-related accidents in 1978. Baker et.al. found that 11 percent of the accident victims had excessive blood-alcohol levels (i.e., exceeding 80 mg/dl or the equivalent of four drinks on an empty stomach during the previous hour for a 155 pound person). No attempt was made to extrapolate these results to an economy-wide estimate of the effect of alcohol consumption on workplace accidents or on the magnitude of the cost impact.

In their own study which was based on a random sample of New England workers, HLC found the associations linking accident involvement with overall alcohol consumption to be more consistent than those linking accident involvement to drinking on the job. That is, although the frequency of on-the-job drinking was not significantly associated with various accident measures, respondents who average five or more drinks daily were 2.0 times more likely to experience an accident at work and 3.8 times more likely to be hospitalized as a result.

More recent research provides only marginally more information. Another 1985 report¹⁸, which cites no supporting information, suggests that 10 percent of occupational injuries are associated with alcohol. A study by Carels and Kirsay (1987) based on a sample of hospital emergency room records, estimates that 17 percent of work-related accidents involve alcohol abuse. The authors estimate that such accidents accounted for \$23.5 million in workers' compensation claims in 1985. Other researchers have attempted

to estimate the total societal cost of alcohol consumption including the costs of workplace accidents. While not strictly comparable to the estimates above, they are indicative of the wide variance in extant estimates. One such study finds that alcohol consumption cost the U.S. economy \$89.5 billion in direct and indirect costs in 1980 (Research Triangle Institute Report 1980), while a 1987 study by Fein estimates the total bill for substance abuse to exceed \$120 billion. These findings are all based either on small samples or on indirect measurement due to a lack of information and do not allow for robust or consistent estimates of the impact of drinking on workplace accidents.

A recent study by Lewis and Cooper (1989) examined blood alcohol levels for 196 work-related deaths in Harris County, Texas during 1984 and 1985. Their analysis found that 13 percent of the workers autopsied had detectable blood-alcohol content and 7 percent had detectable traces of drugs with psycho-tropic qualities. However, they were unable to determine if the proximate cause of death was alcohol or drug related.

The nature of the existing research on the effect of alcohol consumption on workplace accidents is not only rather thin, but there is no consensus as to the magnitude of the problem. Estimates of the total effect vary by orders of magnitude or do not bear any resemblance to the existing information on the costs of workplace accidents. The extant studies are often based on small specialized samples. The

usual strategy has been to sample blood alcohol levels of workers who have been killed on the job. While this is certainly a worthy group to investigate, the frequency of deaths attributable to workplace accidents is quite rare: On average across 46 states with private insurance data available for 1989, there were 9 workplace deaths per 100,000 workers. In comparison, there were 662 permanent partial injuries and 1,940 temporary total injuries per 100,000 workers. As a percent of total costs, deaths account for 2.8 percent, permanent partial injuries account for 48.35 percent and temporary total injuries account for 8.84 percent¹⁹. Estimates of the effect of drinking on workplace accidents (and their costs) which only consider deaths only capture a small portion of the total effect.

One of the problems in obtaining reliable estimates of the effect of alcohol consumption on workplace accidents is that insurance carriers and employers often do not collect information on workers' drinking and drug use patterns. Also, employees clearly have incentives to not reveal this information especially in cases of workplace injury. This explains, in part, the variance of the estimates of the impact of alcohol consumption on work-related accidents. In addition, reporting errors on alcohol consumption and injuries might compromise the integrity of the estimates, and any calculation of economy-wide or aggregate effects would be difficult.

C. Relevant Research: The Role of Workers' Compensation in Workplace Accident Costs

One of earliest attempts to estimate accident frequency elasticities with respect to WC benefit levels was undertaken by James Chelius for the National Commission of State Workmen's Compensation Laws convened by President Nixon in the early 1970s. Chelius (1977) analyzed a cross-section of relatively homogeneous industries in 18 states. Based on an injury rate equation that also accounted for the fact that the level of wages may be related to job risk as proxied by the injury rate, Chelius found a positive, statistically significant relationship between WC benefits and injury rates. In a later study, Chelius (1983) analyzed the injury-rate experience of two-digit SIC manufacturing industries over the 1972-1978 time period in 28 states. He found a statistically significant positive relationship between the percentage of income replaced by the expected workers' compensation indemnity benefits and the industry's injury rate.

Butler and Worrall (1983) examined the relative frequency of particular benefit types (i.e., benefits for temporary total, permanent partial and permanent total injuries) over the 1972-1978 period for 35 states. Although they observe only those firms in the aggregate that insured through the private market (a problem with the data used in this paper as well), they found, even in the presence of controls for the secular increase in injury rates and real

benefits, an average benefit elasticity with respect to claim frequency of about .4.

Butler (1983) found significant large benefit elasticities based on different data. He examined 15 industries within a single state over a 32 year time span. The use of a single state holds constant some of the variation between states that can exist because of unobservable or difficult to quantify differences in state workers' compensation laws. On the other hand, identifying benefit effects for a single state net of wage effects may be difficult since benefits are a deterministic function of wages. Butler reported benefit elasticities generally around 1 for the various benefit types, with the indemnity claim rate being higher for more serious claims.

Bartel and Thomas (1982) include controls for the impact of the OSHA program on injury rates while simultaneously evaluating the frequency elasticity of WC. They estimate a frequency elasticity of .63 which lies in the middle of the .4 to 1 range derived in the above studies. Although their measure of frequency is lost workdays due to job injury as reported to OSHA for a 22 state sample of various manufacturers during 1972-1978. This is different from the Butler and Worrall studies which use workers' compensation claims as an accident metric since the OSHA data actually includes both a frequency and severity component.

Ruser (1985) estimates the determinants of injury rates using a reduced form specification that treat wages and hours

as independent factors, in contrast to the studies cited above which treat them as jointly determined. He analyzes data from 1972 to 1979 on 25 three-digit SIC manufacturing industries for 41 states and finds a frequency elasticity of .35. A major difference between Ruser and the other research cited is that he also attempts to control for employer incentives due to the experience rating of WC by including controls for firm size and an interaction between firm size and benefits. Ruser hypothesizes that, since workers' compensation is experience rated, the frequency elasticity should decline as firm size increases. As expected, he finds that larger firms have fewer accidents.

There have also been several sets of analyses of claim frequency using micro level data on individuals. This has the obvious advantage of allowing for more demographic information about the individual claimant or claim, but at the cost of having to calculate potential workers' compensation benefits for each individual instead of a representative or average individual. Leigh (1985) uses logit analysis to examine how benefit levels affect claim frequency. He finds a benefit elasticity of .4 in a specification which does not control for year and state effects, and an elasticity of .5 when these factors are held constant. These are comparable to the elasticities from the aggregated analyses discussed above.

There are two additional studies that use individual data to examine claim frequency. Krueger (1988) uses a

matched set of workers from 1983-84 and 1985-86 from the Current Population Survey to estimate the correlates of claim participation in the workers' compensation system. He estimates the frequency elasticity to be .54 for the entire sample. He also obtains separate elasticity estimates for manufacturing employees (.57) and for nonmanufacturing employees (.51).

The other disaggregated analysis, a study done by Moore and Viscusi (1988), imputes not only various measures of benefits to individuals in their sample, but also imputes a risk variable. This risk variable is derived based on the employees' states of residence and reported industry. They find, contrary to the studies listed above, that an increase in benefits leads to a small but significant decrease in the frequency of injuries. They argue that employer responses are stronger than employee responses, so that higher levels of workers' compensation payments actually save employers money since it promotes workplace safety. One reason their results may differ from the others cited above is that Moore and Viscusi concentrate on death claims which comprise such a minor portion of total workplace accidents.

As discussed in the first chapter, claim frequency is only one piece of the workers' compensation claims cost equation. The severity or duration of claims obviously has a significant impact on total costs. There are only a few studies examining the effect of benefits on claim severity (generally measured as time on a claim rather than costs per

claim). Many of these studies model the rate of transition from a disabled to a nondisabled state as a function of the wage, workers' compensation benefit, and other demographic information. The underlying model framework is analogous to labor search models used in analyses of the effects of unemployment insurance. The worker selects to return to work when the opportunity costs to being out of work (collecting benefits) exceed wages earned working.

Worrall and Butler (1985) use proportional hazard models to fit a general class of distribution models to duration data for a particular type of claim (low back injury) in a single state. Worrall et.al (1988) expand the analysis to 13 states. The severity elasticity is about .2 in these studies.

Johnson and Ondrich (1988) estimate the distribution of nonwork spells for workers who were permanently partially injured in three states in 1970. They estimate severity elasticities of about 1.0, significantly higher than the above studies.

There has also been some recent research on the rate at which injured workers "transit" from a temporary benefit status to a permanent benefit status. Using longitudinal data on a sample of individual injured workers, and controlling for the severity of the injury, Worrall, Durbin, Appel, and Butler (1992 forthcoming) estimated a benefits elasticity with respect to the probability of claim transit of 1.4. Their analysis suggests that a 10 percent increase in the amount of permanent partial claims will give rise to a 14

percent transit from temporary total to permanent partial claim status. This is often an overlooked part of the benefit utilization phenomena: to wit, benefit provisions for different claim types may create incentives to extend the duration of being on a claim, even if some return to work is possible.

More recent work adopts a "natural experiment" approach. Meyer, Viscusi and Durbin (1990) analyze a one year time period prior to and subsequent to significant benefit changes in two states. They focus on the duration (severity) of WC claims and exploit the particular nature of the benefit changes. In many instances, benefit increases will take the form of increasing the maximum benefit amount while retaining the benefit replacement rate. Thus, compared to before a change, only those workers who are above the old maximum actually have a benefit increase. The natural experiment occurs since many workers with wages that do not exceed the old maximum have no real benefit change. This group of workers provides a control group to contrast the claims behavior of workers with a de facto benefit change. By focusing on an increase in a single state, unobservable characteristics of the workers' compensation systems can be controlled and underlying labor market conditions will also not be dramatically different.

Meyer et. al. find that for each 10 percent increase in benefits, the median duration of spells rises between 3.8 and 5.7 percent. Krueger (1990) uses a similar approach in

analyzing Minnesota claims but obtains severity elasticities exceeding unity. Using two-stage least squares regression on a sample of closed claims he estimates benefit elasticities of 1.7. Although the results are not strictly comparable because of slight differences in approach and nature of the sample, Krueger's results are substantially higher than other research. Both the Meyer et al. and Krueger studies make some allowances for the highly skewed nature of workers' compensation duration data (most claims are short in duration but a few claims have extremely long durations), in the spirit of the sophisticated distributional work of Butler and Worrall.

The extant research is in virtual agreement that there is a benefit response to WC benefits, but the magnitude of this effect is still an open issue. As mentioned in the introductory chapter, Gardner (1989) in a comprehensive review of the labor economics literature pertaining to both workers' compensation and the labor supply affects of other income transfer programs such as unemployment insurance and SSDI, concludes that increased utilization of WC in response to greater benefits poses a significant phenomena. (The term of art that has evolved in the insurance and research communities is to refer to this phenomena as "benefit utilization".) His previously cited estimate is that a 20 percent increase in weekly temporary total benefits for all claimants and all types of lost-time claims may increase temporary total benefit payments by as much as 30 percent.

A recurring theme in the literature is the confirmation of benefit utilization or claim inflation. Yet, it is also generally regarded that this phenomena may itself be comprised of a "real" effect and a "reporting" effect. Although the incentives of the workers' compensation will be more full developed in the next section, it is worth noting that changes in utilization may not be due solely to changes in underlying job risk. Rather, there may simply be a willingness by workers to report more injuries as claims. The incentives of workers' compensation may also affect the opportunity cost of injury as well as employers' expenditure on safety. This may in fact affect workers job choice and assumption of on-the-job risk. The existing literature offers no empirical evidence as to the extent of the reporting or real effect.

Kneiser and Leeth (1988) offer a simulation analysis of hedonic labor market equilibria. Their analysis suggests that the real effect is significant. That is, they find the existence of workers' compensation insurance actually leads to a less-safe workplace as workers accept greater job risk compared to the case where there is no insurance. The Kneiser and Leeth findings may offer an explanation regarding the contrary findings of Moore and Viscusi (M&V). M&V may have been capturing only the reporting effect and not holding the real effect constant. Clearly, further work is needed to better understand the hedonic labor market dynamics, although the resolution of this issue is beyond the scope of the

present investigation.

The analysis and estimates I will develop in the later sections of this paper will extend the existing literature by explicitly considering workers' behavior (i.e., in terms of alcohol consumption), rather than relying on induced outcomes that operate through wage and benefit effects. Further, the data will be more extensive than employed by other researchers.

III. Model Development

A. Model Framework

In this Chapter, a formal theoretical model to analyze both the impact of workers' compensation benefits and the role of alcohol consumption on workers' compensation costs will be developed. The basic accounting foundation outlined in Chapter I will be used in the econometric implementation of the model to investigate the separate effects of these factors on the frequency of accidents and the average costs of those accidents.

The basic analysis presented here applies a health state dependent utility framework which provides the underlying theoretical foundation for much of the literature on workplace frequency and duration²⁰. This model hypothesizes that the decision to file a workers' compensation claim or extend the duration of disability is conditional on an individual workers' comparison of welfare in an injured versus noninjured state. Workers will evaluate the expected utility of income received in the two states - injured versus noninjured. The workers' compensation weekly benefit represents the income in the injured state; wages obviously represent income in the noninjured state. Clearly, as benefits increase (more specifically the benefit parameters such as the replacement rate, the percentage of the SAWW, or the allowable maximum) or as wages decrease, everything else held constant, the relative utility of being in the injured state increases and the number of reported injuries should

rise. Utility is defined to include the amount of time for leisure and work activities as well as any restrictions in activities that may be injury related.

Note that the model does not imply that workers deliberately have accidents, but it does imply that workers have some discretion over their actions and can make choices. For example, individual workers make decisions on the amount of injury risk to accept in their choice of occupation.²¹ This decision is predicated in part on the opportunity cost of being injured and the degree to which job risk is compensated by wage differentials. (Although at the aggregate level, workers job risk decisions may have less of an impact on overall injury rates.)²² Workers can also choose how cautious to be in a given occupation. Finally, given an injury, workers have the choice of filing a claim, and once on a claim, have the choice of extending their duration of disability.

Workers' expected utility decisions are not made in a vacuum; they will also be conditional upon expectations about future employment and current and future economic conditions. As prospects dim, and the possibility of being out of work involuntarily increases, workers may seek to subsidize their nonwork status by filing or extending a workers' compensation claim.

Employee Incentives

A number of authors have used some form of this model

which stresses the incentives affecting workers. For example, Viscusi (1979) has formally developed a "health state approach". In Viscusi's basic framework, which is essentially a static single-period model without explicit allowances for insurance or taxes (he later adds these factors), there is no income uncertainty associated with any job, but rather, it is the health state resulting from one's activities that is uncertain.

It is useful to consider Viscusi's model and later variants by Viscusi and Moore, and Krueger to flesh out the model's essential characteristics. In particular, these models generate hypotheses regarding the effect of workers' compensation benefits and wages on the probability of injury and thus participation in the WC program. The models also provide guidance to econometric specifications. Later, I will extend these models by allowing for the consumption of alcohol to enter the worker's "production function" of safety and observe the implications for the probability of injury.²³

Formally, two health states are considered: State 1 represents a healthy state, while state 2 represents ill health such as being injured. A worker's utility function is dependent on his health state, and it is assumed that a given level of consumption yields a greater total utility when the worker is healthy. Viscusi also makes the assumption that the marginal utility of consumption is greater in the healthy state. This later assumption seems a bit restrictive. Indeed you might hypothesize that state 2 simply shifts the utility

function down and that the slope (of the utility function graphed against a composite consumption good) remains the same. Although Viscusi's assumption may be overly restrictive, relaxing it will not significantly alter the analysis.

