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Michael S. Lewis-Beck

University of Iowa

John R. Alford

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Can Government Regulate Safety? The Coal Mine Example

MICHAEL S. LEWIS-BECK
University of Iowa

JOHN R. ALFORD
Oakland University

With the 1970 passage of the Occupational Safety and Health Act (OSHA), federal regulation reached the American workplace. Given the newness of the legislation, any firm conclusion on its effectiveness seems premature. However, there is ample evidence on federal safety regulation of a specific workplace: the coal mine. The federal government has been directly involved in coal mining safety for over 35 years, operating under three major pieces of legislation, enacted in 1941, 1952, and 1969. Opposing opinions regarding the effect of this legislation can be grouped into three categories: radical, reactionary, and reformer. A multiple interrupted time-series analysis indicates that, in fact, the 1941 and 1969 regulations significantly reduced the fatality rate in coal mining. Certain conditions seem related to the effectiveness of this safety legislation: birth order, provisions, enforcement, target population, and goals. The first two conditions would appear to work for the success of the OSHA, the latter three conditions to work against it.

Skepticism over the effectiveness of government intervention is spreading. In retrospect, it is clear that the heralded social programs of the 1960s fell far short of their promise. Currently, there are questions about the utility of the government’s attempts to manipulate the economy in order to fight inflation, provide energy, or maintain competition. Of course, such doubts do not necessarily stem government involvement. On the contrary, the identification of new problems seems to lead inevitably to further federal action. One of these new areas for federal concern is work safety which, until the 1970 passage of the Occupational Safety and Health Act (OSHA), was the province of state regulation.

The Occupational Safety and Health Act was born of the liberal impulse for reform. The discovery of an intolerable situation, e.g., the hazardous working environment in a wide variety of jobs, generated a demand for remedial legislation (Special Task Force Report, 1973; Stellman and Daum, 1973; Wallick, 1972). Unfortunately, as policy research and contemporary events suggest, legislative intent is not always fulfilled by passing laws and appropriating money. Therefore, we should seriously consider whether, despite its bold design, the OSHA has actually managed to reduce occupational accidents. In this regard, there are strong reasons for supposing the OSHA is another instance of the failure of liberal reform. The very magnitude of the problem argues against its success. How can government effectively police five million workplaces, each a potential source of occupational accidents? Even the very term, “accidents,” implies events beyond the control of government, or any other human institution. Perhaps, then, one might argue that the fundamental cause of these accidents lies with individual workers who make mistakes, either out of carelessness or ignorance. In this case, a preferable approach would be education of workers about on-the-job hazards, leading them to demand higher wages, a demand which management tends to avoid by implementing safety measures. Any direct government intervention in this free-market process, according to this argument, would only result in a sub-optimal level of safety.

These considerations provide a prelude to the empirical query, “Has the OSHA made work less hazardous?” Lamentably, we cannot provide a direct answer to this research question. Leaving aside the obvious data-gathering problems, any answer would be premature. The OSHA has existed only since 1970, and it seems hasty to assert anything definite about its effect (for an attempt, see Nichols and Zeckhauser, 1977). Nevertheless, a current assessment of federal safety legislation need not rely solely on speculation. There is one workplace where the federal government has been involved in safety regulation for many years: the coal mine. On this subject, data are plentiful, although their systematic study has been slighted. Further, the origins and intent of the coal mining safety legislation seem typical of much federal regulatory legislation, the OSHA in particular. An examination of the impact of this legislation

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should shed some light on the effectiveness of government safety legislation.

There are three major pieces of federal coal mine safety legislation. Below, we first discuss briefly the possible effects of this legislation. Then we evaluate its impact quantitatively through multiple interrupted time-series analysis, a neglected policy assessment tool which seems widely applicable. Next, from this evaluation, we consider the conditions under which safety regulations are effective. Finally, we draw out the implications of the findings with regard to the effect of the OSHA.

The Background of Coal Mine Safety Legislation

In perhaps no other regulatory context is the clash of public and private purposes clearer than that of coal mining safety. In fact, some critics reduce this contest to “safety versus profit.” Accepting this dichotomy, Edward Greenberg (1977, p. 13) actually argues that the struggle for coal mining safety captures “the essence of American political life.” How successful has the federal quest for safety in the coal mines been? Compared to other regulatory agencies, few have less ambiguous and more commanding measures of success than the Bureau of Mines (later the Mining Enforcement and Safety Administration)—this measure is the number of miners killed or injured.1 Historically, no other occupation has been so dangerous as mining coal. Since 1900, over 100,000 miners have met death on the job. To this figure could be added the hundreds of thousands of miners who were permanently injured or died a “slow death” from “black lung.”

