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Abstract. This paper studies the link between occupational health hazards and job security. Consistent with the underlying hypothesis that firms utilizing hazardous technologies tend to employ low-skilled workers who can be discharged easily in case of a downturn in business, the analysis indicates that workers in hazardous positions are more likely to face involuntary job loss than are those in safe positions. These workers may be particularly sensitive to political arguments that efforts to reduce exposure to toxins in the workplace and the general environment are responsible for layoffs and plant closures. The paper discusses policy alternatives that could reduce the impact of health regulations on job security.

The political success of preventive health strategies designed to reduce hazards in the workplace through occupational health and safety regulations is directly dependent on the overall state of the economy. The original enabling legislation for the Occupational Safety and Health Administration (OSHA) was passed in 1970, after almost a decade of steady and unprecedented economic growth. However, opposition to OSHA regulations grew within the business community during the economically stagnant seventies, and became especially heated during the recession of the early eighties. The dependence of regulatory programs on local economic conditions was graphically evidenced when exposed workers themselves requested exemption from OSHA lead standards when the Bunker Hill smelter in Idaho threatened closure.[1] More recently, the Environmental Protection Agency explicitly stated that enforcement of the arsenic standard at a smelter in Tacoma, Washington was a case of "jobs versus health."[2]

This paper focuses on the link between occupational health regulation and economic security, arguing that the issue could influence the attitudes towards regulation held by the intended beneficiaries of public health measures—workers exposed to hazards on the job. If workers are forced to choose between immediate, certain loss of economic livelihood and distant, probabilistic health problems, they are unlikely to support health measures.

The first section of this paper presents a theory of why workers in hazardous jobs are likely to be disproportionately exposed to the risk of both temporary

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layoffs in response to business cycle fluctuations and permanent job loss due to workforce reductions, plant closures, and firm bankruptcies. The second section discusses data sources used in analyzing the effect of working conditions on management layoff policies and workers' perceptions of those policies. The third section presents the econometric specification employed. Statistical evidence is then presented indicating that workers in more dangerous jobs and industries do in fact suffer higher rates of both temporary and permanent layoffs, and that they are aware of their higher probability of job loss. The final section discusses the public-policy implications of the empirical findings.

Job hazards and job security

The relationship between workplace hazard levels and the overall state of the economy is clear. During recessionary periods, alternative job possibilities dry up, and workers become less willing to quit[3] or engage in a strike.[4] They become less successful at gaining wage increases and preventing wage decreases,[5] and since safe conditions may be viewed as part of a total compensation package, it is likely that they are less effective in any efforts to reduce hazards.[6]

Less obvious is the dependence of layoff rates on the organization of production and, hence, on the level of health hazards in different firms and industries at any point in time. For any given level of unemployment and consumer demand for products, different employers manifest different levels of willingness to lay off workers, close their plant, and move elsewhere, as opposed to riding out troubles with existing workers in anticipation of better times to come.

The relationship between job hazards and job security is complex because working conditions are both a technological constraint on employer decisions and the result of employer decisions concerning safety investments. From the worker's point of view, working conditions are a dimension of job quality analogous to wage levels, so employers must consider the influence of hazard on the type of workers available for hire and the likelihood that existing employees will quit. In principle, even the most hazardous worksite can be made very safe, but often at such high economic cost that it will be more profitable to adopt strategies other than safety investments to obtain a workforce. Wages can be raised to compensate workers for the risks they face, and skill levels can be reduced to allow the firm to hire socially disadvantaged workers with few job alternatives. In practice, the firm will choose some mix of safety investments, wage premiums, and skill changes, then resign itself to the resulting mix of new hires and quits.

The process of discharge without prejudice is also composed of two distinct elements. Most layoffs in the U.S. are temporary, made in response to fluctuations in consumer demand for products, seasonal influences on the production process (as in agriculture and construction), or other events viewed as passing.[7] Some layoffs are permanent, however, and result from lasting adverse changes in consumer demand or the introduction of labor-saving technology. The key

determinants of temporary layoffs include fluctuations in consumer income and confidence, the ease with which employers can substitute one input for another in responding to a fall in demand, the flexibility of input prices, and the perceived cost to the firm if laid-off workers find jobs elsewhere and are unavailable for rehire when consumer demand picks up again. Key determinants of permanent layoffs are long-run changes in consumer demand, substitution possibilities between inputs, and perceived costs of terminations.

The economic theory of labor market response to job hazards emphasizes the role of wage premiums that compensate workers for risks on the job.[8] The traditional focus has been on monetary wages and fringe benefits, but in principle workers could be compensated by any type of desirable job quality. Since workers utimately care about total income rather than hourly wages, job security is a particularly important attribute and could hypothetically depend on working conditions. In this case, workers in particularly dangerous positions will have greater job security than workers in safer positions (other things equal) perhaps via some form of seniority system.