Workers select from jobs with varying levels of job risk as measured by p , the probability of ill health or injury. It is assumed that the set of alternative jobs to be considered can be restricted to the efficient set of offers. That is, the only jobs considered are those that offer the highest wages for any value of p . It is also assumed that other conditions of work from which compensating differentials may arise (e.g., fringe benefits) are uncorrelated with the riskiness of the job. Hours of work are assumed fixed and identical for all jobs. Thus, the representative worker's objective is to select the job and consumption that maximize expected utility. Specifically, the worker selects p and x to maximize the following Lagrangian:

$$(3) \quad L = (1-p)u^1(x) + pu^2(x) + \Gamma[x - A - w(p)]$$

where, adopting the same notation as Viscusi:

u^j = the utility function in state j , where $j = 1, 2$

x = the composite consumption good whose price equals 1

p = the probability of ill health or injury

$w(p)$ = the wage for a job offering probability p of state 2 (ill health)²⁴

A = initial assets

Γ = the shadow price of the goods constraint

Denoting partial derivatives with subscripts, the following are the first-order conditions:

$$(4) \quad L_x = 0 = (1-p)u_x^1 + pu_x^2 + \Gamma$$

and

$$(5) \quad L_p = 0 = -u^1 + u^2 - \Gamma w_p$$

Solving for w_p produces:

$$(6) \quad w_p = [u^1 - u^2] / [(1-p)u_x^1 + pu_x^2]$$

Thus, assuming that an individual's utility in a healthy state is higher than his utility in an unhealthy state, the first order condition implies that for any individual $w_p > 0$. Put differently, the first order conditions imply that the wage must increase with the probability of injury on the job.

Viscusi elaborates on this framework:

"... the job market equilibrium function $w(p)$ is necessarily an increasing function of p if workers are employed at each level of p . Jobs with identical stochastic properties will be rewarded equally in equilibrium: The positive sign of w_p is a result of the job choice problem. It is not an assumption. The derivation of this result did not require that workers be risk averters. The only key assumptions required are that the good health state be more desirable than the ill health state and that the marginal utility of consumption be positive."²⁵

To make sure equation (6) produces a point of maximum utility, the second-order condition that the marginal rate of

change of w_p with respect to further increases in p must be negative, or if positive not too large. That is, the following condition is required:

$$(7) \quad w_{pp} < \{-(w_p)^2[(1-p)u_{xx}^1 + pu_{xx}^2] - 2w_p[u_x^2 - u_x^1]\} / \{pu_x^2 + (1-p)u_x^1\}$$

If there is diminishing marginal utility of consumption in both health states ($u_{xx}^1 < 0$ and $u_{xx}^2 < 0$) and the marginal utility of consumption is greater in the healthy state than in the injured state ($u_x^1 > u_x^2 > 0$) then the right side of equation (7) is positive, and the second-order condition is satisfied. The result will also hold if $u_x^1 = u_x^2$, which relaxes Viscusi's assumption somewhat.

The compensating wage differential result in (6) implies that the curve relating w to p must have a positive slope if workers are to be attracted to jobs along it. Thus, if the wage premium per unit of risk declines with the level of p , or is constant, or increases with p at not too great a rate, the second-order condition will be satisfied. Viscusi presents empirical evidence for death risks that indicates w_{pp} is indeed negative.

The analytic advantages of Viscusi's framework, besides deriving conditions for compensating wage differentials, is that the optimal job risk selection can be further investigated. For example, Viscusi shows that by totally differentiating the first-order conditions, including the

budget constraint, one can solve for dp/dA , or the relationship between assets and the optimal probability of injury. By further complicating this basic model structure, the effects of workers' compensation insurance, taxes, and even worker behavior on optimal wages and job risk can be captured.

An interesting feature of this analysis is the implication for worker wealth, and by extension income (given the strong positive correlation between income and wealth), and optimal job risk. Viscusi shows that $dp/dA < 0$; this depends on the second-order condition (7). This feature is confirmed by empirical observation: Thus, if you compare individuals with different wealth levels, one would expect those with greater wealth to have jobs with lower risk.

A number of authors have used this framework to investigate the impact of workers' compensation benefits on workers' decisions, and further to analyze whether such benefits are optimal. A significant public policy question is whether the existence of workers' compensation benefits alters workers' job selection and whether this will affect compensating wage differentials for risky jobs.

Viscusi and Moore (1987) use a variant of this approach to find that higher levels of workers' compensation benefits lead to a reduction on wages, and that the estimated risk/wage tradeoff is larger when a control for workers' compensation is included. The model that V&M develop expands Viscusi's earlier model by explicitly considering the

tradeoff between wages when healthy versus workers' compensation benefits when injured. V&M find that the rate at which workers are willing to trade off wages for the level of workers' compensation benefits exceeds what one would expect given the implicit actuarial tradeoff between insurance prices and benefits (i.e., taking into account that not all insurance premiums are returned as benefits but that there are also administrative expenses and insurer profits), and thus, benefit levels are suboptimal. This later finding is important because it takes into consideration the above model where job injury is assumed to lower a worker's marginal utility of income, and as a consequence less than full compensation is desirable. That is, this framework considers that a worker would not choose to equalize income levels in the healthy and injured states if the injury reduces the ability to derive utility from consumption (expenditures).

The simple version of the V&M model uses the framework established above but now includes:

w_1 = wage when healthy

w_2 = workers' compensation benefits when injured

t = tax rate on wages²⁶

Utilizing the same assumptions as before, the representative worker's expected utility is:

$$(8) \quad L = (1-p)u^1((1-t)w_1) + pu^2(w_2)$$

and solving for the first-order conditions to determine the rate of tradeoff that maintains the worker's level of welfare yields:

$$(9) \quad dw_1/dw_2 = -L_{w2}/L_{w1} = -pu_x^2/(1-p)(1-t)u_x^1$$

V&M develop various estimates of (9) with the inclusion or exclusion of taxes and an "actuarial constraint" (workers marginal productivity set equal to wages plus workers' compensation benefits plus administrative expenses). Note that in this model formulation, V&M do not consider the utility a worker may derive from leisure. That is, there may be a potential moral hazard problem with this analysis since an injured worker has more leisure time, which will in some sense generate utility, that has not been taken into consideration.

Krueger (1989) extends this framework by parameterizing the probability of injury (unhealthy state) to be a function of the level of effort a worker devotes to safety. As Krueger theorizes, "workers choose over a continuum of non-negative effort levels to devote to safety". This takes the form of time spent in accident prevention like wearing goggles and hard hats as well as time spent in formal accident prevention training programs. The level of effort a worker devotes to safety in period t , denoted s_t , inversely affects the probability that he or she will incur a disabling injury or illness, and thus qualify for workers' compensation benefits

in period $t+1$. Unlike the model by Viscusi and Viscusi and Moore, Krueger does not consider the worker's initial assets.

Krueger's model is effectively a two-period model that also considers (at least implicitly) employers' incentives. This latter factor is also captured by the existence of workers' compensation benefits. Since workers' compensation insurance is mandatory in all but three states and is typically experience rated, firms have a direct financial incentive to reduce injuries and their costs. These incentives exist at least up to the point where the marginal costs of safety reduction equal the marginal benefits to be gained by reducing insurance costs.

Formally, the probability of an accident is assumed a concave function with the following properties:

$$\begin{aligned} p &= p(s_t) && \text{with} && p'(s_t) < 0, \\ & && && p''(s_t) > 0, \\ & && && 0 < p(s_t) < 1 \end{aligned}$$

and s_t is assumed unobservable to employers and insurers. The representative workers' utility function is assumed time separable with personal rate of time preference α , and all workers are assumed to work a fixed number of hours in time t with consumption equal to w_t , which is labor income.

The first period utility function is: $u = u(w_t, s_t)$ with positive marginal utility of wage income and negative marginal utility of safety effort. Thus, $u_{wt}(w_t, s_t) > 0$ and $u_{st}(w_t, s_t) < 0$. If the worker is injured after investing s_t units in safety, then he or she will receive expected

workers' compensation benefits B_{t+1} in lieu of wages.

A disabled workers' utility function is $v=v(B_{t+1})$ with positive marginal utility of expected benefits, $v'(B_{t+1}) > 0$. Otherwise, a healthy workers' second period utility function is simply: $u=u(w_{t+1}, s_{t+1})$ with the same properties as before²⁷. In addition, similar to the Viscusi models, marginal utility in the healthy state is assumed to exceed marginal utility in the disabled state.

Workers set the level of effort expended on safety to maximize expected utility (using Krueger's notation):

$$(10) \quad EU = u(w_t, s_t) + \alpha\{p(s_t)v(B_{t+1}) + [1-p(s_t)]u(w_{t+1}, s_{t+1})\}$$

Solving for the first order condition yields:

$$(11) \quad s_t\{u_{st}(w_t, s_t) + \alpha p'(s_t)[v(B_{t+1}) - u(w_{t+1}, s_{t+1})]\} = 0$$

For an interior solution (11) must be concave with respect to s_t ; there must be diminishing marginal returns to safety.

By differentiating the first order conditions, Krueger derives two important results. The first relates to the change in safety effort for a change in expected workers' compensation benefits and is shown to be negative:

$$(12) \quad ds_t/dB_{t+1} = -\alpha p'(s_t)v'(B_{t+1})/\Delta < 0$$

where, given the model assumptions ($\alpha > 0$, $p' < 0$, $v' > 0$), the inequality is dependent on the sign of Δ , the second-order condition which is negative if s_t is concave. That is the second-order condition is:

$$\Delta = u_{stst}(w_t, s_t) + \alpha p''(s_t) [v(B_{t+1}) - u(w_{t+1}, s_{t+1})] < 0$$

It also follows that an increase in expected benefits will lead to an increase in workers' compensation claims (assuming the probability of filing a claim given an injury is positive). That is:

$$(13) \quad dp/dB_{t+1} = -\alpha [p'(s_t)]^2 v'(b_{t+1}) / \Delta > 0$$

Note that as discussed previously, the model does not distinguish between an increase in participation in the workers' compensation program as a result of workers having more injuries (being less safe on the job) or by workers filing more claims.

Finally, the model also allows a prediction of the effect of an increase in the wage rate on participation in the workers' compensation program. Krueger argues that an increase in second period wages, holding first period wages constant, unambiguously leads to an increase in a worker's safety effort. An increase in the first period wage has an ambiguous effect and depends on the sign of the cross-partial derivative $u_{wtst}(w_t, s_t)$. However, if an individual's wage rate

is constant over time ($w_t = w_{t+1} = w$), then the total effect of a change in the wage rate on the probability of experiencing an injury and thus participating in the workers' compensation program is:

$$(14) \quad dp_t/dw = p'(s_t) [\alpha p'(s_t) u_w(w, s_t) - u_{wst}] / \Delta$$

If the first term in brackets dominates the second, or if the cross-partial is nonnegative (a sufficient condition for a normal good) then an increase in the wage rate will lead to a decrease in the probability of injury (decrease in program participation).

To summarize the results from the Viscusi and Krueger models, from the individual workers' perspective there are three important implications. First, assuming that workers' compensation benefits are exogenous, individual safety effort is a decreasing function of expected workers' compensation benefits. Second, the probability of injury is affected by safety effort and is an increasing function of expected benefits. Finally, under some not too strict assumptions, the probability of injury is a decreasing function of wages. In effect, the intuition reduces to the notion of opportunity costs: As benefits increase, all else the same, the cost to being disabled decreases (the loss from not pursuing safety diminishes) and both the probability of injury and workers' compensation participation increase. Conversely, as wages increase, the costs of being disabled increases (in terms of

foregone wages and decreasing proportion of income replaced) and thus the returns to safety increase and workers' compensation program participation decreases. Note there is an implied assumption that the probability of filing a claim given injury is positive for these predictions to hold.²⁸

Another way of viewing employee incentives with respect to changes in wages and benefits is to consider income and substitution effects. Considering wages first, the income and substitution effects are in opposite directions. As wages increase, workers' time is more valuable (relative to nonwork activities) and there are incentives to substitute work for nonwork. On the other hand, there is an income effect and incentives to trade the higher income for leisure. The net effect in general must be determined empirically.²⁹

However, an increase in weekly benefits (in any income replacement program) will unambiguously reduce time spent working. In this instance the income and substitution effects reinforce one another. The substitution effect is effectively negative because time away from work now has a larger payoff.

Employer Incentives

There is, of course, another side to the analysis which needs to be developed. Although not as widely researched as employee incentives, employer incentives will also affect the use and costs of workers' compensation. Krueger (1989), Chelius and Smith (1983), Ehrenberg (1988), Harrington

(1988), Kahn (1987), Butler and Worrall (1988), Butler, Appel and Worrall (1991), Ruser (1985 and 1991), and Victor (1985) have discussed employer incentives.

The key to the employer incentives is the extent that workers' compensation benefits alter firms' financial incentives to expend resources to reduce injuries, as well as the extent to which wage differentials are offset by workers' compensation benefits. In this section, I will briefly review some of the results of the earlier research.

In general, the underlying rationale that drives employer incentives derives from the assumption that firms are profit maximizers who will expend resources on safety up to the point where the marginal benefits to be gained (from lower insurance costs) are just equal to the marginal costs of the safety expenditures. In addition, workers' compensation insurance is experience rated with the level of experience rating an increasing function of firms size³⁰. Thus, firm size will affect the level of safety expenditure because technology may vary by firm size (i.e., there may be economies of scale in the provision of safety) and because of experience rating.

In the perfectly competitive labor market model³¹, where workers are mobile and have perfect information on job safety and rationally interpret that information (i.e., there is no cognitive dissonance), wage differentials should arise to fully equate the marginal costs and the marginal benefits of safety investment. If workers are risk neutral and there is

no difference in the treatment (i.e., taxes) of benefits and wages, the Coase theorem would predict that perfectly experience rated and actuarially fair insurance rates will have no impact on workers' compensation participation. Under these conditions, wage adjustments would completely offset workers' compensation benefits.

There are reasons to believe, however, that this idealized world may not exist. For example, workers' compensation insurance rates are not perfectly experience rated; only for a small proportion of very large employers are rates determined solely by their own loss experience.³² In this case, even if labor markets generate fully compensating wage differentials, the net marginal benefit to firms of preventing accidents would decrease (or at least not increase) with an increase in benefits. Put differently, the reduction in wage costs resulting from the payment of benefits would be greater than the employers' liability for the benefits. In this situation, the employer response would be either neutral or actually reinforce the worker response and injuries would increase with increases in benefits.

Alternatively, if labor markets fail to generate fully compensating wage differentials, then it could conceivably be the case that partially experience rated insurance rates would increase the marginal costs of work accidents to firms. This would have the effect of firms allocating more resources to preventing injuries.³³ In this particular instance, the inability of firms to shift the effect of higher benefits

onto workers' coupled with the experience rating of workers' compensation premiums results in an increase in the marginal costs of accidents. There would then be an increasing payoff to investing in safety. As a consequence, combined with the worker response, the net theoretical effect of workers' compensation benefits on job safety is ambiguous and can only be determined empirically.

However, it should be recognized that even if increasing workers' compensation benefits does not alter employer resources to prevent injuries, the fact that workers' compensation is at least partially experience rated suggests that firms will have incentives to affect the number and duration of workers' compensation claims. Firms will have at least some incentives to question the compensability of some claims as well as question the length of disability once an injury has occurred.

Employer incentives have typically been investigated by considering an interaction term between firm size and workers' compensation benefits. With the exception of the paper by Chelius and Smith (1985), all the other papers find that experience rating matters and that injury rates are a decreasing function of firm size.

For example, Harrington (1988) uses individual state data and estimates the level of actual to expected losses (based on the actuarial forecast including the effect of experience rating which underlies the insurance premium) as a variety of functions of firm size (linear, quadratic, and

exponential). Harrington finds, with one exception, that the relationship between firm size and the ratio of actual to expected losses to be negative and statistically negative. That is, larger firms tend to have lower actual losses relative to their expected losses. These results were maintained when the data were disaggregated into the three broad industry categories used in workers' compensation ratemaking.³⁴

Butler, Appel, and Worrall (1991) in a similar spirit find that the elasticity of both the frequency and severity of workers' compensation claims with respect to benefits declines as firm size increases. Their analysis is based on the actual distribution of firm sizes for a number of states and years, and also includes controls for the statewide average weekly wage, the expected workers' compensation weekly benefit, and differences in the industrial mix across states.