These extremely hazardous working conditions brought early federal attention, beginning with the formation of the Bureau of Mines in 1910. Eventually, in 1941, 1952, and 1969, Congress passed major legislation designed to improve coal mining safety. These pieces of legislation are products of spectacular mining disasters (Bethell, 1972, pp. 77–80; Coleman, 1943, p. 281; Graebner, 1976, pp. 1–2; McAteer, 1973, p. 213; Wieck, 1942, pp. 6, 116). Following a pattern common to other regulatory enactments, public outrage culminated in the passage of laws to prevent recurrence of such unwanted events. Referring to the 1941 Mine Inspection Act, Wieck laments (1942, p. 131), “Dead miners have always been the most powerful influence in securing passage of mining legislation.” Ushering in this 1941 legislation were the deaths of 91 miners at Bartley, West Virginia on January 10, 1940 and of 73 miners at Neffs, Ohio on March 16, 1940 (Wieck, 1942, p. 6). A series of explosions in 1951, highlighted by the West Frankfort, Illinois blast killing 119, led to the introduction of various bills and the eventual acceptance of the 1952 Federal Coal Mine Safety Act (Bethell, 1942, p. 79). The latest set of regulations, that of the Federal Coal Mine Health and Safety Act of 1969, came about principally in response to the 1968 explosion in Farmington, West Virginia of the No. 9 mine of the Consolidation Coal Company, which left 78 dead (Bethell, 1972, pp. xii–xiii, 80).

What has been the impact of this regulatory legislation? The responses to this specific question mirror the broader controversy over the effectiveness of government safety regulation. The participants in this particular debate may be grouped, albeit roughly, into three categories: radicals, reactionaries, and reformers.

To the radicals, the coal mine operators’ need for profit overrides any concern they may have for miner safety (Caudill, 1977, p. 493; Graebner, 1976, pp. 3–10; Greenberg, 1977, pp. 10–13; McAteer, 1973, pp. x–36; Nyden, 1970, p. 200; Vecsey, 1974, p. 70). As one miner expressed it, the operator “talks safety in the bath house and ‘Cut Coal’ underground” (Seltzer, 1974, p. 17). Safety is mostly just talked about, because it costs money. To avoid these costs, coal mine owners and operators lobby vigorously to defeat safety legislation. Failing that, according to the radical critics, they “capture” the regulatory agencies, the key legislators, even the miners’ union. Bemoaning the domination of the Bureau of Mines by the coal industry, David Brooks, former chief economist for the bureau, commented, “The Bureau of Mines still doesn’t know it’s a regulatory agency” (Bethell, 1972, p. 96). After the Farmington disaster of 1968, only one West Virginia member of Congress, Ken Hechler, bucked local coal interests and took a strong stand for forceful safety legislation (McAteer, 1973, pp. 181–84). Tony Boyle, president of the United Mine Workers of America at the time of the Farmington explosion, absolved Consolidation Coal of responsibility, explaining that “as long as we mine coal, there is always
this inherent danger. ... This happens to be one of the better companies” (Greenberg, 1977, p. 6). In sum, the radicals believe that the negative influence of the coal industry guarantees that any regulatory activity will be largely symbolic, salving the public conscience until the next big mine disaster. This disaster, which inevitably erupts, reinforces the radical view that federal mine safety legislation has had no effect.

Reactionaries share with radicals the belief that these regulations will not make the mines safer, but their reasons are very different. In the words of George Judy of the Bituminous Coal Operators Association, “I don’t think you can legislate safety” (Bethell, 1972, p. 81). From this perspective, laws cannot significantly affect mine safety because they fail to touch on the two principal causes of mining accidents: the inherent dangers in the activity of mining coal and the carelessness of the miners (Bethell, 1972, pp. 14, 81; Graebner, 1976, pp. 94–95, 162; McAteer, 1973, pp. 13–16, 28–31, 231). Summarizing state inspectors’ reports in the Progressive era, Graebner (1976, p. 95) illustrates the second point: “Everywhere ... [miners] rode illegally on mine cars, carried too much powder into the mines, used the wrong oils in their lamps, failed to timber properly their working places, and were careless in handling explosives.” Recently, Ralph E. Bailey, chairman of Consolidation Coal Company, the industry’s largest employer, asserted that such carelessness, lack of motivation, and human error remain the real causes of accidents in the mines (Business Week, 1977, p. 79).

Reformers are more optimistic about the effects of legislation than either radicals or reactionaries. They come from that broad sector of liberal opinion which believes it desirable and possible to enact laws reducing dangers in the mines. Admittedly, the competitive market pushes coal operators to pursue profit over safety. Therefore, if safety is wanted, according to the reformers, the government must impose regulations to induce companies to do what would not normally be in their economic interest (Anderson et al., 1978, p. 349; Hair, 1968, p. 560). And, for the true reformer, this regulatory legislation is more than symbolic. Instead, it is guided by what has been referred to as the British theory of “rigid laws and law enforcement” for coal mine safety (Wieck, 1942, p. 106).

These perspectives—radical, reactionary, reformer—provide an orientation to the coal mine safety issue. It is now appropriate to move to a statistical model which allows us to assess the actual effects of the legislation.