The compensating differentials theory is most directly applicable to guarantees against permanent layoff, since this is an obviously undesirable event. Temporary layoffs are not necessarily so undesirable, especially to the extent they are predictable, of known duration, and generously compensated by unemployment insurance. Economic analyses of temporary layoffs focus on alternative employer responses to business cycle fluctuations, including reductions in wages, employee hours (worksharing), and employment (temporary layoffs and permanent quits).[9] Wage reductions directly reduce production costs, but also reduce employment because they cause higher levels of quits. Higher quit rates, in turn, reduce the necessity for layoffs and make layoffs that do occur more risky to the firm, since a greater proportion of laid-off workers will actively seek employment elsewhere and be unavailable for rehire. In general, one would expect firms paying high wages to make greater use of temporary layoffs in response to business cycle fluctuations than firms paying low wages. Similarly, one would expect firms with safe technologies to use temporary layoffs more frequently and firms with hazardous technologies to use them less often. Therefore, although temporary layoffs are less undesirable to workers than permanent layoffs, the negative relationship between hazardous conditions and threat of job loss is predicted to apply to temporary layoffs as well.

Other considerations lead one to predict the opposite relationship between hazards and layoffs, however. Workers in hazardous positions should be more, rather than less, susceptible to job loss than workers in safer positions because of the role skill and on-the-job training levels play in determining employer layoff policies. Economists consider the process of on-the-job training as an investment made by both the employer and the employee. The employer pays the direct cost of the training in order to have a more productive employee. The employee pays indirect costs of the training by accepting during the training period a wage lower

than he or she could obtain elsewhere, anticipating wage increases once the training period is over.[10] Firms offering considerable on-the-job training tend to have wage scales that rise more sharply with worker seniority (and hence with extent of training) than firms offering little training.

The process of on-the-job training influences employment patterns as well as wages. Once a worker has been trained in the peculiarities of a given production process, he or she is more valuable to the employer than any newly hired replacement. If a drop in consumer demand for the employer's product reduces the need for workers, the employer will be especially reluctant to lay off workers with considerable on-the-job training. Employers have tended to institute (or accept labor union demands for) personnel policies dictating that layoffs be conducted on the basis of inverse seniority, with the most recently hired being the first discharged. Such systems guard training investments, since the extent of training generally increases with length of worker tenure.

The relation between on-the-job training and job security extends to permanent as well as temporary layoffs. Firms eliminating one shift or closing down one plant will seek to transfer their most highly trained employees to those shifts or plants that continue in operation. Firms in industries where bankruptcy levels are high will tend to utilize production processes requiring little on-the-job training, since they are unsure of being in business long enough to recoup the investment costs of such training through higher productivity.

This discussion is relevant to the examination of job hazards and job security, since employers using hazardous technologies face strong financial incentives to reduce the level of on-the-job training they provide. The level of wage compensation that must be paid to induce individuals to work in the face of health and safety risks depends on the extent of alternative employment options they possess. Workers with fewer skills and those who face employment discrimination will generally be more willing to work in hazardous jobs at lower levels of additional wage compensation than more socially advantaged workers. The wage cost of a given increment of hazard will thus be greater for firms whose jobs require considerable on-the-job training than for firms whose jobs require little such training. Employers will be motivated both to hire disadvantaged workers for risky jobs and, where necessary, to reduce the level of skill and on-the-job training necessary in risky jobs to avoid the need for skilled workers.

Studies of racial inequality in occupational exposure to accidents and toxins have found that blacks are disproportionately represented in the more hazardous employments in the economy, as are those workers with few years of education and experience.[11] These findings are consistent with the hypothesis that the labor market sorts workers with fewer skills and less-advantaged social status into jobs with unsafe and unhealthy working conditions. These studies do not, however, provide any insights into the issue of whether workers in hazardous employments receive less on-the-job training and hence have fewer possibilities to raise their level of skill than do workers in safer jobs. To the extent differences in on-the-

job training exist, they will result in increasing divergence between the economic well-being of workers in different jobs. An evaluation of the relationship between hazardous working conditions and layoff probabilities does allow some insights into this important question, albeit indirectly, since the extent of on-the-job training rather than skills possessed at the time of hiring is hypothesized to exert the dominant influence over layoff probabilities.

The decision to lay off some workers or close down a plant is one made by the employer, not the employee. This does not imply, however, that workers have no choice in the matter. Different types of jobs and different types of firms offer workers different degrees of employment security, and the actual extent of security may not be difficult to ascertain. For example, it is common knowledge that employment in the public sector tends to be steadier than employment in the private sector. Similarly, layoffs are known to be more common in manufacturing and construction than in service industries (such as health care). The greater risk of job loss in more hazardous jobs is likely to be evident to workers themselves, and thus will be taken into account when choices of job, occupation, and industry are made. Those workers who do accept hazardous jobs are likely to be aware of their high risk of layoff.

The foregoing hypotheses may be subjected to two sorts of statistical tests using available data on working conditions, layoff probabilities, and other job and worker characteristics. The relative strengths of the compensating differentials effect (workers in hazardous jobs should enjoy extensive employment security) and the selection effect (employers with hazardous technologies modify the mode of production to utilize less-skilled and socially less-advantaged workers who can be laid off cheaply) can be tested with the simple correlation between hazard levels and layoff probabilities. To the extent the selection effect is dominant and workers in hazardous jobs face higher risks of permanent and temporary job loss, employees may be particularly susceptible to claims that regulatory attempts to reduce occupational hazards will result in further job loss.