In a recent article, Ruser (1991) uses a longitudinal establishment data set to investigate the effect of changes in workers' compensation benefits on the incidence of lost workdays due to illnesses and injuries as reported to the Bureau of Labor Statistics. Using both ordinary least squares and more sophisticated maximum likelihood count data models, Ruser interacts workers' compensation benefits with firm size and finds, after controlling for wage effects, that the effect of raising weekly benefits by \$50 in 1989 would increase the lost workday rate by 1.2 - 1.26 cases per 100

workers. However, in establishments with 500 or more workers, the resulting increase would only be between .27 and .31 cases. In models controlling for fixed effects, the results are more dramatic: The \$50 increase is predicted to lead to an increase of .6 cases for the smaller establishments, but a .03 case decrease in the larger establishments. In either specification, the finding is that larger firms respond more to changes in benefits due to the impact of experience rating or as the result of economies of scale in safety investment. Note that, in general, Ruser observes that employee responses dominate as increases in benefits are associated with an overall increase in injuries.

Yet another confirmation of the effectiveness of the experience rating plan comes from a simulation analysis performed by Victor (1988). Victor compares the present value of the savings from avoiding a workers' compensation claim under the experience rating program with the savings from avoiding the same claim for a firm that self-insures its workers' compensation insurance that is the same size and in the same industry. He finds that the safety incentives arising from experience rating may actually be greater than those for a self-insured firm. The reason is that, under experience rating, the savings from loss prevention accrue over three future years whereas the savings to the self-insurer is only for the current period. Victor's results were maintained for a number of states and industries.

The results from the research on employee and employer

incentives make apparent as Ehrenberg observes in his review article that:

"In sum, workers' compensation benefit levels, operating through both the employer and employee side of the market, should be expected to influence the magnitude of compensating wage differentials, efforts by employers to reduce injury rates, injury rates per se, the number and types of workers' compensation claims, the duration of different types of claims, and the labor force attachment and hours of work of injured workers."³⁵

However, as mentioned above, the net theoretical outcome of the employee and employer incentives on total workers' compensation claims and costs is ambiguous and can only be determined empirically.

B. Parameterizing Workers' Safety Effort: The Impact of Alcohol Consumption

The model developed in this section extends the framework specified in the above sections by considering workers' safety effort and, indirectly, their behavior by looking at the effect of alcohol consumption. Similar to the research on the effects of alcohol consumption on automobile accidents, the critical assumption is that alcohol diminishes motor skills and level of attention. The result is to increase the probability of accident and hence workers' compensation claims. This will have an obvious impact on workers' compensation costs. However, both the probability of an accident and the consumption of alcohol are conditional on a host of observable and unobservable factors. The

following model accounts for these phenomena and will be used to generate an estimating equation that specifies workers' compensation costs (frequency and severity) as a function of exogenous and endogenous factors.

To fix the idea, the probability of an accident may be thought of as a technical relationship analogous to a production function. The individual worker provides inputs to this "process" which will influence the outcome. Specifically, changing the notation slightly from that developed earlier, if ϵ is the probability of an accident, the relationship becomes:

$$(15) \quad \epsilon = \epsilon(a, s, z, v)$$

where,

a = alcohol consumption

s = resources devoted to safety by the worker
(equipment, training, etc.)

z = exogenous observed determinants of ϵ

v = unobserved determinants of ϵ

Note that both a and s are endogenous; the probability of an accident will affect both alcohol consumption and safety resources and are related to the unobserved determinants (v). It is assumed that increased consumption of alcohol increases the probability of an accident and that an increase in safety effort reduces the accident probability.

Or, denoting partial derivatives by subscripts: $\epsilon_a > 0$ and $\epsilon_s < 0$. Further, wage rates and workers' compensation incentives do not directly affect ϵ . Instead, they have indirect effects through a and s .

To simplify the modelling for the moment, let the representative workers' utility function be:

$$(16) \quad u = u(a, x_i)$$

where x = consumption of the composite good

$i=1,2$ the healthy and accident states

If p is now the price of a and w is the full-time wage, and the prices of x and s equal \$1, then the following are the relevant budget constraints:

$$(17) \quad x_1 = w - pa - s$$

$$(18) \quad x_2 = w(1-k) + wbk - pa - s$$

where in (18) $k < 1$ and represents the fraction of time lost from work due to an accident, and $b < 1$ represents the proportion of wages replaced by workers' compensation benefits. To simplify, I assume that $k=1$; indeed, most lost worktime accidents start as a temporary total claim where the injured worker is unable, at least initially, to supply any labor. Thus,

$$(19) \quad x_2 = bw - pa - s$$

The workers' expected utility (EU) becomes:

$$(20) \quad EU = (1-\epsilon)u^1(a, w-pa-s) + \epsilon u^2(a, bw-pa-s)$$

This formulation assumes that a and s are determined before the state of the world is known. That is, workers will still expend resources on safety in the injured state. This is analogous to spending resources on safety in the second period of a two-period model such as the one developed by Krueger. The expression for expected utility can be simplified for exposition and estimation purposes by assuming u is additive in a and x , and linear in x :

$$(21) \quad u = F(a) + x_i$$

where $F_a > 0$ and $F_{aa} < 0$ (increasing but diminishing marginal utility of alcohol consumption) and $\epsilon_{ss} > 0$ (diminishing marginal productivity of safety effort given $\epsilon_s < 0$). These conditions guarantee the satisfaction of the second-order conditions.

Rewriting (20), expected utility becomes:

$$(21) \quad EU = F(a) + w - \epsilon(1-b)w - pa - s$$

and the first-order conditions for a and s become:

$$(22) \quad F_a = p + \epsilon_a(1-b)w$$

$$(23) \quad 1 = -\epsilon_r(1-b)w$$

If the production function for safety (15) is specified as:

$$(24) \quad \epsilon = a^{\Gamma} s^{\alpha} z^{\nu}$$

then it follows that:

$$(25) \quad -\epsilon_s = \alpha a^{\Gamma} z^{\nu} s^{\alpha-1}$$

Using (24) and (25), taking natural logarithms and combining terms:

$$(26) \quad \ln s = (\alpha+1)^{-1} \ln(1-b) + (\alpha+1)^{-1} \ln w + \Gamma(\alpha+1)^{-1} \ln a \\ + (\alpha+1)^{-1} \ln z + (\alpha+1)^{-1} \ln v + (\alpha+1)^{-1} \ln \alpha$$

and substituting (26) into (24) and ignoring $(\alpha+1)^{-1} \ln \alpha$ (which will only affect intercept) yields:

$$(27) \quad \ln \epsilon = (\Gamma/\alpha+1) \ln a - (\alpha/\alpha-1) \ln(1-b) - (\alpha/\alpha+1) \ln w + \\ (1/\alpha+1) \ln z + (1/\alpha+1) \ln v$$

In words, equation (27) implies that the probability of an accident is log-linear function of alcohol consumption, workers' compensation benefit rates, wages, other exogenous determinants, and a disturbance term. This equation can be estimated given existing information and forms the basis of

the empirical analysis.

It is important to realize this model captures employee incentives as this is the focus of my analysis. Thus, there is no explicit accounting for employer incentives, but the data used in the empirical analysis represents overall workers' compensation claims and costs and thus incorporates both employee and employer incentives. Moreover, the model as specified in equation (27) captures employee incentives with the term $(1-b)$, which is a slightly different variant than considered by other researchers who have considered either b (the replacement rate) or the actual amount of benefits.

A model which incorporates employer incentives is specified in the Appendix. That model essentially adds a term to the accident production function (equation 15) which represents resources devoted to safety by the firm. Assuming the firm to be a profit maximizer and working through the same logic as outlined above for the employee, an estimating equation is generated which includes an additional term that is equal to the natural logarithm of b (the proportion of wages replaced by workers' compensation benefits). In the empirical analysis, estimates of both equations will be presented. Note that the additional term $(\ln b)$ will be correlated to the workers' compensation variable $(\ln (1-b))$ in equation (27), and is another reason for considering the model with and without the inclusion of the employer incentives.

There is an additional implication that comes out of

this formulation; a and v (the disturbance term) are correlated. This result is obtained from the initial assumptions embedded in the production function specified in (15). To see this more explicitly, consider the following simplified specification for the utility of alcohol consumption:

$$(28) F(a) = a^\theta, \text{ with } \theta < 1$$

therefore, from (22),

$$(29) \theta a^{\theta-1} = p + (1-b)w\epsilon_a$$

which becomes,

$$(30) \theta a^{\theta-1} = p + (1-b)w\Gamma a^{\Gamma-1} s^\alpha z v$$

This last equation can be solved for a , which yields:

$$(31) a = \text{function}[p, w, (1-b), z, v, \theta]$$

The estimation strategy is to fit equation (31) using ordinary least squares regression (OLS) including both the exogenous determinants of the probability of an accident and exogenous determinants of alcohol consumption (θ). The price of alcohol is also included. The equation is effectively a reduced form demand equation for alcohol consumption. The

predicted values from this instrumenting equation are substituted into (27) which is estimated using OLS. The exogenous determinants of alcohol consumption (θ) effectively provide additional information that allow the identification of the alcohol measure in the accident equation. This instrumental variables technique yields consistent and unbiased estimates of (27) and is formally identical to more sophisticated simultaneous equation techniques.³⁶

It is important to note that wage effects enter indirectly through alcohol consumption and worker safety effort, which are assumed endogenous, an argument can be made that wages are also endogenous to the probability of an accident. That is, wages may be positively related to injuries in the above equations since workers require positive compensating differentials to work at more hazardous jobs. A number of researchers (Butler and Worrall (1983), Krueger (1989), Viscusi and Moore (1987)) have indeed estimated simultaneous equations models to handle this issue. However, because alcohol consumption is explicitly considered endogenous, and instrumental variables techniques are used in the empirical analysis, and since all the available variables seem to belong in either the injury, alcohol or wage equations, there are no remaining variables to identify the system. In any event, while the coefficient on the wage variable may be biased upward, there is no apparent reason the benefit or alcohol measures should be affected. Indeed, Ruser (1991), in his investigation of employer effects on

OSHA data makes a similar argument.

Wilkinson (1987) develops a similar framework for investigating the impact of alcohol consumption on automobile accidents. He estimates a reduced form demand equation for alcohol consumption and uses the results from that first-stage equation in an accident equation. Although, Wilkinson's model is recursive; he allows the risk of an accident to enter the alcohol demand equation. The difference in my model is that in the technical relationship specifying the probability of an accident (15), alcohol consumption is assumed endogenous.³⁷

c. Empirical Implementation: Frequency Versus Severity Issues

In the introductory chapter, I outlined an accounting framework that decomposes workers' compensation costs into frequency and severity components. This framework will be used in the actual empirical estimation. In effect, three workers' compensation or accident equations are estimated using the same set of explanatory variables. The basic model is specified in equation (27), or to simplify:

$$(32) \ln \text{ frequency} = X\beta_1$$

$$(33) \ln \text{ severity} = X\beta_2$$

$$(34) \ln \text{ costs/employee} = X\beta_3$$

where X is a vector of exogenous determinants of workplace accidents and also includes the endogenous alcohol consumption measure. This formulation will allow for tests of the effects of the X vector not only on the total accident costs per employee but also separately on the frequency and severity of accidents. By definition, $\beta_1 + \beta_2 = \beta_3$, since real costs per employee is the product of frequency and severity, and claim frequency, severity and costs are expressed in natural logarithms.

IV. Empirical Analysis: Data and Econometric Concerns

A. Data

Data on aggregate workers' compensation costs and number of injured workers have been constructed from data collected by the National Council on Compensation Insurance (NCCI). The final data set used in the analysis contains information on 27 states for the 21 years 1964 - 1984.³⁸ The aggregate workplace accident data have been transformed to a per covered employee or per worker basis. Number of accidents and the total dollars of claims (both indemnity and medical) have been divided by the number of workers in the given state and year.³⁹ This yields the appropriate frequency and severity measures to be used in the estimating equations.

The workplace accident data (the dependent variables) are for the private insurance carrier and state fund markets only. That is, it does not contain information from firms who self-insure their workers' compensation obligation. Firms who self-insure have to meet certain size thresholds mandated by the state regulators. Since insurance prices are actuarially determined, and since workers' compensation is experience rated, larger firms will tend to self-insure and will tend to be safer. This is due to the fact that the costs are borne by the firm directly, instead of spread through the insurance mechanism. As a result, self-insureds will tend to be more aggressive in administering their accident claims resulting in lower average costs.

Because these data are limited to firms that purchase

insurance, there may be a problem using statewide information on average wages, employment and other economic and demographic variables. Therefore, a dummy variable was added to the analysis that equals one if a state allows employers to self-insure. The expected sign on the coefficient of this variable is positive, as the allowance of self-insurance implies that the private market is left insuring the relatively worse risks with higher claim frequency and severity.⁴⁰

The three important variables to be used in the analysis to capture employee and employer incentives are of course wages, workers' compensation replacement rates, and alcohol consumption. The wage data are average annual earnings from the U.S. Department of Labor⁴¹. A priori, as in the models in the literature, the wage variable measures the foregone cost of an injury, and thus its coefficient is expected to be negative. Although as discussed above, there may be a positive bias in the wage coefficient because wages may be positively related to injury rates.

Workers' compensation expected benefits (and replacement rates which are simply the expected benefits divided by the wage variable) are developed for each state and year given the various parameters that are legislatively determined. The expected benefit variable uses the benefit formulas for temporary total disability by state. The benefit is determined by the nominal replacement rate, the maximum weekly benefit, the minimum weekly benefit, and the statewide

average weekly wage. In addition, information from NCCI on the cumulative distribution of wages is used to adjust the benefit measure. An actuarial technique employed by NCCI is formally used for the calculation. The benefit measure represents the expected dollars of weekly benefits for all workers in a state. Using temporary total benefits as the basis for the expected benefit measure in the empirical analysis seems reasonable since this benefit category represents more than half of all claims and the formulas for permanent disabilities are often identical (except their duration will be of course longer).⁴² This same benefit construct has been used previously by other researchers,⁴³ and is described in some detail by Butler (1983). A priori, the model developed in the previous section hypothesizes that benefits will be positively related to workplace injuries and costs (i.e., that $1-b$ will be negative).

Data on aggregate alcohol consumption were developed using information from the U.S. Department of Health and Human Services, the National Institute on Alcohol Abuse and Alcoholism.⁴⁴ The alcohol consumption data have been constructed by summing consumption levels for beer, wine and spirits that have been adjusted to reflect total ethanol consumption.

There are a few potential shortcomings to these data for the purpose at hand. First, the alcohol consumption data are derived from total sales within the state, and do not solely reflect the consumption of the working population. That is,

there is no way to measure alcohol sales across state lines or to account for the effect of tourism, business travel, or commutation. Second, the legal drinking age varies across states, and may therefore distort interstate sales patterns. This might distort the alcohol consumption data for a particular state as people take advantage of the lower drinking age laws in neighboring states. Each of these issues is discussed below.

Since workplace accidents only affect the population of employed persons, it would be desirable to have data on alcohol consumption of the working population. However, the only available data are for total statewide (per capita) consumption. In the statistical analysis, regressing per capita consumption on workplace accidents or costs per worker implicitly assumes that there are no differences in drinking patterns between employed and unemployed persons. The two-stage model construction will allow a partial control for this by including an unemployment measure as a regressor in the first-stage alcohol demand equation, as well as interacting (predicted) alcohol consumption with unemployment in the workers' compensation frequency and cost regressions. However, to the extent that differences in consumption between employed and unemployed have remained constant over time, the potential measurement error should be mitigated and the analysis presented herein should not be affected.