The Effects of Coal Mine Safety Legislation

To evaluate the impact of coal mine safety legislation, we employ multiple interrupted time-series (MITS) analysis, a procedure which policy studies have neglected. Application of an interrupted time-series logic to policy evaluation has been advocated for some time (Campbell, 1969; Campbell and Stanley, 1966). However, methodological difficulties, mostly involving the modeling of the interruption and of the error process, retarded its statistical use. These problems now seem largely overcome (Box and Tiao, 1975, Campbell and Cook, 1979; Hibbs, 1977). This methodological resolution has coincided with the appearance of a number of substantive examples of simple interrupted time series (SITS) involving assessment of a single policy intervention (see Albritton, 1979; Lewis-Beck, 1979; McCrone and Hardy, 1978). Thus SITS analysis is a rather well-established research tool among practicing policy evaluators. But interest in MITS has remained essentially in the methodological domain (Box and Tiao, 1975; Hibbs, 1977). This article counters such emphasis by providing a substantive policy investigation which employs the MITS design. We hope that this example will heighten the reader’s appreciation of the utility of the design for research in other policy areas. Whenever one wishes to assess the impact of repeated policy changes over time, MITS analysis seems the preferred strategy. A number of areas of federal policy, e.g., housing, antitrust legislation, labor-management relations, would appear to lend themselves to this approach.

This introduction opens the way for detailed consideration of the effects of coal mine safety legislation. Annual figures on a measure of coal mining injuries, \( Y_t \), can be plotted over an extended number of years. The research issue is whether the observations in this time series have been affected by the safety legislation. Take the Mine Inspection Act of 1941 as an example. Informally, to assess the effect of this act, we can simply look at the shift in injuries after 1941. Formally, we worry about whether the observed change is statistically significant, thereby reducing the likelihood of chance differences. Correct estimation of the following regression equation would permit statistical evaluation of this simple interrupted time-series design:

\[
Y_t = b_0 + b_1 X_{1t} + b_2 X_{2t} + b_3 X_{3t} + e_t, \tag{1}
\]

where \( Y_t \) = annual observations on coal mining injuries; \( X_{1t} \) = a counter for years, from 1 to \( N \),
the number of observations; $X_{2t}$ is a dichotomous variable scored 0 for observations before 1942, and 1 for 1942 and after; $X_{3t}$ = a counter of years, scored 0 for observations before 1942, and 1,2,3... for 1942 and after; $b_0,b_1,b_2,b_3 = \text{parameters to be estimated, } e_t = \text{error.}$

The parameters $b_0$ and $b_1$ indicate, respectively, the level and slope of the time-series prior to implementation of the 1941 regulations. To evaluate whether $b_0$ and $b_1$ were altered by these new federal regulations, we must examine $b_2$ and $b_3$. If the estimate for $b_2$ is not significantly different from zero, then we infer the legislation had no effect on the level of the time series. Similarly, if the estimate for $b_3$ does not differ significantly from zero, the inference is that the legislation had no effect on the slope of the time series.

Of course, Equation (1) is only expository, for it ignores the impact on injuries of the 1952 safety legislation. Introducing these interventions involves a straightforward extension of the preceding logic, and yields a multiple interrupted time-series design represented by the ensuing regression equation:

$$Y_t = b_0 + b_1 X_{1t} + b_2 X_{2t} + b_3 X_{3t} + b_4 X_{4t} + b_5 X_{5t} + b_6 X_{6t} + b_7 X_{7t} + e_t,$$

where $Y_t$, $X_{1t}$, $X_{2t}$, $X_{3t}$ are defined as with Equation (1); $X_{4t}$ is a dichotomous variable scored 0 for observations before 1953, and 1 for 1953 and after; $X_{5t}$ is a counter for years, scored 0 for observations before 1953, and 1,2,3... for 1953 and after; $X_{6t}$ is a dichotomous variable scored 0 for observations before 1970, and 1 for 1970 and after; $X_{7t}$ is a counter for years, scored 0 for observations before 1970, and 1,2,3... for 1970 and after. Hence, $b_4$ and $b_5$ capture the short- and long-run impacts of the 1952 legislation, $b_6$ and $b_7$ those of the 1969 legislation. Through estimation of this model, then, we are able to determine the probable effects of the various pieces of federal safety legislation on coal mine safety.

We have now developed measures for our independent variables, the federal safety regulations, but our dependent variable, coal mining injuries, has been left undefined. While coal mining accidents can be counted a number of ways, we have selected “fatalities per million man-hours” worked during the year, $F_t$, as our central measure.\(^2\) Several advantages accom-

\(^2\)For continuity, we keep the Bureau of Mines description, “million man-hours,” although since

pany this measure. First, it focuses attention on the most serious type of injury. Second, it also serves as a more general indicator of mining injuries, correlating .81 with “non-fatal injuries per million man-hours.” Third, it is standardized, varying neither with the annual number of strike days (as the annual “fatalities per thousand employed” would) nor the size of the work force (as “number of fatalities” would). Fourth, of all available safety measures it is the most relevant for miners, informing them whether their chances of being killed on the job are increasing or decreasing. For this variable, in conjunction with the other variables eventually to be considered below, annual data back to 1932 are obtainable, providing a sample adequate to test the MITS model of Equation (2).\(^3\) Estimating that model with ordinary least squares (OLS) yields:

$$F_t = 1.493 - .001X_{1t} - .096X_{2t} - .045X_{3t} (18.7) (-.1)(-.9)(-2.6)$$
$$+ .151X_{4t} + .047X_{5t} - .120X_{6t} (1.7)(3.7)(-1.1)$$
$$- .091X_{7t} + e_t; \quad (3)$$

where the values below the parameter estimates \(= \text{the } t\)-ratios; \(R^2 = \text{the coefficient of multiple determination; } N = \text{the number of observations (1932–1976); } D-W = \text{the Durbin-Watson statistic.}^4\)