More specific insights into the dynamics of working conditions and employment relations can be obtained using a multivariate statistical methodology. The key hypothesis under examination in this paper is that the presence of hazardous technologies gives employers incentives to reduce the extent of on-the-job training, which in turn reduces the cost of layoffs to the employer. A multivariate regression strategy can identify the separate influence of working conditions on layoff probabilities if it can isolate working conditions from other layoff determinants. To the extent that available data sources provide good measures of on-the-job training, one would expect the residual association between hazard and layoffs to be negative, as predicted by the compensating differentials theory. To the extent measures of on-the-job training are not available, the residual association between hazard and layoffs will be the net effect of two opposing tendencies—the compensating differentials effect and the selection effect.

Data sources

The empirical analysis is conducted using three data sets: the years 1976–1978 from the Panel Study of Income Dynamics;[12] a data set composed of aggregate injury rates, layoff rates, and other information on four-digit standard industrial classification (SIC) manufacturing industries;[13] and the 1977 Quality of Employment Survey.[14] The three data sources are complementary and allow an examination of the relationship between working conditions and worker layoffs from several perspectives.

The longitudinal Panel Study of Income Dynamics (PSID) is a continuous study of 6,000 individuals who are interviewed annually by the University of Michigan's Survey Research Center. It can be used to link job characteristics faced in one year with turnover (or lack thereof) in the next. Two variables are available in the PSID to measure involuntary job loss. The first is the number of days the respondent reports as lost from work in the previous twelve months due to temporary layoff, and is thus a measurement of the extent to which the respondent's employer adjusts to temporary cyclical changes in product demand by laying off workers. The second is a binary variable, taking a value of one if the respondent lost his or her job over the previous twelve months due to permanent layoff, discharge, plant closure, firm bankruptcy, or end of seasonal employment, and taking a value of zero if not. Since the PSID is a longitudinal data set, information on temporary and permanent job loss from one interview can be matched with information on job characteristics from the previous year's interview, thereby permitting a prospective analysis of the influence of working conditions on turnover.

Since the PSID represents the entire U.S. adult population, not just members of the workforce, a considerable number of respondents are excluded from this study because they are, for example, students, retirees, or unemployed. In order to achieve a large sample, three consecutive years of the study (1976–1978) are used, producing 11,187 observations.

While the PSID offers good measures of temporary and permanent job losses, it provides a poor measure of working conditions. No questions are asked concerning job hazards, but each respondent's two-digit SIC industry code is noted. Each worker can then be ascribed the average risk of injuries resulting in at least one day lost from work for all workers in the appropriate category, as measured by the injury rate of the two-digit industry as a whole. This provides only a crude index of working conditions actually faced by the particular respondent, because it ascribes the same level of risk to all workers in an industry regardless of occupation.

The second data set is constructed using published sources of information on manufacturing industries.[15] The Bureau of Labor Statistics publishes data on injury rates, layoff rates, recall rates, and the percentage of the workforce that is female. Census Bureau publications provide information on average wages, per-

centage of unionization, percentage of blacks in the workforce, median years of worker tenure with current employer, and other industry characteristics. The analysis is limited to the manufacturing sector because aggregate layoff rates by industry are not published for most other sectors of the economy.

Two dependent variables are available in the manufacturing data: the annual rate of temporary layoffs, and the annual rate of permanent layoffs. Following Lilien[16] the rate of permanent layoffs is calculated as the rate of total layoffs minus the rate of recalls. Temporary layoffs are equivalent to layoffs resulting in recall.[17] The principal independent variable is the rate of injuries resulting in at least one day lost from work. This is the same measure used in the PSID analysis, but it is available here at the detailed four-digit level.

The third source of data is the 1977 Quality of Employment Survey (QES), a study of 1,515 individuals working at least 20 hours per week. The QES is cross-sectional and thus provides no direct information on job change events. It does contain one variable, however, that may be used to examine worker expectations of future job loss events. This is of particular importance given that it is the workers' perceptions of job security, rather than the actual layoff risk, that directly influence their attitudes towards health and safety regulations. The QES poses the following question to respondents: "Sometimes people permanently lose jobs they want to keep. How likely is it that during the next couple of years you will lose your present job and have to look for a job with another employer?" The dependent variable for the QES analysis is constructed as a binary variable taking the value of one if the respondent reports him or herself to be "somewhat likely" or "very likely" to lose his or her job, and taking the value of zero otherwise.

The primary strength of the QES is the variety and quality of available measures of working conditions. The survey asks respondents if they are exposed to any of thirteen different hazards and, if so, to what extent. The thirteen categories include dangerous chemicals; dangers from fire, burn, or shock; air pollution from dust, smoke, gas, fumes, or fibers; working outside in bad weather; extremes of temperature or humidity indoors; dirty or badly maintained workplaces; things that are stored dangerously; too much noise; dangerous tools, machinery, or equipment; risk of catching diseases; risk of traffic accidents while working; risk of personal attack by people or animals; and dangerous work methods. The questions are utilized in this study as the basis for a single binary variable that takes the value of one if the respondent reports "significant" or "great" levels of exposure to at least one hazard, and takes the value of zero otherwise. The industry injury rate used for the PSID and manufacturing analyses is merged with the QES data at the three-digit level.