A further complication arises since the legal drinking age has varied over time and across states. As mentioned

above, this might distort the alcohol consumption data for a particular state as people take advantage of the lower drinking age laws in neighboring states. A dummy variable which equals one if the drinking age is 21 is added to both the alcohol and accident specifications. Another variable was constructed that considers the legal drinking age and the proportion of the population of legal drinking age and likely to be employed. This is an attempt at controlling for the so-called experience effects whereby older workers, by virtue of their drinking and work experience, are better able to "hold their liquor" and avoid workplace accidents after consuming alcohol. The analog in the literature on automobile accidents is that younger drivers who are less experienced both as drinkers and drivers are more susceptible to alcohol-related accidents.⁴⁵

Since one purpose of the study is a more comprehensive investigation of the underlying determinants of workers' compensation and costs, there a host of exogenous determinants that are considered in the empirical analysis. Following the models in the literature and the theoretical framework developed in Chapter III, claims frequency and severity are both investigated as a (log) linear function of these variables.

Additional controls are considered in the regression analysis to capture differences across states and across time in the labor market, industrial mix, the level of economic activity, the size of the labor market, the age and

educational levels of workers, along with some workers' compensation administrative controls. These additional controls serve as proxies for the occupational and demographic factors that have been found to influence workplace accidents. Recall, the model is effectively a reduced form capturing elements of both the supply and demand for labor and the supply and demand for workplace safety. The intent is to observe the aggregate impact of changes in workers' compensation benefits, changes in economic conditions and changes in alcohol consumption patterns on the frequency and severity of workers' compensation claims, holding constant factors which will affect the demand and supply for labor. As such these additional variables are designed to capture both employee and employer incentives. The effect and rationale of these additional variables will be discussed with the empirical results; a priori, the expected signs on these additional control variables are not theoretically determined by the modelling. All monetary variables have been deflated by the Consumer Price Index and are thus in real terms.

An additional factor was considered in the empirical analysis. As mentioned earlier, in 1972 the National Commission on State Workmen's Compensation Commission released its findings and recommendations regarding the heterogeneous benefit structures across states. The Commission's report was aimed at promoting consistency and equity in the way states administer their workers'

compensation systems. As a result many states implemented changes in both the benefit structure and the administration of their workers' compensation systems. Thus a dummy variable was considered that took a value of one for the years 1972-1984 and a value of zero for 1964-1971 to control for any structural changes.

Finally, since the data are pooled time series and cross sectional, there are concerns about the structure of the error term in a regression analysis. There are concerns over the possible heteroskedasticity of the disturbance term across states, or possible autocorrelation of the disturbance term within each state. In such situations, it is common to test for so-called fixed and random effects. The most common treatment of this potential problem is to allow differential intercepts and disturbance terms across the cross-sectional units and over time. Johnston (1984) has a discussion and presents a taxonomy of time series, cross-section models. Since this potential problem is essentially one of estimation, which may affect the efficiency of the estimates (they remain unbiased and consistent), the most common strategy is to empirically test whether the heteroskedasticity or autocorrelation problems exist.

In the extant workers' compensation literature, fixed effects models are generally tested⁴⁶. In the same spirit, state and individual year controls are added to the specifications and their effects observed. Joint tests of significance for both the year and state effects are

performed. State controls serve to not only control for econometric concerns, but also to capture any effects not otherwise measured. Such effects may include features of the individual state workers' compensation systems that are not readily quantified.⁴⁷ Krueger and Burton (1990) provide a justification and discussion of the effect of state controls in their analysis of workers' compensation premium costs. Coate and Grossman (1988) provide a similar discussion in their cross-state analysis of the effect of alcoholic beverage prices on consumption by younger people. In addition, statistical tests are performed to determine if other econometric or estimation problems need to be addressed.

It should be noted however, that the use of pooled data will help to overcome another problem that has been discussed in the literature. As Ehrenberg (1988) and Krueger (1989) both point out, there are often empirical difficulties in distinguishing the workers' compensation benefit effect from the wage effect in an injury rate or duration model. These difficulties stem from the fact that in an individual state and year, benefits are a deterministic function of wages. The additional variation introduced by the sample used in this analysis mitigates this problem.

Table 1 contains the variable definitions and expected signs for the frequency and severity regressions based on the theoretical priors established earlier as well as on previous research. Table 2 contains variable definitions and expected

signs for the alcohol demand equation.

Table 3 contains means and standard deviations for variables considered in the analysis. The first thing to note is that although the costs of workplace accidents have risen dramatically, the frequency of claims per worker held fairly constant between 1964 and 1974 (.076 versus .078), and actually declined in 1984 (.065). However, the average real cost per claim in 1972 dollars increased from \$675 in 1964 to \$1037 in 1985, to \$1724 in 1984. This amounts to a 4.6 percent annual average increase in excess of the inflation rate. In per worker rather than per claim terms, the real cost per employee more than doubled, from \$52 in 1964 to \$109 in 1984.

Turning to some of the economic data, wage growth during this time was substantial; the annual average growth rate was 6 percent from 1964 to 1984. This has a large impact on workers' compensation costs since approximately 60 percent of all benefits go for replacing lost earnings and indemnity benefits are linked to pre-injury wages. Economic growth was also strong as measured by the value added of manufacturers, and interest rates and unemployment rates also tended to grow throughout this time period.

Alcohol consumption per capita increased over the 21-year period as well. In 1964, per capita ethanol consumption for the 27 states sample averaged 1.48 gallons, growing to 2.09 gallons in 1974 and 2.26 gallons by 1984. (More recent data shows a levelling off or perhaps a decline in per capita

consumption in the past few years). This growth was undoubtedly occasioned by many factors, two of which seem particularly significant. First, real alcohol prices as measured by a price index for distilled spirits, fell over this time period.⁴⁸ Part of this was due to the decline in the real excise tax on alcohol. Second, the legal drinking age for the 27 states was almost universally 21 years old in 1964. In the middle 1970s many states liberalized their laws to 18 or 20 years old, but by 1984, states were beginning to change their drinking ages back to 21. Twenty-six of the states in the sample had legal drinking ages of 21 in 1964. This dropped to 15 states in 1974, but increased to 21 in 1984.

It is interesting to note changes in some of the institutional features of the workers' compensation systems. Real expected benefits for temporary total injuries⁴⁹ increased 36 percent from \$128 to \$174 between 1964 and 1984. The proportion of states that allow firms to group together and self insure has risen dramatically from 4 percent in 1964 to 19 percent in 1974 to 67 percent in 1984. In part, this reflects political pressures by business associations who, in the face of rapidly rising workers' compensation costs, feel they can cover their workers' compensation exposure more cheaply than in the insurance market.

The waiting period, the de facto deductible for workers' compensation which is included in the models as an additional workers' compensation control, has dropped to a little less

than 5 days on average for the 27 states. The waiting period represents the lost worktime an injured worker must sustain before indemnity benefits become payable. Since there are no direct out-of-pocket outlays by injured workers, at the margin as the waiting period decreases, the attractiveness of workers' compensation benefits would be expected to increase. The waiting period was one of the issues addressed by the National Commission in 1972: it urged states to adopt uniform three day periods. The compliance with this recommendation has been less than perfect as reflected in the variable means in Table 3.

The remaining variables in Table 3 are used in the regression analyses to capture differences in the demographic composition of individual state populations which include a crude human capital proxy -- the proportion of the population age 25 and over with at least a high school education. This proportion has grown from 47 percent in 1964 to 72 percent in 1984. Controls are also used for the proportion of the population that is Mormon, Catholic, Southern Baptist, and of women who have been divorced. These later variables are used to provide additional information that allows the identification of the alcohol equation. In effect these are cultural controls that are assumed unrelated to workplace accidents, but which have been empirically demonstrated to be related to alcohol consumption. Gerstein (1981) presents a discussion of the social, demographic and cultural factors associated with alcohol consumption.

B. Econometric Estimates

To reiterate, the primary purpose of this study is to investigate the relationship between per capita alcohol consumption and workplace accidents. In addition, the analysis will more fully explore the underlying determinants of workers' compensation utilization and costs. Ideally, information on the cause of each accident would be used to investigate this issue. However, such data is unfortunately not widely available; insurers have typically not collected such information, and both employers and workers may have incentives not to reveal all available information regarding the cause of an accident. The analysis presented here is a second-best strategy; the aim is to eliminate possible sources of (statistical) distortion by controlling for a wide range of economic, demographic and state specific cultural and institutional factors which can influence both alcohol consumption and workplace accidents.

The basic regression models are thus:

$$(35) \ln \text{ cost/employee} = f(\text{predicted alcperc, lnwages, lnben, exogenous determinants of workplace accidents})$$

where predicted alcperc comes from the following:

$$(36) \ln \text{ alcperc} = f(\ln \text{ price, lnwages, lnben, exogenous}$$

determinants of workplace accidents, exogenous
determinants of alcohol
consumption)

where $alcperc$ is per capita alcohol consumption, $wages$ are annual average wages, and $lnben$ are expected WC benefits. Notice that equation (35) is the empirical version of equation (27), and to be more precise of equations (32) - (35). Also, equation (36) is the empirical version of equation (31).

To ease the exposition, regression results will first be presented for the total response or cost per employee models. In the next section, the total response will be decomposed into the frequency and severity components. Results from the first-stage or instrumental variables equation on alcohol consumption will then be discussed, and this chapter will close with a section discussing econometric concerns.

Workers' Compensation Regressions: Total Response

Table 4 contains regression results for models where the dependent variable is workers' compensation costs per employee (i.e., labelled "the total response"). Although Butler (1989) considers the same dependent variable (and also the decomposition of costs into their natural components), he does so in a much more limited manner. The intent of that analysis was to measure the secular time trend in workers'

compensation benefit costs⁵⁰. The data employed in this analysis is much richer in that there are more demographic and economic controls considered.

Results in Table 4 are for the two-stage procedure whereby alcohol consumption is first regressed against the complete set of economic and demographic controls that affect workers' compensation costs plus additional economic and cultural controls thought to influence alcohol consumption. The second step is to regress workers' compensation costs against the set of exogenous determinants of workplace accident costs and the predicted value from the alcohol consumption equation. As developed in Chapter III, the models are run in natural logarithms, thus the estimated coefficients may be interpreted directly as elasticities. Results are reported with and without a set of individual state controls and with and without a set of individual year dummy variables. It is worth reiterating that the data represent total workers' compensation costs and thus include both employee and employer incentives and responses. The focus of the modelling was to generate an estimating equation that was based on employee incentives; therefore, the empirical results need to be carefully interpreted.

Moreover, results reported in Table 4 are for model specifications that are compatible with previous research in that the actual dollars of expected benefits is entered as a regressor. Later, as a contrast, results will be reported and discussed that follow directly the model developed in Chapter

II where one minus the replacement rate (1-b) is entered as regressor. Finally, results will also be presented which include both one minus the replacement rate and the replacement rate as a test of the robustness of the results for the employee incentive effects when a control is included for employer incentives. As shall be shown, the general findings will be maintained across the various specifications.

Before analyzing specific coefficients in Table 4, there are several general comments worth noting. First, the models explain a significant portion of the variation in total workers' compensation costs. In addition, the inclusion of the state controls enhances model performance; the state controls are jointly significant indicating there are important differences in workers' compensation programs across states, and that including them as an econometric control for the problems with pooled time series data is also appropriate. (The adjusted R^2 for the state effects models is always greater than .70.) However, the inclusion of the individual year controls is only marginally significant ($F=3.410$ in model (2)), and as shall be discussed, the parameter estimates do not differ qualitatively when the year controls are excluded and other year-specific controls (i.e., interest rates and the National Commission control) are included⁵¹. The implications for the time series issues inherent with this data set will be discussed further in the section on econometric concerns.

Model (1) contains the entire set of explanatory variables but excludes the state and year effects. The predicted per capita alcohol measure has a very strong positive impact on workers' compensation costs. The total response or cost per worker coefficient is .691 and is significant at the one percent level; thus a 10 percent reduction in per capita alcohol consumption would reduce WC costs per worker by 6.9 percent. However in model (1), the signs of the estimated benefit and wage coefficients run counter to expectations based on an interpretation of employee incentives.

In order to validate the model structure and performance, it is useful to consider some of the other explanatory variables in the model. With a couple of exceptions, the estimated coefficients are consistent with prior expectations. Recall the models are derived from the notion that workers' evaluate the tradeoff between workers' compensation benefits and wages. The model predicts that the wage coefficient would have a negative sign and benefits a positive sign. Note however, as mentioned above, wages may also be considered endogenous to this model; however, as argued above, the effect should be to bias the coefficient towards zero and there is no reason to expect that this will affect the estimated parameters on the other variables.

In model (1) without state and year effects, the wage coefficient is .111, although not significantly different from zero, while the expected benefit coefficient is -.434

and significant. These coefficients are contrary to the model predictions. However, the inclusion of the state and year effects reverses the sign pattern on both wages and benefits conforming with prior expectations. In model (2), the wage elasticity is $-.408$ (but not significant) and the benefit elasticity is $.290$ (significant at $.01$).

The parameter estimates on the other controls are somewhat difficult to interpret in model (2). The asset income measure (dividends, interest and rental income), which might also be construed within the context of the choice theoretic framework, has a negative coefficient ($-.213$). Thus as income from other sources increases, workers' compensation costs per employee decline. This is somewhat counterintuitive; increased income from nonwage sources, holding wages constant, ought to allow workers the ability to afford to file and be on a workers' compensation claim. It is highly likely that the high degree of correlation between wages and nonwage income may be influencing this coefficient. It is also possible that high asset and income workers exhibit stronger labor force attachment than lower wage workers and thus return to work sooner or choose not to file marginal WC claims.

The two explicit workers' compensation controls -- the waiting period and the allowance of group self-insurance -- perform as might be expected. The parameter estimate on the waiting period measure is $-.260$, i.e. a 10 percent increase in the time an injured worker must wait before filing a claim

would reduce total WC costs per employee by 2.6 percent. Put differently, states who followed one of the essential recommendations of the National Commission and reduced their waiting period from five days to three days would experience as much as a 17.16 percent increase in WC costs. This estimate is an upper bound which assumes that the elasticity of WC costs with respect to the waiting period is constant; of course, the elasticity would actually go to zero if the waiting period were to go to zero.

The allowance of group self-insurance increases WC costs by 5.2 percent⁵². This conforms with the hypothesis that firms that opt out of the private insurance market to self-insure do so because they have better than average loss experience and it is less expensive to self-insure. The employers that remain in the market must, by definition, have worse than average loss experience and hence higher WC costs.

There are a number of additional economic and demographic controls which are considered in model (2), most of which are not significantly different from zero. The one variable that is significant is the unemployment rate; the parameter estimate is $-.219$. The conventional wisdom has been that increased unemployment would give rise to increased WC claims and increased costs under the notion that workers would use the WC system to subsidize their nonwork status (i.e., in periods of rising unemployment workers who felt they may be susceptible to lay-off may have incentives to instead file a WC claim). This thinking has not, however,

been subjected to rigorous analysis and is often based on anecdotal observations and not on a marginal analysis such as is considered here. The age distribution of the work force ($\ln_{age}$), the age distribution of the population ($\ln_{pct21}$), the economic growth variable ($\ln_{valadd}$), and the human capital control ($\ln_{hsed}$) are not significant in model (2). Note the intent of these variables is to capture elements of both the supply and demand for labor, and consequently capture both employee and employer incentives.

The remaining models in Table 4 consider the robustness of the parameter estimates by examining the effects of altering the state and year effects and by including and excluding certain of the explanatory variables. In particular, as mentioned above, given the marginal significance of the year effects, plus the findings by other researchers that these may not be significant (see Krueger and Burton 1990), models were estimated without the year effects but including other measures which are year (but not state) specific. These additional regressors are an interest rate measure (annual average 3-month Treasury bill) and a dummy variable that takes on the value of one for years subsequent to the National Commission's report (i.e., post 1972). The interest rate measure is added to capture short-term economic fluctuations that may influence decisions by employers to substitute labor for capital (or vice versa) in the production process.