\footnote{1973, more than 2,000 women have begun working in the mines (Joffe, 1979, p. 23).}

\footnote{2The data for annual fatalities per million man-hours ($F_t$), nonfatal injuries per million man-hours ($N_t$), fatalities per thousand employed ($E_t$), percentage of mines producing less than 10,000 tons of coal ($S_t$), tons of output per man-hour ($T_t$), and percentage of miners working underground ($U_t$), were gathered from volumes of the Minerals Yearbook, the Bureau of Mines, Department of the Interior. The figures on annual appropriations for health and safety to the Bureau of Mines (later MESA), $B_t$, are from the relevant volumes of the Budget of the United States Government. For all these variables, observations were available from 1932–1976, except for $S_t$ and $U_t$, with observations from 1932 to 1975.}

\footnote{3For ordinary least squares (OLS) to yield desirable estimators, one necessary assumption is that the error terms are not autocorrelated. A Box-Jenkins (1970) analysis of the autocorrelation and partial autocorrelation functions of the residuals from Equation (3)
The scores on the fatality index range from 1.7 in 1932 to .4 in 1976, indicating that the risk of fatal injury from coal mining is less than one-fourth what it was 45 years ago. How much did federal mine safety legislation contribute to this reduction in the death rate? The $R^2$ of .88 demonstrates that the ensemble of safety legislation variables accounts for the downward trend in deaths rather well. Inspection of the parameter estimates offers more detail. The short-run changes (1941-42, 1952-53, 1969-70) are statistically insignificant at the .05 level, two-tail (none of the t-ratios of $b_2$, $b_4$, $b_6$ exceed 1.2). This absence of a significant short-run influence is unsurprising, for one would not expect the safety regulations to be fully operative so soon after passage of the legislation. Rather, if there is a deterrent effect, it should emerge over the span of years, as it indeed appears to.

Proper combination of the Equation (3) parameter estimates provides a simple regression fit within each time period, and these are sketched over the observations plotted in Figure 1. One sees that in the 1930s, without the impetus of federal regulation, the risk of a mortal accident in the coal mines was high, and exhibited no downward drift (regard $b_1$). However, after the Mine Inspection Act of 1941, the death rate steadily moved downward. This improvement in mine safety is quantified by $b_3$, which is statistically significant. Again, subsequent to the Federal Coal Mine Health and Safety Act of 1969, we witness a significant slide in the fatality rate (see $b_7$). Substantively, the gain in safety during this period is far from inconsequential. To illustrate, a coal miner in 1964 was about twice as likely to be killed on the job as a coal miner in 1974 ($F_{64}/F_{74} = 2.1$).

The 1941 and 1969 federal safety legislation appear to have diminished significantly the risk of receiving a fatal injury while mining coal. However, we have thus far ignored the anomalous results of the 1952 legislation. This set of

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### Figure 1. Multiple Interrupted Time-Series Analysis of the Coal Mining Fatality Rate (1932–1976)

regulations did not increase mine safety. Instead, it apparently arrested the downward trend in the death rate stimulated by the 1941 legislation \((b_3 + b_5 \approx 0)\). The stabilization of accident conditions in this epoch is easily seen in Figure 1, where the points trace a flat line from 1952 to 1969. Why did the 1941 and 1969 laws work? While this 1952 law did not? We pursue this question in detail below. First, though, we must strengthen confidence in the findings of Equation (3). While these results convince us, the skeptic might find them somewhat remote. After all, the independent variables in the equation simply count years, not "real" legislative action. If these time counters are actually capturing the course of legislative impact on coal mine safety, then the Equation (3) findings should survive tests of spuriousness.