Econometric specifications

The simple correlation between hazard level and layoff probabilities is calculated by dividing each data set into two subsamples: those individuals and in-

dustries with hazard exposure levels equal to or greater than the sample mean, and those with hazard exposure levels less than the sample mean. Layoff probabilities, duration, and rates are calculated for both the high- and low-hazard subsamples. This procedure is equivalent to regressing the layoff measure on a binary (high/low) hazard measure alone, and yields in an easily interpretable form the basic correlation between the hazard and layoff variables. (Univariate regression of the layoff variables on the continuous hazard measures produces qualitatively similar results.)

Multivariate regression techniques are then employed to isolate the separate influence of hazard on layoffs from other determinants of job loss. Regional variables are employed in all three data sets to control for broad sectoral differences in consumer demand. Dichotomous SMSA variables are available in both the PSID and QES. The PSID also contains the unemployment rate in the respondent's county of residence. Differences between jobs in the elasticity of substitution between inputs are measured using dichotomous union status variables in the PSID and QES and using the percentage of the industry production workforce that is unionized in the manufacturing data. Medoff argues that unions reduce the flexibility of hours (and possibly wages) with respect to fluctuations in product demand, thereby increasing mangement's reliance on temporary layoffs.[18] No clear predictions are made concerning the relationship between unionism and permanent layoffs. In some cases, unions prefer permanent closures of certain plants or firms rather than changes in union–management relations, such as wage reductions, that will undermine contracts elsewhere in the industry. In other cases, unions will actively cooperate with management to find ways to save the jobs of their members. Three dichotomous firm-size variables are available in the QES as additional measures of differences in the ease of substitution between inputs.

When deciding which workers to lay off, crucial factors of interest to the firm are the extent of investment in on-the-job training (representing the cost to the firm if the worker accepts employment elsewhere), the level of wages and working conditions (reflecting the quality of the job in the eyes of the worker, and hence his or her willingness to accept employment elsewhere), and demographic characteristics of the workers such as race, sex, education, and years of general labor force experience (reflecting the quality of the worker in the eyes of other employers, and hence the likelihood that he or she will receive competing job offers if laid off).

The principal measure of on-the-job training is years of tenure with current employer in the PSID and QES, and median years of tenure for the industry workforce in the manufacturing data set. Tenure directly measures the number of periods a worker has received training. Current tenure level captures the cumulative effect of past decisions by the employer not to discharge the worker permanently, and decisions by the worker not to quit the firm. Since both discharge and quit probabilities are inversely related to the extent of investment in on-the-job training, current tenure level also indirectly measures the intensity of

on-the-job training per period in the past. It is hypothesized that current tenure level will be strongly and inversely related to layoff probabilities in the present period.

Earnings are measured in the form of hourly wages (in cents) in the PSID, annual earnings (in dollars) in the QES, and average hourly wages (in cents) for industry production workers in the manufacturing data set. Measures of workplace hazard include the industry injury rate in all the data sets, measured at the two-digit level in the PSID, at the three-digit level in the QES, and at the four-digit level in the manufacturing data set. The QES also allows the use of the dichotomous hazard exposure variable discussed earlier. Dichotomous variables for fast pace, repetitive tasks, and lack of worker control over job duties are also available in the QES and are included to permit that analysis to distinguish the separate influences on layoff probabilities of different undesirable working conditions. Measures of race, sex, years of education, and years of general labor force experience are included in all three data sets to capture the effects of skills not specific to one firm and the effects of discrimination on layoff probabilities. Self-perceived health status is also available in the PSID and QES.

The principal variables for the PSID and QES, as well as their means and standard deviations, are presented in Table 1. Data sources and descriptive statistics for the principal variables used in the manufacturing industry analysis are presented in Table 2.

Findings

The statistical analysis of the correlation between hazardous conditions and both layoff spells and job loss probabilities presented in Table 3 provides strong support for the hypothesis that workers in hazardous jobs and industries are more likely to lose their jobs due to layoff or plant closure than are those in safer positions. Job loss probabilities are significantly greater in hazardous positions than in safe positions, using all three data sets and all five measures of temporary and permanent job loss.

Workers in industries with high rates of job-related injuries lose more days during the year due to temporary layoff and are at greater risk of losing their jobs permanently, as indicated in the PSID data in the first two rows of Table 3. According to these figures, a worker in a hazardous industry (one with an injury rate equal to or greater than the economy-wide mean) would on average lose 5.8 more days due to temporary layoffs and be 1.0 percentage points more likely to lose his or her job permanently than a worker in a safe industry (one with an injury rate below the mean).