The results of the full model specification but without

the year dummies are reported in models (3) and (4). These results are qualitatively similar to those in model (2) with a couple of notable differences. Once again the per capita alcohol instrument is positive and significant at the one percent level. In model (3), which includes the interest rate measure, the estimated elasticity of WC benefits with respect to alcohol consumption is .337; that is, a 10 percent increase in per capita alcohol consumption will increase workers' compensation costs per employee by 3.37 percent. In model (4), which includes the National Commission time dummy, the elasticity estimate is .303.

In models (3) and (4), the wage and benefit measures perform as expected. The estimated wage coefficient is $-.479$ in (3) and $-.495$ in (4). The magnitude of the wage coefficient is comparable to estimates reported by other researchers. The estimated benefit coefficient is .274 in (3) and .270 in (4). Recall, these represent the elasticity of total workers' compensation costs with respect to expected temporary total benefits. These estimates are slightly lower than those in the literature, but recall the benefit measure in this analysis is effectively capturing both employee and employer effects; the positive coefficient suggests that employee effects dominate. This difference will be explored further in the section which decomposes the total costs into the frequency and severity components, and in models that include explicit controls for the employer incentives.

As in model (2), the coefficients in models (3) and (4)

on waiting period and self-insurance are correctly signed and of the same order of magnitude. Similarly, the estimated asset and unemployment rate coefficient remain negative and significant. Interestingly, the human capital measure (proportion of high school graduates) now has a positive and significant coefficient. In model (3) the elasticity of WC costs with respect to high school education is .612; in model (4) the elasticity is .720. Thus, more education increases total workers' compensation costs. This finding should be interpreted with some care although even though wages are held constant, to the extent that the wage coefficient may be biased upward, the estimate on the high school education variable may be affected. Nonetheless, this is the first time that this, or a similar, variable have been used in analyzing WC costs.

The two new time related measures -- interest rates and National Commission dummy -- are both significant across a number of model specifications. The estimated coefficient on short-term interest rates implies that as interest rates increase workers' compensation costs decline, all else held constant. This finding is somewhat difficult to interpret. It would seem that the coefficient ought to be positive: As the cost of capital for a firm increases, investments in safety and new physical plant should decline. Further, firms may have incentives to substitute relatively cheaper labor for capital when capital costs are high. As such, workplace accidents and their costs should increase. However, to the

extent that the interest rate measure is influenced by other secular time changes, the parameter estimate may be affected.

Krueger and Burton (1990) argue in another context (looking at the net cost of WC to employers) that by not including time dummies, time series variations in benefits will allow identification of the benefit measure. This is in response to criticisms mentioned in the last chapter by Ehrenberg and Krueger that since benefits are a deterministic function on wages, separately identifying their effects is problematic. Given this argument and the finding by Krueger and Burton of no structural time change plus the marginal significance of the year dummies in model (2), the remaining models that are reported exclude the time dummies⁵³. However, in model (8), the first-stage alcohol instrument equation is estimated with time dummies to account for any temporal changes in alcohol consumption. Indeed, in the first-stage equation both the year and state dummies are (individually) jointly significant, and for the same reasons discussed earlier, the pooled time series nature of the data can pose econometric problems. As such, controlling for fixed effects in the alcohol equation will temper these concerns and reduce the possibility the coefficient on alcohol consumption in the WC regressions is contaminated by time trend problems.

Models (5) - (8) contain estimates dropping some of the exogenous WC determinants. Note these excluded variables are also dropped from the first-stage alcohol equation. To reiterate, the first-stage equations (with the exception of

model (8)) were estimated including the set of exogenous WC variables that are included in each specification. Additional controls were added to the alcohol equation to identify the model. The alcohol equation and additional controls will be discussed in the next section.

Excluding some of the demographic and business cycle variables that had little explanatory power in models (1) - (4) has little affect on the principle variables of interest. Indeed, the age distribution of the workforce or the population have little affect on aggregate WC costs. This contrasts with previous research⁵⁴ on micro level data where older workers have been associated with higher WC costs (or at least higher claim severities). This also suggests that concerns cited in the automobile literature about older drivers "holding their liquor" is not relevant in the current context. It is possible given the aggregate nature of the data used for this analysis that these two factors are offsetting, and that micro level data is necessary to identify these effects.

The coefficient on per capita alcohol consumption is still strongly positive and significant with coefficients ranging between .237 and .418 in models (5) - (8). The later being the estimate when the year dummies are included in the alcohol equation. The wage and benefit measures also continue to perform as expected thereby validating the model structure. The estimated wage coefficient varies between -.304 and -.525 with the later estimate in the system where

the year dummies have been included in the first-stage equation. These estimates are always significant at least at the .10 level or higher. Finally, the estimated coefficient on expected benefits is always significant and positive and ranges from .232 to .318.

The relative robustness of the alcohol, wage and benefit measures, combined with the relatively high explanatory power of the equation not only provides further evidence that workers' compensation costs are affected by the structures of the program, but also confirms that alcohol consumption is a serious problem which costs the U.S. economy a significant amount of resources. The latter issue will be addressed in the concluding chapter.

The exclusion of the insignificant demographic and business cycle variables also has little affect on the other variables. The waiting period and self-insurance measures continue to perform as expected, while the unemployment rate continues to be negative and counter to the conventional wisdom. It may well be the case that aggregate data mask the true nature of employee responses to an increase in unemployment, since after all, once unemployed, it is more difficult to apply for WC benefits. However this finding, as well as the finding on the education variable (positive coefficient) have not heretofore been established. Thus a 10 percent increase in the unemployment rate can be associated with a 1.8 percent decline in workers' compensation costs, and a 10 percent increase in the proportion of the population

over age 25 with a high school education will result in approximately a 6 percent increase in workers' compensation costs.

WC Cost Decomposition: Frequency v. Severity

Tables 5 and 6 present the results from the regression analyses performed separately on WC claim frequency and claim severity. Recall, by definition, the sums of individual variables' coefficients will equal the coefficient in the total response model. Models (1) through (8) in the frequency and severity equations are the same specifications as in the total response models (1) through (8) including the inclusion/exclusion of the exogenous controls in the first-stage alcohol equation. This decomposition will be useful in determining the relative sensitivity of the frequency and severity components with respect to the major policy variables.

There are a number of interesting observations regarding the three major policy variables in the regression models and their relative magnitudes in Table 5 versus Tables 6. In the frequency model, the predicted alcohol per capita measure is always positive and significant. The size of the elasticity depends on whether the state and year controls have been included. In models without these controls the estimated elasticity is .169; the inclusion of both sets of controls results in an elasticity of .364. Once again, the state

controls are always jointly significant, while the year controls are only marginally significant. In the full model specification which includes all the demographic and economic controls, model (5), the estimated coefficient is .198 and is significant at 1 percent. Thus, a 10 percent increase in alcohol consumption can be expected to increase the number of workplace accidents per worker by almost 2 percent.

The estimated frequency elasticity with respect to alcohol consumption is somewhat sensitive to the inclusion or exclusion of the some of the other controls. For example, in model (6) where the demographic controls are excluded, the elasticity estimate is .185. In model (8) the elasticity estimate is .128 in an equation where year controls were included in the first-stage alcohol equation.

In contrast, the alcohol elasticity estimates reported in Table 6 for the severity model vary over a wider range than those in the frequency models and are sometimes not significantly different from zero. Indeed, it would appear that, at least for the full model specifications without the year dummies but including the other time related variables, and including or excluding the demographic variables, the estimated alcohol elasticity in the severity models is lower than in the frequency models. Put differently, alcohol consumption appears to have a larger impact on the frequency of accidents. The estimated impact of alcohol consumption on the average cost of workers' compensation claims varies between .105 and .134 in models (3) through (6) and is

usually significant at the .10 level or better.

It would seem logical that the frequency response to alcohol consumption should be stronger than the severity response. Alcohol consumption increases the likelihood of an accident because of carelessness and slowed reflexes. Injury severity, while also affected, is more dependent on the nature and type of accident. It would also seem less likely that alcohol consumption would create additional incentives to increase the duration of a workers' compensation claim given that benefits are being held constant. The finding that the frequency response to alcohol consumption is stronger than the severity response is consistent across the specification with state controls and the inclusion of year specific measures (models (2) through (7)).

Turning to the variables that embody the health state expected utility model -- wages, asset income, and expected benefits -- there are some inconsistencies in the estimated coefficients. In the frequency models in Table 5, the estimated wage coefficients are negative in all equations except model (7), however the magnitude and significant of these coefficients varies considerably. On the other hand, in the severity models in Table 6, the pattern of the estimated wage coefficients is more consistent with a range between -.281 through -.431 in equations (3) through (8), where the state and year specific (but not the year dummies) controls are included. These coefficients are always significant at the .05 level or higher.

An even starker contrast is drawn when comparing the estimated expected benefits coefficients in Tables 5 and 6. In Table 5, not only are signs on expected benefits counterintuitive, but they are also occasionally significant. In the severity models however, with one exception (model (1)), the estimated benefits coefficients are always significantly positive and range between .319 and .410. These estimates are consistent with prior research. Indeed, the health state expected utility approach seems to reasonably well explain workers' compensation claim severity. This finding in and of itself is not surprising since, moral hazard concerns notwithstanding, it is perhaps plausible that workers would respond more to the financial incentives of the workers' compensation system once an injury has occurred. It is surprising however that the frequency models do not offer much verification of the previous research; this may well be due to the highly aggregate nature of the data being used in this study. Much of the prior research on the frequency response of workers' compensation used data at the industry level.

As previously mentioned, using aggregate data can be misleading since, on average across a state, benefits are a deterministic function of wages. The argument is that individual claim data is needed to obtain sufficient variability in the effective benefit replacement rate to yield meaningful results. In addition, some have argued that the existence and changes in workers' compensation benefits

may affect program utilization in one of two ways. Higher benefits might induce workers to simply file more claims for minor injuries that might otherwise go unreported. On the other hand, higher benefits might cause workers to take more risks on the job leading to more expensive accidents. (Butler 1989, Ehrenberg 1988, Kneiser and Leeth 1989). However, the data used in this study represent actual claims filed and not the true incidence of injuries, therefore disentangling the two effects is not possible.

There are a couple of additional comments regarding differences between the frequency and severity models. The estimated unemployment rate coefficients are negative in both models with the larger effect observed for the frequency model. For example in model (6) which includes state effects and year specific measures (but excludes some demographic) measures, the frequency elasticity with respect to unemployment is $-.148$ and the severity elasticity is $-.033$. Although the conventional wisdom, at least in the insurance community, has been that the unemployment effect is positive, this notion is rejected by the analysis presented here, and may be a function of the aggregate data used in the analysis.

The waiting period effects and self-insurance effects are also stronger in the severity models. Both of these would seem to make sense. In the case of the waiting period, an increase would probably tend to reduce the phenomenon where workers seek medical care to support their claim (i.e., so-called "doctor shopping"); consequently, average costs would

increase. Similarly, an increase in self-insurance implies employers feel the average costs embedded in WC premium are too high for their own loss experience. As a result, firms with better experience opt out of the market and average costs increase. The estimated waiting period coefficient is relatively robust in Table 6 and suggests that a 10 percent increase (which is small: a change from 3 to 5 days is a 67 percent increase) in the waiting period will decrease the average cost or severity of workers' compensation by about 3 percent. The severity response of the waiting period is the driving force behind the total response as the frequency response is extremely small and insignificant.

Allowing firms to group together and self insure will tend to leave relatively worse risks in the private market. This is confirmed by the regression models where the sign on the self insurance variable is consistently positive. The estimated coefficient on self-insurance is consistently about .039 in the severity model and ranges between .011 and .023 in the frequency model.

The results on the education variable, the proportion of the population over age 25 with a high school education, are considerably different between the frequency and severity models. Recall, the total effect of higher education was observed to increase costs in Table 4. This may be perhaps unexpected, but the decomposition makes the result more understandable. This education effect is solely a severity response. The frequency response is negative with the effect

ranging between $-.415$ and $-.588$ in models (3) through (8). More highly educated workers are more likely to avoid accidents and filing workers' compensation claims perhaps due to increased awareness and recognition of job risks as well as tending to work in lower risk industries and occupations. On the other hand, once injured, they are more likely to have higher claim costs perhaps due to increased awareness of workers' compensation benefits and a greater propensity to litigate claims.⁵⁵ Indeed, the estimated impact is large; the coefficient on high school education varies between $.939$ and 1.212 in models (3) through (8) and is always significant at the $.01$ level.

The National Commission dummy variable, which takes a value of one for years subsequent to 1972, is consistently positive coefficient in the frequency models. The estimated coefficient is about $.6$, although the estimated coefficient in the severity models is never different than zero and negative. The analysis indicates that the frequency of accidents per worker have been about 6.2 percent higher, all things else held constant, since the National Commission issued its recommendations. The positive frequency response overwhelms the severity response and is the driving force behind the total response discussed previously. This finding suggests that one of the significant by-products of the National Commission was to draw attention to the WC system with the result that, everything else held constant, more claims have been filed as a result.

The remaining variables do not always exhibit a pattern consistent with prior expectations. Interest rates are negative in both the frequency and severity response decline. As discussed in the total cost section this is difficult to interpret since an increase in interest rates presumably implies an increase in the cost of capital to employers and a propensity to substitute labor for capital.

The remaining economic and demographic controls vary in sign and magnitude depending on the inclusion or exclusion of the state and year controls. For example, the sign of the economic growth variable as measured by the value added measure varies across models and specifications. In addition, the demographic controls for the age distribution of the labor force or of the population are never significant in the total response models. In some of the frequency and severity models the estimated coefficients on these models are occasionally significant, but in these models the frequency and severity equations completely offset one another. It is interesting to consider the differences between the estimated coefficients in the frequency and severity models on $\ln p_{ct21}$, the percent of the population over age 21. As the working population over the age of 21 increases, the frequency of workers' compensation claims tends to decrease, while severity tends to increase. The result is that total costs decrease. This is consistent with the hypothesis that older workers are more experienced and less likely to have an accident, but once injured, are likely to take longer to heal

and return to work.

As mentioned, the state controls are jointly significant indicating they should be included in the model. The difference in results when the state controls are included may be an indicator that the models are not fully specified; other factors are influencing costs. However, the goodness of fit tests indicate the unexplained portion of costs is small.

The fact that the year effects are only marginally significant plus the findings that the results do not change qualitatively with the exclusion of the year dummies and the inclusion of the time-related measure, or when the first-stage model is run with the year dummies, provides evidence that the error structure of the model is not overly sensitive to the time component. Indeed as discussed earlier, Burton and Krueger (1990) observe the same phenomena, and further argue that the time varying aspect of workers' compensation costs will allow the identification of the benefit variable when aggregate state/year data are used.

To summarize the most salient finding across both the frequency and severity models (and thus the total response model as well), alcohol consumption has a very strong association with workplace accidents and their costs, with a slightly stronger frequency than severity effect. Across the various specifications, the total response effect is approximately .3, which is comprised of a frequency response of .18 to .19 and a severity response of .11 to .12.

Employer Incentives

Before addressing the first-stage alcohol regression estimates as well as the econometric concerns raised earlier, it is worth exploring how the models perform when an explicit measure for employer incentives is included. Recall, the data represent total workers' compensation costs and therefore represent both employee and employer incentives. Also in this section, as a contrast to the earlier results, models will be considered with one minus the replacement rate as the employee incentive measure. This contrasts with the existing research; its derivation falls out of the model developed in Chapter III. The intent of this section is to observe the robustness of the alcohol consumption results in a slightly different variant of the health state dependent utility approach.

Table 8 contains the results from supplemental regression analyses. The dependent variable is the total accident costs per worker (the "total response"). In addition to one minus the replacement rate to capture employee incentives and the replacement rate to capture employer incentives (see the Appendix), a control for the proportion of the workforce engaged in risky employment is added. The risky employment measure is intended to further capture employer incentives since WC costs will be relatively higher in these industries and employers will have incentives to contain workplace accident costs. Butler and Appel (1990)

used the same measure and found it to be positively associated with WC costs.