Suppose other variables influencing coal mining fatalities are correlated with the MITS independent variables and are actually responsible for the findings. Then, if these "third variables" were controlled for, the apparent regulatory effect would disappear. Of the several variables, besides federal regulation, which might be expected to influence coal mining injuries, we managed to assemble satisfactory measures on three: technology, mine size, type of mining. Technological advances in coal mining involve the introduction of machines to do work formerly done by hand. Such mechanization has frequently been held responsible for heightening the risk of death in the mines (Coleman, 1943, p. 281; McAteer, 1973, pp. 16–17, 198; Wieck, 1942, pp. 79–103). For example, Wieck charges that it increases the amount of explosive gas, coal dust, electricity, fire hazard, and total work time, thus reducing mine safety (1942, pp. 98–100). There is some evidence, however, that technology can make mining less risky (Andrews and Christenson, 1974, pp. 169–73; Hair, 1968, pp. 550–54). Regarding measures of the technology variable, Andrews and Christenson (1974, p. 367) argue on conceptual grounds for "tons of output per man-hour," \(T_t\), which is the indicator we shall employ. Many smaller mines make their appearance during boom periods, only to disappear when demand slackens. Seltzer (1947, p. 9) well describes the historic pattern: "When times were good, a half-dozen strong-backed men with dynamite, picks, shovels, some lengths of mine track, and a couple of ponies could punch a mine into the side of a hill." These and other small mines have been regarded as less safe by some, more safe by others (Andrews and Christenson, 1974, pp. 369–73; Hair, 1968, pp. 554, 558; McAteer, 1973, pp. 237–38). The extent of small mining operations, \(S_t\), will be indicated by their annual percentage in the mine population (technically, this means the percentage annually classified as producing less than 10,000 tons of coal).

There are two general categories of mining: underground mining (or deep mining), and surface mining, which consists of strip and auger mining. While surface mining is dangerous, it is less so than deep mining (National Safety Council, 1977, p. 35). In recent years, the portion of total United States coal production mined underground has decreased (Dials and Moore, 1974, pp. 19–20). The reduced production costs of strip mining, the more limited unionization of strip miners, the low sulfur content of western strip coal, have been offered as reasons for moving away from underground mining (Nyden, 1970, p. 197; Seltzer, 1974, pp. 19–20; Williams et al., 1978, p. 35). This implies the significant safety effect we found for the 1969 legislation is spurious, attributable in fact to the decline in hazardous deep mining which occurred in the post-1969 period. To check this possibility, we introduce the variable, \(U_t\), annual percentage of miners working underground, as a control.

Our original Equation (3) uncovered significant, long-run effects for federal safety legislation (see \(b_3, b_5, b_7\)). Here we have cast doubt on these results, speculating they are caused by the "third variables," \(T_t, S_t, U_t\). Below, we enter these variables into the MITS model indicated by the Equation (3) findings, in order to investigate this prospect (the Durbin-Watson statistic from OLS estimation suggested an autocorrelation problem; therefore, the parameters were estimated with the Cochrane-Orcutt procedure; see Kmenta, 1971, pp. 287–89):

\[
F_t = 0.322 + 0.14 X_{1t} + 0.057 X_{3t} + 0.068 X_{5t} - 0.124 X_{7t} - 0.131 T_t + 0.006 S_t + 0.009 U_t + e_t;
\]

\[
R^2 = .90 \quad N = 43 \quad D-W = 2.1.
\]

Equation (4) provides a more satisfactory specification of the determinants of the coal mine fatality rate. Although variations in mining technology do not appear important, the presence of small mines and the degree of deep mining do contribute significantly to an explanation of mine safety. Smaller mines seem
riskier, as do underground mines. These variables round out our understanding of what brings death to the miner, but they do not substitute for the regulatory influences described earlier. In fact, according to Equation (4), the effects of the federal safety legislation are not at all spurious. Instead, we continue to observe the pattern of significant legislative intervention noted in Equation (3), with effects fully as robust (compare $b_3, b_5, b_7$ from both equations).

The Conditions for Effective Safety Legislation

Thus far, we have not explained why these coal mining safety laws have worked as they do. When we examine the content of the laws, and the context of their passage and implementation, suggestive associations are discovered. These relationships point to some necessary ingredients for effective coal mine safety legislation, as well as for safety legislation generally. Below, we focus on the conditions of enforcement, provisions and position in a sequence of legislation (referred to here as "birth order"). In the conclusion we find it appropriate also to consider the factors of target population and goals.

1941: The "First" Law. Under the Mine Inspection Act of 1941, federal mine inspectors were given the right to enter the mines, where they could carry out inspections, investigate accidents, and make safety recommendations. The beneficial effect of this law, which the MITS analysis detects, is perhaps surprising, for the safety recommendations were not mandatory. Why, then, did it bring about a significant reduction in the coal mining fatality rate? The law appears to have been effective because it was the first law introduced into a lawless situation. At the national level, the rules for mining safety were suddenly changed from none to some. Until then, safety conditions were determined by the operators, who had neutralized the influence of the state regulatory agencies. In this highly competitive industry plagued by narrow profit margins, safety was routinely sacrificed to production and profit. The arrival of the federal inspectors, who had never before been permitted to enter the mines, unsettled operators, many of whom branded the law as "sheer Communism" (Bethell, 1972, p. 78). Still, the presence of federal inspectors was bound to produce safety improvements, even if grudgingly instituted. Workplace safety had been so neglected that a number of improvements could be made simply and cheaply. Surely, in response to or in preparation for the federal inspector's visit, some operators would be moved to narrow the spacing of the roof bolts, replace a fallen support, remove piles of explosive dust, check the machinery wiring, or put a protective canopy over the mine entrance.