Manufacturing industries with higher injury rates experience significantly higher temporary and permanent layoff rates than those with lower injury rates, as evidenced in the third and fourth rows of Table 3. The annual rate of temporary layoffs in hazardous industries are 2.7 percentage points higher than in safe in-

Table 1. Means and Standard Deviations, 1976–1978 Panel Study of Industry Dynamics and 1977 Quality of Employment Survey

	PSID		QES	
Variables	Mean	Stand. Dev.	Mean	Stand. Dev.
Annual days of temporary layoffs	10.2	40.5	—	—
Annual probability of permanent layoff	0.06	0.24	—	—
Expectations of permanent layoff	—	—	0.15	0.35
Industry injury rate per 1000 workers per year	37.21	19.91	37.46	23.86
Presence of hazard	—	—	0.38	0.48
Fast-paced work	—	—	0.56	0.50
Repetitive tasks	—	—	0.58	0.49
No control over duties	—	—	0.52	0.50
Hourly earnings (in cents)	610	480	—	—
Annual earnings (in dollars)	—	—	13,928	10,655
Years of tenure	8.15	8.44	7.20	7.53
Worker is black	0.37	0.48	0.08	0.27
Worker is female	0.28	0.45	0.36	0.48
Union representation	0.31	0.46	0.29	0.45
Unemployment rate in county	6.00	1.98	—	—
N	11,187		1,111	

dustries. Industries with high injury rates report annual rates of permanent layoffs 1.0 percentage points above those in industries with low injury rates.

As indicated in the fifth row of the table, a QES worker in a hazardous industry is 3.4 percentage points more likely to report job loss expectations than a worker in a safe industry. Presence of at least one significant or great hazard at work raises by 8.9 percentage points the probability a worker in the QES data set will report susceptibility to permanent job loss during the next few years.

In order to gain insight into the causal mechanisms underlying these correlations, multivariate analyses of the determinants of layoff spells and job loss probabilities are conducted using the three data sets. Table 4 presents regression results for the temporary and permanent job loss variables using the PSID; Table 5 presents results for the annual rates of temporary and permanent layoff using the manufacturing industry data; and Table 6 presents analogous figures using the job loss expectations variable in the QES.

Table 2. Means and Standard Deviations, Manufacturing Industry Analysis

Variables	Mean	Stand. Dev.
Annual rate of temporary layoffs[a]	9.89	5.90
Annual rate of permanent layoffs[a]	3.04	2.68
Injury rate per 1000 workers per year[b]	54.34	28.79
Average hourly wage for production workers[c]	5.63	2.76
Median tenure of workforce[d]	5.08	1.60
Percentage of workforce that is black[e]	8.70	3.58
Percentage of workforce that is female[a]	31.42	20.33
Percentage of production workers unionized[f]	45.84	14.17
N	420	

Sources:

a. U.S. Bureau of Labor Statistics, *Employment and Earnings*, March 1978.

b. U.S. Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the United States by Injury*, 1977, and Bulletin 2047, 1980.

c. U.S. Bureau of the Census, "Concentration Ratios in Manufacturing," in *1977 Census of Manufacturers*, 1981.

d. U.S. Bureau of Labor Statistics, *Job Tenure of Workers*, Special Labor Force Report 172, 1975.

e. U.S. Bureau of the Census, *1970 Census of Population: Detailed Characteristics*, PC(1)-D1, 1973.

f. Richard Freeman and James Medoff, "New Estimates of Private Sector Unionism in the United States," in *Industrial and Labor Relations Review* 32 (January 1979): 143–174.

Controlling for other important determinants of job loss probabilities, including tenure and wage levels, does not alter the basic conclusions drawn from the simple correlation between hazards and layoffs. Workers in more hazardous positions are substantially more likely than comparable workers in safer positions to suffer a temporary or permanent layoff. They are also likely to lose more days of work than those in safer positions. This indicates that the selection effect is far more important than the compensating differentials effect in the labor market's response to job hazard. The large number of additional variables included to control for the selection effect was not sufficient to isolate the compensating differentials effect.

As indicated in the coefficients on the industry injury rate variable in Table 4, PSID workers in more hazardous industries lose significantly more days per year due to temporary layoff and are significantly more likely to lose their jobs permanently than are comparable workers in safer industries. According to these figures, a worker in a typical hazardous industry (one with an injury rate at the mean for all hazardous industries) would lose 4.4 more days per year and be 1.5 percentage points more likely to lose his or her job permanently than a comparable worker in a typical safe industry (one with an injury rate at the mean for all safe industries.[19]

Hazardous manufacturing industries have significantly higher rates of temporary and permanent layoffs than do safe manufacturing industries, controlling

Table 3. Average Probability and Duration of Job Loss in Safe and Hazardous Employments

	Hazardous Industries[a]	Safe Industries[b]	*p*
Days of temporary layoff (1976–1978 PSID)	13.4	7.6	<.0001
Percent permanently losing job (1976–1978 PSID)	6.9%	5.9%	.0308
Annual rate of temporary layoffs (Manufacturing)	11.4%	8.7%	<.0001
Annual rate of permanent layoffs (Manufacturing)	3.6%	2.6%	<.0001
Percent expecting future job loss (1977 QES)	16.9%	13.5%	.0802
	At Least One Hazard in Job	No Hazards in job	*p*
Percent expecting future job loss (1977 QES)	20.2%	11.3%	<.0001

a. Injury rate ≥ economy-wide mean.
b. Injury rate < economy-wide mean.

for other industry characteristics, as indicated in Table 5. According to these figures, the typical hazardous manufacturing industry experiences an annual rate of temporary layoffs 1.6 percentage points higher and an annual rate of permanent layoffs 0.9 percentage points higher than the typical safe industries.