To facilitate the comparison, models in Table 8 have all been run with the set of year dummies in the first-stage alcohol equation, and are hence comparable to model (8) in the previous tables. Interestingly, the estimated alcohol coefficients are slightly higher than those reported in Table 4, and are always statistically significant at the one per cent level or higher. The coefficient estimates range from .391 in model (2), which excludes the risky employment control and without the year specific variables (*lntbill* and *Natcomm*), to .454 in model (4), which includes the three other variables.

The new benefit measures (*lnnewrep* and *lnrepl*) are intended to capture employee and employer incentives respectively. Although the interpretation of each should consider that aggregate WC costs is the dependent variable. The idea is to attempt to incorporate both employee and employer effects, which may not be truly distinguishable from one another, and observe the impact on the alcohol consumption measure. Because of the variable construction, it is expected that one minus the benefit replacement rate should be negative, and that the sign of the replacement rate should depend on whether employee or employer incentives dominate.

The coefficient on one minus the replacement rate is

always negative and except in model (5) statistically significant. The replacement rate coefficient is always positive and significant. Thus, as in the earlier regressions, an increase in WC benefits is confirmed to increase costs, and, the employee incentives are observed to dominate the employer incentives.

The risky employment coefficient is never statistically different from one and has no real impact on the other parameter estimates. This is contrary to the finding of Butler and Appel (1990).

Turning to some of the other variables in the regression equation, the same qualitative results as observed in Table 4 with the simple benefit variable are maintained. The wage coefficient is negative, although not significant, but the results on the waiting period, unemployment rate, self-insurance, high school education, interest rates and National Commission are essentially unchanged. However, the magnitude of the education variable is lower, and the Natcomm dummy variable is no longer significant.

Without belaboring the point and considering the frequency and severity models once again, it is apparent that the inclusion of employer incentives does not dramatically alter the principal findings that alcohol consumption is a significant contributing factor to WC costs, and that the health state utility framework is useful for investigating WC costs. If the two sets of analyses are combined, the range on the estimated impact of alcohol consumption is from roughly

.3 to .45; thus taking the midpoint as the best estimate, a 10 percent decline in alcohol consumption is estimated to decrease total WC costs per worker by 3.75 percent.

First Stage Alcohol Equation

As formulated, the relationship between alcohol consumption and workplace accidents is endogenous. To estimate this relationship an instrumental variable or two-stage least squares estimation strategy is employed. Besides the exogenous determinants of workplace accidents, additional information is required that allows the identification of the alcohol measure in the workers' compensation equations.

A number of additional economic and social controls thought to affect alcohol consumption were considered and tested. Since the alcohol equation may alternatively be considered a reduced form demand equation, a price variable is included in the model. Also considered were controls for the religious affiliation of the population that are available by state and year, as well as controls for the import and export affect that may distort the alcohol sales data. A control was also included for the proportion of women in the population who have been divorced. These social and cultural controls are assumed unrelated to workplace accidents and are used to provide more information on the determinants of alcohol consumption and therefore identify alcohol consumption in the WC equations.

The only model that varied slightly from this framework was model (8). Because of multicollinearity problems, models

could not be estimated with both year dummies and the year specific controls (interest rates and the National Commission variable). In models (1) through (7) either the year dummies or the time specific variables were included in both the alcohol and workers' compensation equations. In model (8), since there is little reason to believe the National Commission had any affect on alcohol consumption, but that year effects are still important, the alcohol equation was run with the year dummies and without the interest rate and National Commission variables. The workers' compensation equations were run without the year dummies but with interest rates and the National Commission dummy variable. As discussed above, this model did not differ dramatically from models (2) through (7), although both the alcohol and wage effect were slightly larger in absolute value than in the other models. This later effect was driven primarily by the severity response equations.

Supplemental regressions were run which regressed alcohol consumption against only the set of year dummies, and WC regressions were considered with and without alcohol consumption and the year dummies. Although not reported, the results suggest that there is a time trend component to both alcohol consumption and to WC costs only when alcohol consumption is not considered in the model. However, controlling for the year effects in the alcohol model, and using that as the first-stage instrumenting equation results in the year effects being only marginally significant in the

WC equations. Given the argument that it is the time varying component of wages and WC benefits which will allow the separation of the two effects, and controlling for the year effects in alcohol consumption, model (8) offers a model specification that should mitigate any residual year effects.

Results for selected alcohol demand models (the number of the model corresponds to the same models in the WC equations) are included in Table 7. Although the parameters in and of themselves can not be readily interpreted since the exogenous determinants of workplace accidents are also included, the coefficients are reported to highlight some of the parameters and their sensitivity to the inclusion of the state and year effects.

The model performs as might be expected with a strongly negative price elasticity and strong positive wage and asset elasticities. The price elasticity is extremely sensitive to the inclusion of the year effects of although the value of -1.1 is in the mid range of estimates reported by other researchers. For example, Coate and Grossman (1988) report estimates that range from -.2 to -.5, but and Cook (in Moore and Gerstein 1981) report an estimate of -1.6.

Although not shown, the income elasticity and asset elasticity are .85 and .82 in model (5) respectively. These estimates are higher than those suggested by Cook in his review of the literature, but suggest that as real wages have increased the pattern of alcohol consumption follows that of a normal good. Cultural controls do not perform as might be

expected and are often insignificant. Similarly, a legal drinking age of 21 is found to increase per capita alcohol consumption in contrast to work by Coate and Grossman (1988), Phelps (1989), Safer and Grossman (1987) and Wilkinson (1987). Finally, notice that the explanatory power of these instrumental equations are quite high especially in model with the state and year effects ($R^2=.871$ and $.907$), which provides some comfort in using the first-stage results in the WC regressions.

Econometric Concerns

As previously mentioned, the estimation strategy derived from the assumption that alcohol consumption and safety effort are endogenous with respect to the probability of an accident. This follows in spirit some of the models from the literature on drinking and automobile accidents (Coate and Grossman 1988 and Wilkinson 1987). As is the case in the automobile accident literature, statistical tests indicate this structure is appropriate in the context of workplace accidents.

The endogeneity of alcohol consumption to the probability of a workplace accident was tested using the Wu-Hausman endogeneity test. The test involves including both the actual per capita alcohol consumption and the predicated value from the first-stage instrument equation. The null hypothesis of no simultaneity is tested based on the significance of the predicted alcohol variable. In model (5)

of the total response equation, the null hypothesis is rejected with an $F=22.32$. In model (5) of the frequency equation, the null hypothesis is similarly rejected ($F=16.61$). The same finding is maintained in the severity equation ($F=6.68$). All three results are significant at .05 or higher. Similar results are maintained for the other specifications in Tables 4 through 6. This statistical test provides empirical confirmation of the model hypothesis that the unobserved determinants of workplace accidents and alcohol consumptions are correlated.

As another check of the model structure, the first-stage alcohol equations were run with lagged values of the workers' compensation costs per employee. This was to test whether the model might be recursive in nature, that is whether alcohol consumption might not be affected by a prior workplace accident. The lagged value of WC was tested under the premise that injured workers may also suffer psychological effects from their injuries and turn to alcohol as a means of coping with the depression. The workers' compensation cost measure was not significant in the alcohol equation providing additional confidence in the model specification, and therefore the instrumental variables approach is reasonable.

One aspect of the econometric specification that may influence the efficiency of the parameter estimates is the possibility that the errors in the frequency and severity models are correlated. If they are correlated, it is possible through seemingly unrelated regression or maximum likelihood

techniques to exploit this correlation and obtain more efficient parameter estimates. However, the parameter estimates from a two-stage least squares or instrumental variables technique will remain unbiased and consistent. Tests of the correlation between the errors of the residuals from models (5) and (8) of the frequency and severity regressions show the residuals to be uncorrelated. In model (5) the correlation coefficient is .02 and not significantly different from zero ($p < .56$), and in model (8) the correlation coefficient is $-.01$ and also not significantly different from zero ($p < .73$). Consequently, more sophisticated estimation techniques are not indicated.

An additional diagnostic test was performed to evaluate whether the model and data were sensitive to the fact that the sample consists of states that vary greatly in size.⁵⁶ The results of a Breusch-Pagan test for heteroskedasticity and random coefficient variation indicate that neither alcohol consumption nor the three workplace accident equations are affected by any systematic relationship between the residuals of the regression models and the size of the state. Formally, the squared residuals from the first-stage alcohol equation and the three workers' compensation equations were individually regressed against employment levels in the given state and year. The sample size times the R^2 in these regressions provides a test of any relationship (the test statistic is distributed chi-square with one degree of freedom)⁵⁷; the null hypothesis of no heteroskedasticity

is maintained in all four cases. Thus, the parameter estimates and hypothesis testing are not affected by the inclusion of different size states in the data.

V. Conclusions

As outlined in the introductory chapter, workers' compensation costs have risen dramatically over the past two decades. There is a growing sense that alcohol consumption is often a contributing factor and the popular media has been quick to point some of the more sensational incidents. Pilots dismissed for drunken flying; train derailments attributed to drug and alcohol abuse; trucking accidents due to drinking: these are only a few of the dramatic headlines which have attracted media attention in recent years. Yet, however dramatic these items are, they are but a small indication of the pernicious problems associated with alcohol consumption and workplace accidents. Far more common are the incidents that occur daily, which are never reported in the popular press. As an example, a worker who recently lost part of his hand in a wood chipper was found to have a blood alcohol level of .39 percent, nearly four times the usual standard for drunken driving. This is more typical of the impact of alcohol abuse in the workplace⁵⁸.

The estimated costs of drinking on the job vary widely. In terms of workers' compensation costs alone, the literature cited in the review of Chapter II indicates a range of estimates from as little as \$25 million to as much as \$7.5 billion per year. And this reflects just the direct costs of medical care and wage-loss benefits; it fails to include the potentially far greater losses associated with absenteeism,

reduced productivity, and defective or shoddy workmanship. Thus, while there is general agreement that alcohol and substance abuse impose significant costs on the U.S. economy, there has been little systematic study of the magnitude of this problem.

The issue of alcohol related or induced accidents is beginning to generate more than passing interest. As mentioned in the introductory chapter, workplace accidents cost the U.S. economy over \$45 billion in worker's compensation benefits to over 8 million injured workers in 1989. As a consequence, regulators, employers, insurers, labor and other interested parties are now engaged in many cost containment efforts. One of the issues that is being addressed either statutorily or through the judicial system is the compensability of claims when the injured worker is intoxicated. Policymakers are interested in the potential cost savings from either limiting or eliminating benefits in cases where alcohol is the proximate cause of a workplace accident.

This study estimates the impact of alcohol consumption on workers' compensation costs, with the total impact broken down into separate effects on injury frequency and injury severity. A data set containing information on economic, demographic and state specific workers' compensation characteristics has been compiled for 27 states for the period 1964 to 1984. These data have been combined with both alcohol consumption data and information on the number and

average cost of workers' compensation claims. Thus, the analysis is able to simultaneously control for a number of important factors that have been found to affect workplace accident costs.

The results of the study indicate that per capita alcohol consumption and average workers' compensation costs are highly correlated and vary significantly across states. A quick perusal of the data confirms the seriousness of the problem. For example, the five highest alcohol consumption states have more than double the per capita consumption levels of the five lowest states, and also have 33 percent higher average workers' compensation costs⁵⁹.

Although the nature of the data used in this study do not allow an examination of the direct cause of workplace accidents, the analysis suggests that, as a conservative estimate (using the lower bound of the .3 to .45 range of estimated regression coefficients), a 10 percent reduction in alcohol consumption would have reduced workers' compensation costs by approximately \$1.35 billion dollars in 1989 - \$833 million due to a reduced frequency of claims and \$531 million due to a reduction in claim severity. Put differently, a 10 percent reduction in alcohol consumption would have reduced total workers' compensation costs by 3 percent - 1.9 percent due to a reduction in frequency and 1.1 percent due to a reduction in severity.

This analysis further suggests that any accounting of the costs to society of alcohol consumption ought to include

the finding that if alcohol consumption were eliminated entirely, workers' compensation costs would decline by something on the order of magnitude of \$13 billion per year. This is not an insignificant amount and certainly understates the true impact of alcohol consumption on workplace accidents since there is no accounting for the psychological burdens on the families of injured workers nor of the additional costs of retraining and rehabilitation that are absorbed by employers.

The public policy implications of these results are significant. There have been a number of major legislative reforms enacted recently that attempt to address some of the burgeoning cost problems in workers' compensation insurance.⁶⁰ One avenue some of the reforms have taken pertains to the role of worker intoxication. Several states have statutorily restricted or eliminated benefits in cases where accidents have been drug or alcohol related. Provisions have also been considered for premium credits if employers can provide certification - through testing and education programs - of a drug and alcohol free workplace. Other states have let the courts decide the compensability of claims in alcohol related accidents.⁶¹

The results reported here are encouraging for a number of reasons. First, a multivariate investigation of the effects of alcohol consumption on workers' compensation claims has never been attempted and the results confirm a statistically positive association across a number of

alternative model specifications. Second, a full exploration of the frequency and severity responses has been more fully developed using insurance data on the utilization of workers' compensation.

Interestingly, the decomposition of workers' compensation costs into the frequency and severity components illustrated that workers respond to financial incentives especially with respect the duration or severity of a workplace accident. The health state utility framework that was developed in Chapters II and III hypothesizes that workers evaluate the tradeoff between wages and benefits when injured. This evaluation is more readily evident for the severity of a workplace accident, or the notion that once injured, workers have some discretion over when they return to work. Indeed, the benefit utilization phenomenon is validated with a aggregate cross-state and time series data source that differs from those used by other researchers.

In addition, the findings on some of the other variables have not previously been established. For example, the notion that an increase in unemployment would create incentives for workers to utilize workers' compensation benefits to subsidize their nonwork status was not confirmed. Rather, the marginal impact of an increase in unemployment on total workers' compensation costs per worker, and the decomposition into frequency and severity, is negative. Although this issue might be best addressed using individual worker data combined with information on occupational or industry unemployment

rates.

Similarly, the finding that as the education level of the population increases, total workers' compensation costs also increase has not been previously established. Even more interesting is the finding that this is a severity phenomenon suggesting that in a state with more educated workers, even though the incidence of WC claims is lower, all else the same, the more educated workers are more likely to utilize and extend their workers' compensation benefits once an injury has occurred. This finding is established in models which control for wages and the fact that more highly educated workers are likely to work in less risky, higher paying occupations.

It must be stressed that the models investigate the impact of a change in alcohol consumption on a change in workers' compensation costs. From a policy perspective, the models can be used to predict workers' compensation costs, given a particular state's data, with and without particular levels of alcohol consumption. The difference would be the (maximum) savings that could be attributed to denying all alcohol-related claims. However, using the models in this fashion would generate an upper bound of the cost savings under the assumption that the relationship (elasticity) between alcohol consumption and workplace accidents is constant across all levels of alcohol consumption. It can be expected that if legislative or judicial changes are made to deny benefits in cases of alcohol consumption that the

response might diminish over time.

Of course, the ideal research vehicle for examining the issue of alcohol consumption and workplace accidents would be an extensive database of individual claim data that includes the direct cause of injury, from a variety of states and under a variety of economic scenarios. These data unfortunately do not exist. The present analysis is offered as a second best strategy for evaluating this important public policy issue. However, as Gerstein (1981) has written, the distribution of alcohol consumption is asymmetric: a small proportion of drinkers are responsible for most of the alcohol consumed (e.g., Gerstein estimates that 10 percent of drinkers may consume more than 50 percent of the total). As a consequence, policies which could potentially target heavier drinkers (i.e., such as the alcohol and drug free workplace legislation recently adopted in Florida, or through increased incentives for employees to use Employee Assistance Programs (EAP)), may even have a larger impact than the analysis presented here indicates. Future research into these distributional issues may prove useful to refine the present analysis.