Further, more subtle changes were hoped for as a result of the law. Edward Wieck (1942, p. 139), in his otherwise critical review, expresses these hopes well: "Federal inspection of mines will put the Bureau more closely in touch with the industry and bring about a wider acceptance of its safety standards and procedures, particularly by state mining departments, and probably, in the beginning, to a lesser extent by management." That is, the state agencies would be encouraged to apply the federal standards, and the operators would be made to feel a part of the "community of concern" over safety. The latter seems especially important, for it suggests the owners might be socialized, to some extent, to the more public role of promoter and protector of safety.

The 1941 law, then, derived considerable influence from its "birth order." An implication is that the beneficial effects of this "first" law would be short-lived, in the absence of strong provisions which allow its impact to be sustained. That is, once the operators have carried out the low-cost safety improvements and reached a new psychological equilibrium regarding their role in assuring miners' safety, additional safety effort and, hence, further declines in fatalities would be unlikely. If we examine Figure 1, this is in fact the pattern we observe. The scatter of points in the late 1940s and early 1950s indicates a stabilization of the fatality rate. Safety conditions in the mines were entering a plateau when the 1952 legislation was passed. As the MITS analysis demonstrates, this 1952 legislation was too weak to push the fatality rate below that plateau.

1952: The "Symbolic" Law. By 1952, the energies of the 1941 legislation were spent. A new law was needed to restore the downward momentum in the death rate initiated by the earlier legislation. However, this new law had to have rather firm and comprehensive provisions, for it could not benefit from being first, as the 1941 law had. The federal government had now established itself as a presence in the coal fields, and operators had made the necessary adjustments. Tangible changes had to be forthcoming in order to continue driving down fatalities. Unfortunately, the final provisions of the 1952 Federal Coal Mine Safety Act allowed no more than maintenance of the safety level prevailing.
toward the end of the period under the 1941 law (see the flat line, 1952–69, in Figure 1).

In examining the failure of the 1952 act, Andrews and Christenson (1974, p. 374) turn to the weak provisions of the bill. The Bureau of Mines’ enforcement powers were limited to safety measures aimed at preventing major disasters, which accounted for less than 10 percent of all fatalities. Furthermore, the legislation did not cover small mines (employing fewer than 15 miners), which made up about 80 percent of all mines. As noted in Equation (4), it is precisely in these small mines that fatalities are more likely to occur. Thus, the 1952 legislation formally put beyond its reach almost all the sources of fatal mining accidents.

Besides this extreme narrowness of scope, which President Truman himself protested, the coal operators and the United Mine Workers of America (UMWA) exhibited a special lack of commitment to its enforcement (McAteer, 1973, pp. 96–101, 181). The companies, worried about falling production, persuaded the UMWA to accept mechanization of the mines in exchange for better wages and benefits. Given the workings of the agreement, signed by John L. Lewis in 1950, the UMWA began to direct itself to the goal of increasing production rather than safety. As Seltzer reports (1974, p. 10), the 1952 contract was succeeded by an end to the adversary relationship with management, and no official strikes occurred before 1972.

The 1952 law was an exceedingly weak law whose enforcement was pursued by neither the union, management, nor the Bureau of Mines. The public, in response to their outrage over the 1951 West Frankfort mine explosion which killed 119 persons, had received only a “symbolic” piece of legislation. However, after its passage, public concern followed the typical pattern of turning to other issues, assuming the mine safety problem was solved. According to Bethell (1972, p. 80), it was not until the Farmington disaster of 1968 that interest in coal mine safety was rekindled. To borrow Bethell’s dramatic lines, “It was the beginning of a grim realization: that there were actually people running around who still mined coal for a living, and that they were being killed at their jobs by profit-hungry operators, a corrupted union interested only in the health of its treasury, and a government that seemingly could not care less” (1972, p. 80).

1969: A “Tough” Law. The Federal Coal Mine Health and Safety Act of 1969 is a “tough” law, at least relative to the others. As Harry Caudill, long-time advocate for the Appalachian miner, exclaimed, “For the first time the federal government undertook to rein in and civilize the vast, fragmented, widely dispersed and still ideologically laissez-faire coal industry” (1977, p. 493). In particular, under the 1969 legislation the enforcement powers of the federal inspectors were much expanded and a detailed set of health and safety standards made mandatory for all mines (McAteer, 1973, pp. 213–19). Specification of the standards covers hundreds of pages in the manuals of regulation. These standards have, in the words of mineral economist Richard Newcomb, “changed working practices” in the coal mines and contributed to a more than 30 percent reduction in output per miner (1978, p. 207). By another estimate, eastern deep mining costs have been rising at an annual rate of 10 percent in constant dollars, an increase attributed largely to implementation of the 1969 requirements (Gordon, 1978, p. 155). Thus the stiffer 1969 regulations have advanced their primary goal of providing safer working conditions for miners, even in the face of a costly drop in productivity.