Workers in hazardous jobs and industries appear to be aware of their higher risk of job loss as indicated by the QES figures in Table 6. Controlling for other job and worker characteristics, a QES worker in a typical hazardous industry is 3.8 percentage points more likely to report expectations of permanent future job loss than a worker in a typical safe industry. Workers reporting the presence of at least one "significant" or "great" hazard on the job are 8.0 percentage points more likely to report expectations of future job loss than workers reporting no such hazards.

As hypothesized, years of worker tenure is strongly and negatively correlated with temporary and permanent job loss. PSID and QES workers with more seniority are significantly less likely to report actual or expected permanent job loss and to report significantly fewer days per year on temporary layoff than comparable workers with less seniority. As indicated in Table 5, manufacturing industries with higher median years of tenure report fewer permanent layoffs. No correlation is found with temporary layoffs.

The association between earnings and job security is mixed. Higher-paid PSID workers report significantly fewer days per year on temporary layoff and sig-

Table 4. Job Hazards and Individual Layoff Possibilities: The 1976–1978 Panel Study of Income Dynamics[a]

	Annual Days of Temporary Layoff		Annual Probability of Permanent Layoff	
	Mean	Stand. Dev.	Mean	Stand. Dev.
Industry injury rate	0.1198***	0.0203	0.0072***	0.0020
Hourly earnings	−0.0044***	0.0011	−0.0012***	0.0002
Black	5.82***	1.02	0.266***	0.098
Female	0.526	1.081	−0.301***	0.106
Union	0.083	0.892	−0.260***	0.096
Tenure	−0.325***	0.069	−0.084***	0.011
Unemployment rate in county	0.870***	0.194	0.006	0.019
R^2	0.03		—	
Chi Square	—		262.82	
Degrees of freedom	—		14	
N	10,543		11,187	

a. Coefficients in the first column are estimated by ordinary least squares. Coefficients in the second column are logistic parameters estimated by maximum likelihood. Model chi-square is for testing the hypothesis that all nonintercept coefficients are zero. Regressions also include years of education and experience, self-perceived health status, and three regional and one SMSA variable.

*significant at 90% confidence level.

**significant at 95% confidence level.

***significant at 99% confidence level.

nificantly fewer permanent layoffs than less-well-paid workers. Manufacturing industries with higher average wages report fewer permanent layoffs than industries with lower wages, and highly paid QES workers report fewer expectations of permanent job loss than less-well-paid workers, but these effects are small and not statistically significant. Manufacturing industries with high average wage levels report slightly higher rates of temporary layoffs than comparable industries paying lower wages, but once again the effect is small and not statistically significant. Working conditions other than hazards are only weakly correlated with job loss expectations, according to the QES data in Table 6.

The association between unionism and layoffs is also mixed. Unionized PSID workers are less likely than their nonunion counterparts to report permanent layoffs, while unionized QES workers are more likely than comparable nonunion workers to report expectations of permanent job loss. More heavily unionized manufacturing industries manifest higher rates of temporary layoffs than do less heavily unionized manufacturing industries, but unionized PSID workers report days lost to temporary layoffs at levels similar to those reported by their nonunion counterparts.

Black PSID workers report more temporary and permanent layoffs than white workers, and manufacturing industries with large percentages of black workers

Table 5. Job Hazards and Aggregate Layoff Rates: 1977 Manufacturing Industries[a]

	Annual Probability of Temporary Layoff		Annual Probability of Permanent Job Loss	
	Mean	Stand. Dev.	Mean	Stand. Dev.
Industry injury rate	0.040***	0.011	0.023***	0.006
Average hourly wages	0.053	0.091	−0.071	0.048
% union	0.067***	0.023	0.007	0.012
% black	0.469***	0.099	0.166***	0.052
% female	0.109***	0.017	0.044***	0.009
Median tenure	−0.215	0.193	−0.317***	0.101
R^2	0.38		0.18	
N	420		420	

a. Regression also includes average firm size in industry, percentage of industry workforce residing in the southeast, median workforce years of education, and median workforce years of experience.
*significant at 90% confidence level.
**significant at 95% confidence level.
***significant at 99% confidence level.

report higher annual rates of temporary and permanent layoffs than industries with fewer blacks. Black QES workers report expectations of permanent job loss more frequently than do white QES workers, but the differences are not statistically significant. No consistent pattern of relationships is observed between worker gender and risk of job loss.

Discussion

The statistical evidence presented in this paper provides strong support for the hypothesis that workers in hazardous jobs and industries are exposed to greater risk of both temporary and permanent layoffs than are workers more favorably placed. Worker demands for safety investments and wage premiums in response to hazards give incentives to employers to use unskilled and disadvantaged workers who are cheap to lay off when sales decline. If this explanation is correct, it implies that occupational health and safety regulations that reduce hazards, and thus worker demands, may have indirect as well as direct effects on working conditions.