Table 1
Variable Definitions For
Workers' Compensation Claim Rate Analysis

<u>Variable</u>	<u>Definition</u>
Lntotcst	Accident Costs per Employee, in logs
Lnaccwrk	Accidents per Employee, in logs
Lnavgcost	Average Cost per Claim, in logs
Alcper	Per Capita Alcohol consumption, in logs
Lnwages	Annual Average Wages per employee, in logs
Lnben	Weekly Average Expected Benefits, in logs
Lnrepl	Weekly Benefit Replacement Rate, in logs
Lnnewrep	1 minus the benefit replacement rate, in logs

Table 1 Continued

<u>Variable</u>	<u>Definition</u>
Lntbill	Annual Average 3 month Treasury Bill rate, in logs
Lnage	Proportion of the workforce aged 18-44, in logs
Lnvaladd	Value Added by Manufacturers, in logs
Lnunemp	Annual Average Unemployment Rate, in logs
Lnwait	Waiting Period, in logs
Self	Dummy Variable = 1 if group self-insurance allowed
Lnhsed	Proportion of population ages 25 and over with at least high school education, in logs
Lnrisky	Proportion of labor force in mining, construction, and manufacturing, in logs

Table 1 Continued

<u>Variable</u>	<u>Definition</u>
Lnasset	Annual Average Asset Earnings, in logs
Lnpc21	Proportion of Population ages 21 and over, in logs
Natcomm	Dummy variable = 1 for years 1972-1984

Table 2
Variable Definitions For
Per Capita Alcohol Consumption Analysis

<u>Variable</u>	<u>Definition</u>
Lnfwlipr	Laspeyres Alcohol Price Index, in logs
Lnmormon	Proportion of Population who are Mormons, in logs
Lnsobapt	Proportion of Population who are Southern Baptists, in logs
Lncatholic	Proportion of Population who are Catholic, in logs
Lndivor	Proportion of Women ages 25-34 who are divorced, in logs
Lnacltx	State Alcohol Taxes, in logs
Expfw	Export Variable Based on Fixed Weight Price Index

Table 2
Variable Definitions For
Per Capita Alcohol Consumption Analysis

<u>Variable</u>	<u>Definition</u>
Impfw	Import Variable Based on Fixed Weight Price Index
Control	Dummy Variable = 1 is the state controls alcohol sales
Dage	Dummy Variable = 1 if the legal drinking age is 21

Table 3
Descriptive Statistics
Means (Std. Dev) of Variables Used in Analysis

<u>Variable</u>	<u>1964</u>	<u>1974</u>	<u>1984</u>
Accwrk	.076 (.019)	.078 (.016)	.065 (.013)
Avgcost	674.73 (196.44)	1037.05 (319.40)	1724.19 (605.5)
Totcst	51.61 (21.41)	79.60 (27.40)	109.02 (40.47)
Alcperc	1.48 (.76)	2.09 (.75)	2.26 (.70)
Wages	5246.16 (509.35)	9026.90 (1161.04)	18,002 (2228)
Ben	127.55 (18.90)	149.46 (30.56)	173.67 (26.09)
Asset	1082.97 (317.83)	1540.62 (387.58)	2253.45 (489.8)

Table 3 Continued

<u>Variable</u>	<u>1964</u>	<u>1974</u>	<u>1984</u>
Unemp	4.46 (1.00)	5.09 (1.48)	6.80 (.70)
Hsed	47.07 (7.06)	60.06 (7.52)	72.34 (6.12)
Mormon	1.20 (4.95)	1.37 (5.05)	1.39 (4.71)
Sobapt	8.43 (9.49)	9.58 (10.50)	9.02 (9.75)
Catholic	17.92 (14.72)	18.66 (14.76)	17.84 (14.33)
Divor	3.00 (.72)	6.21 (1.11)	9.71 (1.22)
Self	.04 (.19)	.19 (.40)	.67 (.48)
Wait	NA	5.24 (1.95)	4.97 (1.98)

Table 3 Continued

<u>Variable</u>	<u>1964</u>	<u>1974</u>	<u>1984</u>
Fwlipr	.98 (.09)	.68 (.07)	.44 (.05)
Dage	.96 (.19)	.56 (.51)	.78 (.42)
Tbill	3.55 (0.00)	7.87 (0.00)	9.57 (0.00)
Alctax	3.22 (2.50)	4.26 (2.80)	6.10 (5.20)
Control	.26 (.45)	.26 (.45)	.26 (.45)

Table 4

Workers' Compensation Regression Analysis:
Coefficients with Standard Errors in Parentheses
Total Response (N=551)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Intercep	.208	8.948	6.284	6.729	6.736	6.732	4.453	8.010
	(1.088)	(2.158)	(1.617)	(1.503)	(1.505)	(1.505)	(1.472)	(1.325)
Alchat	.691*	.245	.337*	.303*	.303*	.304*	.237*	.418*
	(.081)	(.178)	(.087)	(.088)	(.089)	(.088)	(.088)	(.065)
Lnwages	.111	-.408	-.479**	-.495*	-.494**	-.510*	-.304***	-.525*
	(.176)	(.346)	(.203)	(.195)	(.203)	(.194)	(.183)	(.189)
Lnben	-.434*	.290*	.274*	.270*	.270*	.261*	.318*	.232*
	(.102)	(.077)	(.074)	(.074)	(.074)	(.073)	(.069)	(.070)
Lnage	-.047	.128	.105	.137	.137	--	--	--
	(.238)	(.170)	(.158)	(.158)	(.159)			

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Lnasset	-.545 [*]	-.213	-.322 [*]	-.303 [*]	-.303 [*]	-.310 [*]	-.244 [*]	-.387 [*]
	(.084)	(.189)	(.083)	(.082)	(.084)	(.081)	(.082)	(.070)
Lnwait	-.296 [*]	-.260 [*]	-.305 [*]	-.294 [*]	-.294 [*]	-.300 [*]	-.305 [*]	-.292 [*]
	(.047)	(.044)	(.043)	(.043)	(.043)	(.042)	(.041)	(.041)
Lnvaladd	.133 [*]	-.062	.006	.000	-.000	.010	--	.024
	(.017)	(.073)	(.053)	(.039)	(.054)	(.038)		(.037)
Lnunemp	.175 [*]	-.219 [*]	-.184 [*]	-.185 [*]	-.185 [*]	-.181 [*]	-.143 [*]	-.188 [*]
	(.049)	(.046)	(.035)	(.034)	(.035)	(.034)	(.031)	(.033)
Self	.011	.051 ^{**}	.052 ^{**}	.059 [*]	.059 ^{**}	.058 ^{**}	.050 ^{**}	.058 ^{**}
	(.041)	(.026)	(.025)	(.025)	(.026)	(.026)	(.024)	(.025)
Lnhsed	1.077 [*]	-.159	.720 [*]	.612 [*]	.612 ^{**}	.602 ^{**}	.689 [*]	.417 ^{***}
	(.104)	(.367)	(.250)	(.252)	(.254)	(.252)	(.189)	(.228)
lnpct21	-4.967 [*]	-.009	-.026	--	.007	--	--	--

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
	(.585)	(.686)	(.606)		(.604)			
Intbill	--	--	-.093 [*]	-.079 ^{**}	-.079 ^{**}	-.076 ^{**}	--	-.093 [*]
			(.034)	(.035)	(.035)	(.035)		(.033)
Natcomm	--	--	--	.051 ^{***}	.052 ^{***}	.049 ^{***}	--	.039
				(.029)	(.030)	(.029)		(.028)
State Effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	No	Yes	No	No	No	No	No	No
Adj R ²	.460	.879	.868	.868	.868	.869	.866	.876

1. First-stage instrument equation run with year dummies.

* significant at .01; ** significant at .05; *** significant at .10

Table 5
Workers' Compensation Regression Analysis:
Coefficients with Standard Errors in Parentheses
Frequency Response (N=551)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Intercep	-2.778	2.911	-.133	1.776	.498	1.955	.295	1.317
	(.666)	(1.545)	(1.159)	(1.082)	(1.154)	(1.079)	(1.059)	(.978)
Alchat	.169 [*]	.364 [*]	.224 [*]	.169 [*]	.198 [*]	.185 [*]	.162 [*]	.128 [*]
	(.050)	(.127)	(.062)	(.063)	(.063)	(.063)	(.063)	(.048)
Lnwages	-.362 [*]	-.501 ^{**}	-.199	-.098	-.218	-.101	.040	-.094
	(.108)	(.247)	(.146)	(.140)	(.145)	(.139)	(.131)	(.139)
Lnben	-.336 [*]	-.120 ^{**}	-.083	-.096 ^{***}	-.091 ^{***}	-.101 ^{***}	-.064	-.086 ^{***}
	(.063)	(.056)	(.053)	(.053)	(.053)	(.052)	(.050)	(.051)
Lnage	-.016	.153	.003	.003	.036	--	--	--
	(.145)	(.122)	(.114)	(.114)	(.113)			

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Lnasset	-.085 ^{***}	-.336 ^{**}	-.138 ^{**}	-.094	-.125 ^{**}	-.104 ^{***}	-.071	-.066
	(.052)	(.134)	(.031)	(.059)	(.060)	(.058)	(.059)	(.052)
Lnwait	-.065 [*]	.010	-.010	.010	.004	.011	.005	.007
	(.029)	(.031)	(.031)	(.030)	(.031)	(.031)	(.030)	(.030)
Lnvaladd	.094 [*]	.096	.079 ^{**}	-.004	.074 ^{**}	-.002	--	-.009
	(.010)	(.053)	(.039)	(.029)	(.038)	(.027)		(.027)
Lnunemp	-.054 ^{***}	-.124 [*]	-.139 [*]	-.147 [*]	-.141 [*]	-.148 [*]	-.124 [*]	-.145 [*]
	(.030)	(.033)	(.025)	(.024)	(.025)	(.025)	(.023)	(.024)
Self	-.040	.036 ^{***}	.014	.019	.023	.019	.011	.019
	(.025)	(.019)	(.018)	(.025)	(.018)	(.018)	(.017)	(.019)
Lnhsed	.328 [*]	-.177	-.415 [*]	-.588 [*]	-.556 [*]	-.614 [*]	-.523 [*]	-.522 [*]
	(.063)	(.262)	(.179)	(.182)	(.181)	(.181)	(.136)	(.169)
lnpct21	-2.982 [*]	-.087	-1.323 [*]	--	-1.298 [*]	--	--	--

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
	(.358)	(.491)	(.434)		(.431)			
Intbill	--	--	-.059 ^{**}	-.037	-.045 ^{***}	-.039	--	-.031
			(.024)	(.025)	(.025)	(.025)		(.024)
Natcomm	--	--	--	.059 [*]	.057 [*]	.057 [*]	--	.063 [*]
				(.021)	(.021)	(.021)		(.021)
State Effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	No	Yes	No	No	No	No	No	No
Adj R ²	.261	.774	.751	.752	.756	.753	.746	.752

* significant at .01; ** significant at .05; *** significant at .10

1. First-stage instrument equation run with year dummies.

Table 6
Workers' Compensation Regression Analysis:
Coefficients with Standard Errors in Parentheses
Severity Response (N=551)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Intercep	2.986	6.037	6.416	4.953	6.238	4.777	4.158	6.692
	(.859)	(1.454)	(1.101)	(1.039)	(1.107)	(1.041)	(1.007)	(.909)
Alchat	.522 [*]	-.118	.113 ^{***}	.134 ^{**}	.105 ^{***}	.118 ^{**}	.075	.290 [*]
	(.064)	(.120)	(.059)	(.061)	(.061)	(.061)	(.060)	(.045)
Lnwages	.474 [*]	.093	-.281 ^{**}	-.396 [*]	-.276 ^{**}	-.410 [*]	-.345 [*]	-.431 [*]
	(.139)	(.233)	(.139)	(.134)	(.139)	(.134)	(.125)	(.130)
Lnben	-.098 [*]	.410 [*]	.357 [*]	.366 [*]	.361 [*]	.361 [*]	.382 [*]	.319 [*]
	(.081)	(.052)	(.051)	(.051)	(.051)	(.051)	(.047)	(.048)
Lnage	-.031	-.024	.103	.134	.101	--	--	--
	(.187)	(.115)	(.108)	(.109)	(.109)			

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
Lnasset	-.460*	.123	-.184*	-.210*	-.178*	-.206*	-.173*	-.321*
	(.066)	(.127)	(.056)	(.056)	(.057)	(.056)	(.056)	(.048)
Lnwait	-.230*	-.271*	-.296*	-.304*	-.298*	-.311*	-.309*	-.299*
	(.037)	(.029)	(.029)	(.029)	(.029)	(.029)	(.028)	(.028)
Lnvaladd	.039*	-.158*	-.072**	.004	-.074**	.011	--	.032
	(.014)	(.049)	(.036)	(.028)	(.037)	(.026)		(.025)
Lnunemp	.229	-.095*	-.045***	-.037	-.044***	-.033	-.019	-.044**
	(.039)	(.031)	(.023)	(.023)	(.024)	(.024)	(.021)	(.023)
Self	.051	.016	.037**	.040*	.036**	.039**	.039*	.038**
	(.032)	(.017)	(.018)	(.018)	(.018)	(.018)	(.017)	(.017)
Lnhsed	.749*	.017	1.135*	1.200*	1.168*	1.216*	1.212*	.939*
	(.082)	(.247)	(.170)	(.175)	(.173)	(.174)	(.129)	(.157)
lnpct21	-1.985*	.078	1.297*	--	1.305*	--	--	--

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) ¹
	(.461)	(.463)	(.413)		(.414)			
Intbill	--	--	-.034	-.042 ^{***}	-.034	-.037	--	-.062 [*]
			(.023)	(.024)	(.024)	(.024)		(.022)
Natcomm	--	--	--	-.008	-.005	-.009	--	-.024
				(.021)	(.020)	(.020)		(.019)
State Effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	No	Yes	No	No	No	No	No	No
Adj R ²	.638	.941	.934	.933	.934	.932	.932	.937

* significant at .01;** significant at .05;*** significant at .10

1. First-stage instrument equation run with year dummies.

Table 7
First-Stage Alcohol Regression Analysis
Coefficients with Standard Errors in Parentheses:
Additional Regressors²

Variable	(1)	(5)	(8)
Intercept	-4.511	-7.575	-6.632
Lnfwlpr	-.752	-1.094	-.026
	(.094)	(.131)	(.151)
Lnmormon	.055	.020	-.057
	(.012)	(.035)	(.032)
Lnsobapt	.002	.101	.070
	(.008)	(.030)	(.030)
Lncatholic	.080	.579	.603
	(.014)	(.098)	(.083)
Lndivor	.344	.229	-.151
	(.044)	(.060)	(.086)
Expfwliq	-.726	-.133	-.443
	(.057)	(.203)	(.176)
Impfwliq	2.278	1.215	.056
	(.246)	(.300)	(.298)

Dage	.012	.059	.060
	(.020)	(.021)	(.018)
State Effects	No	Yes	Yes
Year Effects	No	No	Yes
Time Specific	No	Yes	No
Adj R ²	.744	.871	.907

2. All models are also run with the exogenous variables from the workers' compensation equations. Time specific variables are the interest rate and National Commission dummy.