The 1969 legislation seems to offer a long-run solution to the coal mine safety problem, i.e., under its continued enforcement, safety should eventually reach an acceptable level. The strength of the 1969 act is further appreciated when compared to the 1941 act. The latter, while effective, obviously has the weaker provisions. Therefore, we would expect the 1941 law to have less effect than the 1969 law. Indeed, the relevant coefficients from Equation (3) indicate the 1941 law was about half as strong as the 1969 law has been ($b_3/b_7 = .5$). Beyond doubt, the harsher provisions of the 1969 act have made the coal mines safer.

1941, 1952, 1969: Variations in Enforcement. Above we have tried to explain the relative effect of the federal coal mine safety laws. For the most part, we relied on description of the laws and presentation of seemingly relevant facts. It is to be hoped that this exploration enhances understanding of the workings of this legislation. Still, it would be helpful to have more systematic data on the difference in regulation under the three laws. A critical need here is information on enforcement activity. A law, no matter how well written or favored by birth, comes to nothing if it is not actually enforced. The enforcement of coal mining safety legislation, the responsibility of the Bureau of Mines (later MESA), includes such activities as inspections, investigations, rescues, and research (McAteer, 1973, pp. 196–97). A global measure of these activities over time is available—agency expenditures on safety. Of course, a potential problem with the expendi-
tasures variable is that, while it summarizes enforcement activities, it may nevertheless be unrelated to reduction in fatalities, which is the goal of enforcement. Therefore, the use of safety expenditures as an overall measure of enforcement is justified only to the extent that it is linked to the fatality rate. Fortunately, this link is quite strong.

If the Bureau of Mines (later MESA) health and safety budget, \( B_t \), is a proxy for federal safety enforcement in the coal mines, we would expect a high negative correlation with the fatality rate, \( F_t \), which it has, \( r = -0.78 \). (When the budget figures are deflated, 1967 = 100, the correlation remains virtually unchanged, \( r = -0.77 \).) While this correlation is substantial, the requisite assumption of linearity is unsatisfactory because the budget variable, like many dollar measures across time, follows an exponential path. Therefore, we applied a natural logarithmic transformation to \( B_t \), in order to "straighten it out." This transformation boosts the correlation with the fatality rate to \(-0.90\).

Figure 2 plots the annual federal coal mine health and safety budget (logged). The pattern of points indicate that safety expenditures have responded strongly to changes in federal legislation. Observe, for example, the sharp upward trend in spending after 1941, or the big leap up from 1969 to 1970. These shifts are more accurately described when the original MITS model in Equation (3) is fitted to the data. Assuming the independent variables of the model tap real changes in federal regulatory policy, we would expect findings on the budget would reinforce the fatality findings. That is, the vaunted 1941 and 1969 legislative acts would, in the long run, spur safety spending, whereas the maligned 1952 legislation would slow it; specifically, \( b_3 > 0, b_7 > 0, b_5 < 0 \). Short-run prediction is more difficult. Equation (3) suggests that the fatality rate was not significantly affected the year after the legislation, which is understandable given the time required to implement the regulations fully. When the dependent variable is health and safety spending, however, one supposes that increases would follow passage of the legislation rather quickly. Therefore, we would expect that the 1941 and 1969 bills would precipitate sudden spurts in the budget, while the 1952 act would cause an immediate budget cut; speci-
fically, $b_2 > 0$, $b_6 > 0$, $b_4 < 0$. These predictions are generally sustained in the following OLS equation:

$$\ln B_t = 6.497 - .007X_{1t} + .582X_{2t}$$

(58.5) (-.4) (4.1)

$$+.135X_{3t} - .125X_{4t} -.067X_{5t}$$

(5.7) (-1.0) (-3.9)

$$+ 1.174X_{6t} -.077X_{7t} + e_t;$$

(7.5) (2.4)

$$R^2 = .99 \quad N = 45 \quad D-W = 1.5.$$  

The estimates of Equation (5) repay consideration. In the 1930s, the bureau's annual health and safety budget was merely symbolic, averaging just over $500,000, and changing little from year to year (see $b_1$ and the regression line in Figure 2). However, in the wake of the 1941 act, health and safety appropriations increased significantly, for both the short and long run (see $b_2$ and $b_3$). In fact, they began to rise at an average rate of about 13 percent a year ($b_1 + b_3 = .13$). But the 1952 bill, remarkably, elicited no initial budget increment (see $b_4$), and under it the growth rate was dampened significantly (see $b_5$). These statistics underline the weakened commitment to mine safety during that period. It took the passage of the 1969 legislation to refurbish the financial commitment to coal mine safety. From 1969 to 1970, the bureau's health and safety funding actually increased over 100 percent. And for all the years subject to the legislation, the rate of appropriation growth has been 14 percent, more than double that of the post-1952 era. (This estimate is actually conservative.)

The collection of MITS variables recording changes in coal mine safety legislation faithfully maps variations in federal enforcement, as measured by the budgetary outlay for coal mine health and safety. Indeed, they account splendidly for such expenditures, as the $R^2 = .99$ indicates. These shifts in the safety enforcement effort mirror the shifts in the fatality rate. Under the stronger legislation (that of 1969 and, to a lesser extent, of 1941), safety expenditures were pushed up and the fatality rate pushed down. In contrast, when the weaker law (the 1952 act) dominated, or there was no law at all (the 1932–1941 period), the safety budget and, consequently, the fatality rate held fairly steady.