Labor economists studying the effect of union-won wage increases on management policies have argued that the higher cost of labor gives incentives for firms to increase productivity, in part by hiring more-skilled workers and increasing investment in on-the-job training of existing employees.[20] Two basic modes of production appear possible, one emphasizing high productivity through investments in capital, worker training, high wages, and good working conditions, and one emphasizing low wages and lower levels of productivity.[21] The

Table 6. Job Hazards and Individual Layoff Expectations: The 1977 Quality of Employment Survey[a]

	Expectations of Future Job Loss		Expectations of Future Job Loss	
	Mean	Stand. Dev.	Mean	Stand. Dev.
Presence of at least one hazard	0.626***	0.185	—	—
Industry injury rate	—	—	0.0065*	0.0040
Fast pace	0.319**	0.187	0.320**	0.185
Repetitive tasks	0.015	0.196	0.069	0.194
No control over job duties	0.182	0.188	0.272	0.185
Annual earnings	−0.000022	0.000015	−0.000024	0.000015
Union	0.453**	0.201	0.481**	0.201
Black	0.301	0.291	0.435	0.285
Female	−0.406*	0.213	−0.364*	0.218
Tenure	−0.043***	0.016	−0.043***	0.016
Chi-square	65.48		57.32	
Degrees of freedom	19		19	
N	1111		1110	

a. Coefficients are logistic parameters estimated by maximum likelihood. Model chi-square and degrees of freedom are for testing the hypothesis of all non-intercept coefficients being zero. The regressions also include years of education and experience, self-perceived health status, and three firm size, three regional, and one SMSA variable.

*significant at 90% confidence level.

**significant at 95% confidence level.

***significant at 99% confidence level.

choice of production mode is often made in response to outside pressure, either from unions or from governmental minimum wage and safety regulations.[22] Occupational health and safety standards requiring better working conditions would forestall reliance on less-skilled and minority workers as a means of avoiding safety investments, and thus would provide incentives for firms to adopt a high-skill, high-productivity mode of production. This in turn would increase management reluctance to utilize layoffs and plant closures as the principal response to business cycle fluctuations. These potential benefits must be weighed against the actual costs of the mandated safety improvements.

Finally, this study raises the question of the extent to which workers employed in hazardous jobs and industries should be made to bear the burden of employment insecurity due to governmental efforts to reduce job hazards. While safety regulations may have indirect economic benefits that balance part of their direct economic costs to employers, as argued above, they nonetheless can be expected to raise the costs of production, at least in the short run. To the extent that employers respond by closing down and shifting production to areas of the world where

health regulations are weaker, rather than using the impetus to increase productivity, those individual workers previously employed in the hazardous firms will be forced to pay the costs, through loss of their jobs, of the economy's gradual shift to safer modes of production.[23]

If this process is occurring,[24] then the appropriate policy response may be to devise methods of reducing the cost of regulatory-related job loss to workers in order to forestall a worker backlash against public-health initiatives. Special attention could be given to retraining and relocating displaced workers. Bowles, Gordon, and Weisskopf have proposed such measures in the more general context of industrial policy, arguing that programs guaranteeing general employment security, as opposed to security in keeping any one particular job, will reduce worker resistance to labor-saving technological innovations.[25]

Notes

1. Occupational Safety and Health Reporter, "Settlement Agreement Reached in Effort to Save Bunker Hill," *Occupational Safety and Health Reporter* 11 (1 October 1981): 340.
2. P. Shabecoff, "A City Weighs Cancer Risk Against Lost Jobs," *New York Times*, 13 July 1983.
3. D. Parsons, "Quit Rates Over Time: A Search and Information Approach," *American Economic Review* 63 (June 1973): 390.
4. B. Kaufman, "The Determinants of Strikes in the United States, 1900–1977," *Industrial and Labor Relations Review* 35 (July 1982): 473; and H. Wheeler, "Determinants of Strikes," *Industrial and Labor Relations Review* 37 (January 1982): 263.
5. The association between levels of unemployment and rates of wage change is commonly referred to as the Phillips curve. A voluminous theoretical literature has developed that attempts to explain the mechanisms underlying the association. For a sampling of this literature, see the articles in E. Phelps, *Inflation Policy and Unemployment Theory* (London: Macmillan, 1972); and M. Piore, *Inflation and Unemployment: Institutionalist and Structuralist Views* (White Plains, N.Y.: Sharpe, 1979).
6. The tendency for recessions to reduce worker militancy has less effect on aggregate industry injury rates than the speedups caused by increases in production during business upswings and the hiring of new workers who are unfamiliar with existing hazards. The economy-wide injury rate is thus negatively associated with the unemployment rate. See R. Smith, "Intertemporal Changes in Work Injury Rates," *Industrial Relations Research Association Proceedings*, 1972: 167; J. Mendeloff, *Regulating Safety* (Cambridge, Mass.: M.I.T. Press, 1979); and P. Arno, *The Political Economy of Industrial Injuries*, Ph.D. diss., Graduate Faculty of Political and Social Research, New School for Social Research, 1984.
7. For a discussion of the role of temporary layoffs in the economy, see M. Feldstein, "The Importance of Temporary Layoffs: An Empirical Analysis," *Brookings Papers on Economic Activity*, 1973: 725–44.
8. R. Thaler and S. Rosen, "The Value of Saving a Life: Evidence from the Labor Market," in *Household Production and Consumption*, ed. N. Terleckyj (New York: National Bureau of Economic Research, 1975); W. Viscusi, "Wealth Effects and Earnings Premiums for Job Hazards," *Review of Economics and Statistics* 60 (August 1978): 408; R. Smith, "Compensating Wage Differentials and Public Policy," *Industrial and Labor Relations Review* 23 (April 1979): 339; and C. Brown, "Equalizing Differences in the Labor Market," *Quarterly Journal of Economics* 94 (February 1980): 113.
9. D. Parsons, "Specific Human Capital: An Application to Quit Rates and Layoff Rates," *Journal of Political Economy* 80 (November-December 1972): 120.
10. W. Oi, "Labor as a Quasi-Fixed Factor," *Journal of Political Economy* 70 (December 1962): 538–55; and G. Becker, *Human Capital* (New York: National Bureau of Economic Research, 1964).