Table 8

Workers' Compensation Regression Analysis:

Models with New Benefit Variable and Employer Incentives

Total Response³

Variable	(1)	(2)	(3)	(4)	(5)
Intercep	7.701	6.037	7.778	7.573	6.480
	(1.469)	(1.421)	(1.953)	(1.947)	(1.951)
Alchat	.445 [*]	.391 [*]	.426 [*]	.454 [*]	.402 [*]
	(.067)	(.063)	(.063)	(.064)	(.061)
Lnwages	-.248	.501	-.321	-.278	.016 ^{**}
	(.215)	(.204)	(.220)	(.220)	(.209)
Lnnewrep	-.131 ^{**}	-.066 ^{**}	--	-.135 ^{**}	-.075
	(.059)	(.057)		(.059)	(.059)
Lnrepl	.187 [*]	.274 [*]	.221 [*]	.168 ^{**}	.249 [*]
	(.074)	(.072)	(.072)	(.076)	(.074)

Variable	(1)	(2)	(3)	(4)	(5)
Lnriskey	--	--	-.039	-.037	.022
			(.159)	(.158)	(.159)
Lnage	.069	.014	.105	.042	-.000
	(.156)	(.157)	(.155)	(.157)	(.158)
Lnasset	-.417 [*]	-.352 [*]	-.384 [*]	-.420 [*]	-.363 [*]
	(.073)	(.071)	(.070)	(.071)	(.070)
Lnwait	-.298 [*]	-.296 [*]	-.305 [*]	-.313 [*]	-.310 [*]
	(.042)	(.042)	(.047)	(.047)	(.047)
Lnvaladd	.020	-.012	.036	.033	-.009
	(.051)	(.051)	(.059)	(.059)	(.059)
Lnunemp	-.206 [*]	-.155 [*]	-.195 [*]	-.209 [*]	-.154 [*]
	(.034)	(.032)	(.037)	(.038)	(.035)
Self	.046 ^{**}	.039	.061 [*]	.048 ^{***}	.042 ^{**}

Variable	(1)	(2)	(3)	(4)	(5)
	(.025)	(.026)	(.025)	(.026)	(.027)
Lnhsed	.475**	.459**	.385	.425	.446**
	(.230)	(.221)	(.279)	(.278)	(.264)
lnpct21	-.172	.023	-.142	-.203	.032
	(.584)	(.590)	(.612)	(.610)	(.615)
Intbill	-.116*	--	-.095*	-.114*	--
	(.034)		(.033)	(.034)	
Natcomm	.042	--	.038	.040	--
	(.028)		(.029)	(.029)	
State Effects	Yes	Yes	Yes	Yes	Yes
Year Effects	No	No	No	No	No

Variable	(1)	(2)	(3)	(4)	(5)
Adj R ²	.876	.873	.877	.878	.875
N	551	551	535	535	535

3. Year effects have been controlled for in first-stage alcohol consumption regressions.

End Notes

1. Current workers' compensation costs are derived from 1990 Best's Aggregates and Averages, A.M. Best Company, Oldwick, N.J. Information on other social insurance programs is from the U.S. Department of Health and Human Services, Social Security Administration, Social Security Bulletin: Annual Statistical Supplement, 1989, Washington D.C., December 1989, Table 8.B (page 310).
2. *Ibid.* Costs as a percent of payroll have increased from 1.11 percent in 1970 to 2.15 percent in 1988.
3. The proceedings from a "Workers' Compensation Congress" attended by representatives from organized labor, industry, regulators, legislators and insurers which catalogs the problems facing workers' compensation in the 1990s are published in *NCCI Digest*, Volume IV, Issue IV, December 1989.
4. California AB 2910, Florida CS/HB 3809, Oregon AB 1197 and 1198, Maine H.P. 1397 - L.D. 1981, and Texas SB 1.
5. For a discussion of the historical development of workers' compensation insurance see Berkowitz and Berkowitz (1985).
6. See Chapter 2 in Ehrenberg and Smith (1985), and Worrall and Appel (1988).
7. *The Report of the National Commission on State Workmens' Compensation Laws*, July 1971, p.61.
8. Ehrenberg and Smith *op. cit.*, p.237.
9. See Burton (1988) for a compilation of the compliance record.
10. See *Social Security Bulletin Annual Statistical Supplement, 1989, op. cit.*
11. For an encyclopedic review that develops "consensus" elasticities see, Gardner (1989).
12. Florida, Colorado, Louisiana, and New Hampshire have all recently passed new laws impacting worker behavior. The Florida law has been overturned on constitutional issues and is under appeal.
13. See Ingram, Bradford B. (forthcoming 1992) for a catalog of recent cases and judicial rulings on the compensability of alcohol-related claims.
14. See Gardner (1989) *op. cit.*

15. There are two recent studies that use a portion of the same data. They are, Butler and Worrall (1991) and Butler, Appel, and Worrall (1992).
16. This is not to say that the structure of the system is the same in every state. For example, in most states insurance coverage is provided by the private market. In other states, the state provides the coverage through a monopolistic fund, and in other states a state fund competes with the private market.
17. For a full discussion of the workers compensation system and the various features of the price setting process see Appel and Borba 1989.
18. See Podolsky and Richards (1985).
19. 1990 Annual Statistical Bulletin, National Council On Compensation Insurance. The omitted cost categories include the costs for accidents without lost worktime ("medical only" claims) as well as hybrid claim categories such as temporary partial of permanent total.
20. As mentioned in the literature review, some of the research on WC claim duration, especially the distributional work by Butler and Worrall, makes use of search models for the theoretical foundation.
21. There are, however, suggestions that both informational asymmetries and cognitive dissonance may affect this decision (Dickens 1985).
22. For example, if employment levels across industries are primarily demand determined, then individual choices about which job to take will tend not to affect overall injury rates provided compensating wage differentials develop.
23. I am indebted to Michael Grossman for pointing out this characterization of the model.
24. $w(p)$ really represents total earnings and is a simplification employed by Viscusi. Otherwise the income constraint would be $\Gamma[x - A - Hw(p)]$.
25. Viscusi (1979), *op. cit.* p.12
26. Except for a couple of states (Michigan, Iowa) workers compensation benefits are based on pre-tax wages and are not themselves taxed.
27. Note that expenditures in safety in any given period are made before the state of the world is known. Thus, if a worker is not injured in the first period, in the second period the worker once again faces the tradeoff (in terms of utility)

between wages and expenditures in safety. This is a common feature of health-state utility models. For an exposition see Ehrlich and Becker (1972).

28. Kahn (1987) presents an alternative but conceptually similar model in a different context. She parameterizes the probability of an accident to be a function of the individual workers' accident propensity given the level of firm supplied safety. This framework is used to investigate the relationship between job tenure and safety.
29. Although for prime age males the labor supply curve has been estimated to be backward bending by many researchers. For a review see, Killingsworth (1983).
30. Private correspondence with Mark Mulvaney (an actuary formerly employed by NCCI) suggests that perhaps 15 percent of employers are subject to experience rating but these employers account for as much as 75 percent of the total workers' compensation premium in any given state. However, that is premium that is subject to experience rating, and does not account for the sliding scale nature of the experience rating formula. The experience rating formula is a weighted average of an individual firm's experience and the industry-wide experience, where the individual firm weight increases with firm size. In addition, the formula incorporates the three most recent years of experience such that the experience in any one year is mitigated.
31. The analysis in this section relies heavily on the review article by Ehrenberg (1988).
32. The National Council On Compensation Insurance, the ratemaking organization which also administers most experience rating plans, is currently changing the parameters of the experience rating plan. These changes will actually reduce the number of firms that have full "credibility" or perfect experience rating.
33. As Ehrenberg (1988) *op.cit.* points out, in a world where all workers' compensation costs are not shifted to workers in the form of lower wages (or to consumers in the form of higher prices) there may also be employment effects.
34. The three industry groups are: construction, manufacturing, and other.
35. Ehrenberg *op. cit.* p. 78.
36. Indeed, while maximum likelihood techniques may yield more efficient estimates, the I.V. technique is still consistent and unbiased. The additional complexity of maximum likelihood estimation are often not worth any additional benefits; thus these techniques are not pursued here.

37. In the empirical section, I discuss some further implications of my approach. Specifically, I test whether lagged values of the probability of an accident affect alcohol consumption.
38. The National Council on Compensation Insurance is a voluntary, nonprofit, statistical, research and ratemaking organization. NCCI's primary functions are the preparation and administration of rates, rating plans, and systems for workers' compensation insurance in 32 states and the provision of similar assistance in about one-half of the remaining states. Since workers compensation benefits are attributed to a "policy" year (i.e. the time period for which particular regulated prices are in effect) and may be paid out over several years, it may be several years before the final or ultimate claim costs (even claims in the case of occupational diseases) are known. Since different years and different states will have claims and costs at different stages of "development" (maturity), the data have been adjusted so that it is all on a common reporting basis and set to coincide with calendar years. The details of the adjustments can be provided upon request. After making the calendar year reporting adjustment, a consistent time series of data was available for 27 states for 1964-1984. The states are: Arkansas, Colorado, Connecticut, District of Columbia, Florida, Georgia, Iowa, Idaho, Illinois, Indiana, Kansas, Louisiana, Maryland, Maine, Michigan, Missouri, Nebraska, North Carolina, New Hampshire, New Mexico, Oklahoma, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, and Virginia.
39. Employment data are from U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various editions.
40. Note that the variable is for group self insurance, the allowance of which varies across states. Most states do allow for individual firms of sufficient size to self insure their own workers' compensation.
41. Wage data are from *Employment and Earnings*, *op.cit.*
42. See the NCCI publication *Annual Statistical Abstract*, *op.cit.*, for information on the distribution of costs across claim types. See the U.S. Chamber of Commerce, *Analysis of Workers' Compensation Laws*, for information on replacement rates, benefit minimums and maximums, and waiting periods.
43. See Butler and Worrall (1983) and Ruser (1991) for examples and a discussion of its use.
44. A full discussion of the alcohol consumption data and the method for converting to an ethanol basis can be provided upon request. In addition, Michael Grossman kindly provided information on the apparent consumption of distilled spirits from the Distilled Spirits Council of the US. Although not used in the analysis a simple correlation of .97 was obtained

when comparing the two different data series.

45. See Asch and Levy (1988).
46. See for example Krueger and Burton (1990) and Ruser (1991).
47. For example, how aggressive the state agencies are in handling disputed claims, or even what procedures if any are in place can play an important role. Some states have dispute resolution panels or use physician panels; others require court proceedings.
48. Data on alcohol prices were kindly provided by Michael Grossman. It is to my knowledge the most extensive price information available -- it is both state and year specific.
49. This is calculated using the nominal weekly wage in a state and year, the laws regarding benefit payments, and an actuarial technique employed by the National Council on Compensation Insurance. Specifically, the calculation involves integrating over the wage distribution and looking at the number of workers who fall in the interval below the minimum benefit, between the minimum and the maximum, and above the maximum. That is, the expected benefit is a function of wages, minimum benefits, maximum benefits and the replacement rate. The details can be provided upon request. Also see Butler (1983) for a discussion of the calculation.
50. Specifically, Butler (1988) is interested in actuarial "trend". Ratemaking is by nature a prospective process whereby future costs are estimated on past experience net of benefit changes which are priced separately. In actuarial ratemaking current costs are estimated; recall, WC payments may be made for a number of years for a given accident, and as such, final costs, which are allocated to the period in which the accident occurs, will not be known for some time. After current costs are estimated, the trend in such estimates is used to forecast the next period costs. It is this estimate which determines the ex ante WC costs for the next period. Butler estimated quadratic time models of claim frequency and average costs controlling for wages and benefits.
51. Because of multicollinearity problems, models could not be estimated with both the year dummies and the year specific controls.
52. It is well-known that the interpretation of the coefficient on a dummy variable (such as self-insurance) in a model where the dependent variable is measured in natural logarithms is equal to $e^b - 1$.
53. A number of alternative models were estimated but not reported. Among them were models that interact unemployment with alcohol consumption. This interaction is not significant

and alleviates the concerns about potential errors in variables regarding the drinking and accident patterns of the unemployed versus the employed.

54. See for example, Worrall, Butler, Borba and Durbin (1985).
55. See Borba and Appel (1987) for more on this.
56. This potential problem and test was suggested and performed by Krueger and Burton (1990).
57. See Breusch and Pagan (1979).
58. See Ingram, B (forthcoming 1992), for a catalog of recent cases and judicial rulings on the compensability of alcohol-related claims.
59. For the latest available year in this study (1984), the five states with the highest levels of alcohol consumption were: Washington D.C., New Hampshire, Arkansas, Kansas and Florida (average 3.45 "gallons" in consumption and \$1,909 in workers' compensation costs); and the five states with the lowest levels of alcohol consumption were: Oklahoma, Tennessee, Iowa, North Carolina, and Indiana (average 1.63 "gallons" in consumption and \$1,427 in workers' compensation costs).
60. Major reforms have recently been enacted in California, Florida, Oregon, Maine and Texas. Many other states have enacted more limited reforms as well.
61. See Ingram, *op. cit.*, for a discussion of the relevant legal theories and case law.

APPENDIX

To incorporate the demand for safety by the firm, equation (15), the technical relationship between the probability of an accident and the various inputs, may be expanded as follows:

$$(a1) \epsilon = \epsilon(a, s, r, z, v)$$

where a , s , z , and v are as defined in the text and r represents resources allocated to safety by the firm. Note that in a different context, Kahn (1987) specifies a model which incorporates both an individual's accident propensity and the level of firm supplied safety to investigate whether firms take into account the tenure of workers in what she terms the "safety-setting process".

The firm is assumed to maximize profits (y):

$$(a2) y = px(l) - wl - c - r$$

where,

x = output

p = price

l = labor input

c = workers' compensation premium

and the price of r is \$1.

The workers' compensation premium (c) equals:

$$(a3) \quad c = \epsilon klwb$$

with k a loading factor. Thus:

$$(a4) \quad y = px(l) - w_l - \epsilon klwb - r$$

With wages assumed given, the first-order condition for r is:

$$(a5) \quad 1 = -\epsilon_r klwb$$

If the production function for safety (equation (24) in text) is now specified as:

$$(a6) \quad \epsilon = a^\Gamma s^\alpha r^{-\beta} z v$$

then it follows that:

$$(a7) \quad -\epsilon_r = \beta a^\Gamma s^\alpha r^{-\beta-1} z v$$

and taking logarithms and combining terms yields:

$$(a8) \quad \ln r = (\beta+1)^{-1} \ln \beta + \Gamma(\beta+1)^{-1} \ln a - \alpha(\beta+1)^{-1} \ln s + \\ (\beta+1)^{-1} \ln z + (\beta+1)^{-1} \ln v + (\beta+1)^{-1} \ln l + (\beta+1)^{-1} \ln w + \\ (\beta+1)^{-1} \ln b + (\beta+1)^{-1} \ln k$$

and equation (26) in the text is modified to be:

$$(a9) \ln s = (\alpha+1)^{-1} \ln(\alpha) + (\alpha+1)^{-1} \ln w + \Gamma(\alpha+1)^{-1} \ln a - \beta(\alpha+1)^{-1} \ln r + (\alpha+1)^{-1} \ln z + (\alpha+1)^{-1} \ln v$$

Equations (a8) and (a9) can be solved simultaneously for $\ln s$ and $\ln r$. To simplify, ignore the intercept and the variables $\ln z$, $\ln v$, $\ln l$, and $\ln k$, although these all enter the final equation:

$$(a10) \ln r = [\Gamma/(\alpha+\beta+1)] \ln a + [1/(\alpha+\beta+1)] \ln w + [(\alpha+1)/(\alpha+\beta+1)] \ln b - [\alpha/(\alpha+\beta+1)] \ln(1-b)$$

$$(a11) \ln s = [\Gamma/(\alpha+\beta+1)] \ln a + [1/(\alpha+\beta+1)] \ln w + [(\beta+1)/(\alpha+\beta+1)] \ln(1-b) - [\beta/(\alpha+\beta+1)] \ln b$$

Now, since

$$(a12) \ln \epsilon = \Gamma \ln a - \alpha \ln s - \beta \ln r$$

then,

$$(a13) \ln \epsilon = [\Gamma/(1+\alpha+\beta)] \ln a - [(\alpha+\beta)/(1+\alpha+\beta)] \ln w - [\alpha/(1+\alpha+\beta)] \ln(1-b) - [\beta/(1+\alpha+\beta)] \ln b$$

Note, that unlike equation (27) in the text both $\ln b$ and $\ln(1-b)$ enter as regressors. Thus firm incentives may be captured by adding $\ln b$ to the estimating equations.

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