Conclusions

Our empirical research began with the question, "Has federal safety legislation reduced the hazards of mining coal?" To provide an answer, we employed multiple interrupted time-series analysis, a neglected procedure in substantive policy investigations. The complex of findings from this analysis would have been predicted by no single political perspective—radical, reactionary, or reformer. While the failure of the 1952 legislation may have surprised reformers, it is congruent with a radical interpretation of the effects of this regulation. However, a radical view does not account for the success of the 1941 and 1969 acts. These efforts demonstrate that government can bend the will of the coal operators, regardless of their quest for profit. Further, these results undercut the reactionary critique, for they show that accidents can be curbed, even in a highly dangerous activity carried out by fallible human beings. Apparently, then, it is possible for Congress to enact laws that successfully regulate American business for some public purpose, such as safer coal mines. Indeed, a 1976 coal miner was over four times less likely to be killed while working than a 1932 coal miner, a fact attributable in no small way to federal safety legislation.

Finally, it should be noted that a strong, significant effect of the 1969 legislation (along with the significant effects of the 1941 and 1952 legislation) persists even when these expenditures are deflated (1967 = 100). Thus the budgetary changes detected here are not attributable simply to the force of inflation.

Nevertheless, we should not become complacent about coal mine safety. An idea of coal mining safety advances that could still be made comes from comparing the United States to Great Britain. Unfortunately, the preferred measure, "fatalities per million man-hours," $F_t$, is not available for the British case.
Why did the 1941 and 1969 safety laws work? Our look at the context, substance, and workings of the legislation suggested some simple, proximate conditions: the birth order, enforcement, and provisions of those laws. To this brief list, we might add target population and goals. Let us summarize these conditions as they apply to the legislation at hand. The 1941 act, because it was the first set of rules in a hitherto unruly situation, had an impact which belied its actual content. Further, enforcement of the 1941 law was relatively vigorous, as indicated by the strong increase in the Bureau of Mines’ safety budget. Enforcement was still more intense for the 1969 legislation. Moreover, the provisions of the 1969 act, which are comprehensive, detailed, and mandatory, further enhanced its strength. However, beyond these factors, the smallness of the target population has undoubtedly contributed to the success of both pieces of legislation. That is, they aimed to regulate only coal mining, rather than some larger industry or set of industries. Finally, the nature of their goals must account for part of their beneficial effect. Coal mine safety poses a single, narrow, measurable objective. It is not multiple, broad, or difficult to measure, as the goals of legislation sometimes are.

What are the implications of the coal mine safety experience for federal regulation of safety in other workplaces? Specifically, what is suggested with regard to the impact of the OSHA? Certain conditions conducive to effective safety regulation in the mines would also seem operative for the OSHA. Most obviously, it is the first federal legislation aimed at the general regulation of occupational safety. Nevertheless, not too much should be expected from this birth order advantage, since the federal presence remains remote for most businesses. For example, in 1976, the chances were less than 1 in 50 that a workplace would ever be visited by an inspector (Nichols and Zeckhauser, 1977, p. 53). Still another factor favoring the OSHA is the relative strength of its provisions. Thousands of mandatory standards have been developed, spelling out in detail the safety requirements for different workplaces.

In contrast, other conditions appear to operate against the OSHA’s success. A critical one is the lack of strong enforcement. Budget figures provide dramatic testimony on the limitation of OSHA enforcement. The 1977 budget was $130 million, little more than the amount provided for enforcement of coal mine safety, despite the fact that with this sum the agency must police a target population consisting of the nation’s five million workplaces. Finally, there is a practical problem concerning the detection of the OSHA’s success. The goal of occupational health and safety perhaps seems rather specific when compared to the goals of other regulatory agencies. Yet actually measuring its attainment appears a monumental task, when one realizes the size of the target population. In addition, the measurement problem has been compounded by the OSHA legislation, which changed the method of collecting data on injury rates, thus making pre- and post-OSHA comparisons problematic.

The future of federal policy toward occupational safety is difficult to foresee. However, any politically acceptable approach, whether interventionist or noninterventionist, will probably not have a dramatic effect on the accident rate in the American workplace, at least in the short run. Nichols and Zeckhauser (1977, p. 66), in their discussion of the OSHA, remark, “As distasteful as it may be, given the competing claims for resources, we may have to accept a significant level of occupational accidents as a cost of doing business.” Nonetheless our research indicates that at least under some conditions government can regulate safety. Further, in regard to the OSHA our research on coal mining safety suggests that direct OSHA intervention would be more successful if it confined itself to industries with “high risk” jobs. That is to say, the OSHA should make a special effort to identify occupations which, like coal mining, are unusually hazardous. Then, it should concentrate its resources, which will undoubtedly remain limited, on making those dangerous occupations as safe as work in other industries.

References
Anderson, James E., David W. Brady, and Charles