11. R. Lucas, "The Distribution of Job Characteristics," *Review of Economics and Statistics* 56 (November 1974): 530; D. Kotelchuck, "Occupational Injuries and Illness among Black Workers," *Health PAC Bulletin* (April 1978): 34; M. Davis and A. Rowland, *Occupational Disease Among Black Workers: An Annotated Bibliography* (Berkeley: University of California Labor Occupational Health Program, 1980); and J. Robinson, "Racial Inequality and the Probability of Occupation-Related Injury and Illness," *Milbank Memorial Fund Quarterly* 62 (Fall 1984): 567.
12. Institute for Social Research, *A Panel Study of Income Dynamics: Procedures and Tape Codes* (Ann Arbor: University of Michigan, 1980).
13. An example of a one-digit industry is durable goods manufacturing. It contains two-digit industries such as primary metals industries (SIC 33), which in turn contains three-digit industries such as blast furnaces and basic steel products (SIC 331), which in turn contains four-digit industries such as steel pipes and tools (SIC 3317).
14. Inter-University Consortium for Political and Social Research, *Quality of Employment Survey, 1977, Cross Section*, ICPSR 7689 (Ann Arbor: Inter-University Consortium for Political and Social Research, 1979).
15. Due to budgetary cutbacks, the Bureau of Labor Statistics ceased collecting and publishing layoff rates for manufacturing industries in 1982. Figures used in this study are from 1977.
16. D. Lilien, "The Cyclical Pattern of Temporary Layoffs in United States Manufacturing," *Review of Economics and Statistics* 62 (February 1980): 24.
17. The annual rate of layoffs (AR) is calculated from the average monthly rate (MR) using the formula

$$AR = 1 - (1 - MR)^{12}$$

This figure calculates the average probability of layoff over the course of one year for each worker in each industry, and thus corresponds to the layoff measures used in the PSID and QES. Overall annual layoff rates that allowed for multiple layoffs of particular workers would be calculated as 12 times the average monthly layoff rate.
18. J. Medoff, "Layoffs and Alternatives Under Trade Unions in U.S. Manufacturing," *American Economic Review* 69 (June 1979): 380.
19. This focus on the difference in mean injury rates for safe and hazardous industries, where safe and hazardous are themselves defined as those below or above the economy-wide mean injury rate, was selected as an expository device since it permits direct comparison with the unadjusted differences in average injury and layoff rates in Table 3. A more conventional approach that compares industries with injury rates one standard deviation above and one standard deviation below the economy-wide mean yields qualitatively similar effects, but does not permit direct comparison with Table 3.

Since the variable measuring permanent job loss is binary, the linear functional form is inappropriate. The logistic distribution was thus employed, where

$$Pr[L = 1] = 1/(1 + \exp - XB)$$

where L is the binary variable for permanent job loss, X is a vector of independent variables, and B is a vector of coefficients. To obtain the impact on the dependent variable of a one-unit change in the value of an independent variable, differentiate the above formula by x (one of the components of X):

$$\delta L/\delta x = bL(1 - L)$$

where b is the logistic coefficient on x, and L is evaluated at the sample mean of the job-loss variable.
20. H. Lewis, *Unionism and Relative Wages in the United States* (Chicago: University of Chicago Press, 1963).
21. T. Vietorisz and B. Harrison, "Labor Market Segmentation: Positive Feedback and Divergent Development," *American Economic Review Proceedings* 63 (May 1973): 366.
22. S. Berger and M. Piore, *Dualism and Discontinuity in Industrial Societies* (Cambridge: Cambridge University Press, 1980).
23. J. Valentine and A. Plough, "Protecting the Reproductive Health of Workers: Problems in Science and Public Policy," *Journal of Health Politics, Policy and Law* 8 (Spring 1983): 144.

24. B. Castleman, "The Export of Hazardous Factories to Developing Nations," *International Journal of Health Services* 9 (1979): 569.
25. S. Bowles, D. Gordon, and T. Weisskopf, *Beyond the Wasteland: A Democratic Alternative to Economic Decline* (Garden City, N.Y.; Doubleday, 1983).