Chapter 6

TESTING THE MODEL II: THE EFFECTS OF "HISTORICAL" FACTORS ON ORGANIZATIONAL "CONCERN"

The previous chapter considered the impact of organizational "concern" on radiation in mines. "Concern," it was found, did make a difference. Government regulation was highly effective in lowering radiation. A stepped up program of inspections and sanctions against operators who violated radiation codes was associated with dramatic reductions in radiation. Mines subject to the costly sanctions involved forced removal of men from hazardous mines and cessation of production.

The efforts of the largest Colorado mining companies to monitor radiation in advance of government regulations requiring them to do so also had an effect. Mines owned by such companies had lower radiation levels than their small-company counterparts in the days before regulation. Most company efforts, by small and large firms alike, however, occurred in the 1960s following the initiation of official control programs and restrictive legislation.

This chapter will recede one step further in the hypothesized chain of events that created and ultimately cured a lung cancer epidemic among uranium miners. The question here is, What did it take to arouse the concern of those in a position to do something about the hazard? The answer to that question may also resolve why the mere availability of the necessary technology was not enough.

NATIONAL URANIUM NEEDS

Uranium's importance lies in its energy generating abilities. During the 1940s and early 1950s, it was mined primarily for use in the production and testing of atomic weapons. Today, uranium promises to be indispensable in meeting energy requirements. The demand for uranium, however, has fluctuated widely over the past quarter century. This fluctuation has been critical. It appears that only when demand for the ore has subsided have steps been taken to reduce the hazard. In fact, government and company actions to improve health conditions in mines has always tracked closely with waning demand and the financial decline of the industry.

The uranium industry experienced its greatest boom during the late 1940s and early 1950s. Under the impetus of government efforts to generate

a domestic uranium capability, new producers flocked to the industry. Bonuses were extended to help defray initial production costs, and the government agreed to buy all uranium that was produced at a generous price. Public land was leased to producers for the extraction of uranium and transportation facilities were provided for producers who mined ore in remote places.

In the push for additional supplies during the 1940s and 1950s, there is even evidence that mineral production on public lands in violation of federal mining laws was overlooked. According to a 1972 news bulletin from the American Mining Congress, the federal government failed to take action to halt the illegal removal of uranium from public lands in the late 1940s and early 1950s because of "uranium shortages and the need for uranium production for national defense."[92] It was only in the late 1950s, the 1960s and then again in 1972 that the federal government considered seeking damages from producers who had violated the law. Such efforts were ultimately abandoned for a variety of practical considerations, including the expiration of the statute of limitations.

The impetus behind the expanded procurement program in the 1940s and 1950s, however, did not last long. As early as 1956, it was announced that there was no longer a uranium shortage, that prospective mineral deliveries would exceed military requirements and that the Atomic Energy Commission's policies would have to change accordingly. In a speech to the annual meeting of the American Industrial Forum in 1957, the director of the Atomic Energy Commission's mineral division stated that uranium deliveries were "adequate for military and power requirements...": and that it was no longer in the interests of the Government to expand production of uranium concentrate."[93] Subsequently, the Atomic Energy Commission announced it would discontinue its program of guaranteed ore purchases in 1962 and thereafter pursue a much modified procurement program. In 1962 all government lands were withdrawn from leasing arrangements.

Despite the ultimate extension of government purchasing of uranium until 1970 through a stretch-out program which delayed the termination of government procurement,[94] the scale of government activities to promote uranium in the 1960s was greatly reduced. Pressures for additional uranium supplies that had characterized the 1950s vanished. Uranium reserves in government possession during the 1960s were so adequate[95] that policies toward the industry changed dramatically. Instead of stimulating extraction, the government took steps to discourage uranium operators from producing altogether. In 1968, for example, the Atomic Energy Commission recommended that the United States remove protective restrictions on the use of foreign uranium.[96] A few years later, in 1971, the Atomic Energy Commission released a more damaging pronouncement. It announced its intention to sell 50,000 tons of uranium concentrate on the open market from its own stockpiles.[97] At the same time, government reserves were in excess of 246,000 tons. Both moves served to increase the supply of uranium at a time when demand was weak. As a result, prices fell and the scope of the market

available to domestic producers was restricted even further.

Although this narrative account tends to support the notion that the demand for uranium supplies peaked in the early 1950s and thereafter declined, an attempt was made to quantify the level of demand for uranium during the study period. The aim of such quantification was to be able to associate trends in demand with the tide in organizational concern, a big link in the hypothesis of this study. The following section presents the quantitative evidence on the trend in demand for uranium over time.

Trends in Uranium Needs

The unparalleled interest in generating uranium supplies during the late 1940s and early 1950s is reflected in the rate at which new producers were attracted to the uranium industry over time, the price paid for the ore, the amounts of ore purchased by the government and the incentives extended by the government to enhance production.

Between 1947 and 1959, the number of uranium miners in the uranium producing states increased at an average annual rate of 13%. Between 1960 and 1970, on the other hand, the number of uranium miners in the nation declined at an average annual rate of -3.8%. (See Table 19)

In Colorado, similar patterns occurred. Between 1950 and 1959 the number of uranium mines increased at an average annual rate of 17%. In the subsequent decade they decreased at an average annual rate of -5.1%. (See Table 19)

Levels of government purchases of uranium underwent a parallel series of increases and decreases. Between 1948 and 1960, for example, purchases had grown at an average annual rate of 57.4%. After 1960, the government bought successively smaller amounts of uranium. During the 1960's these purchases declined at an average annual rate of -15.2%. (See Table 20)

In Colorado, the decline in government purchasing was approximately the same. Between 1947 and 1959, the amount of ore purchased by the government increased steadily at an average annual rate of 42.3%. In the next decade purchasing steadily tapered off. Between 1960 and 1969, the amount of Colorado ore bought by the government fell at an average annual rate of -22.7%. (See Table 20)

In addition to buying smaller amounts of ore in the 1960s, the government paid less and less for what it bought. During the 1950s, for example, the Atomic Energy Commission paid an average of $10.79 for every pound of concentrate. In 1953, 1954 and 1955, the price per pound exceeded $12. Such high prices were never realized again. During

Table 19

Average Numbers of Underground Uranium Miners in All Uranium Producing States and Uranium Mines in Colorado, 1947-1970

Year	All uranium producing states		Colorado	
	Miners	Percent Change	Mines	Percent Change
1947	450		n.a.	
1948	500	11	n.a.	
1949	520	4	n.a.	
1950	550	5	115	
1951	660	20	167	45
1952	733	11	192	15
1953	1,000	36	215	11
1954	1,210	21	295	37
1955	1,530	26	335	13
1956	1,630	6	354	5
1957	1,890	15	378	6
1958	2,925	54	459	21
1959	3,300	12	425	-7
1960	3,498	6	422	0
1961	3,881	10	402	-4
1962	3,617	-6	331	-17
1963	2,698	-29	333	0
1964	2,324	-13	265	-20
1965	2,177[1]	-6	279	+5
1966	2,177[1]	0	283	+1
1967	2,177[1]	0	262	-7
1968	2,177[1]	0	257	-1
1969	2,177[1]	0	239	-7
1970	2,177[1]	0	235	-1

[1] projections

Sources:

Joint Committee on Atomic Energy, Radiation Exposure of Uranium Miners, 1967, p.1012

Columns 4 and 5 compiled from the Bureau of Mines, Annual Reports for the Years 1950-1970, Colorado

Table 20

Atomic Energy Commission Domestic Uranium Concentrate Purchases in Tons of U_3O_8, 1947-1970

Year	Tons of Uranium Oxide purchased from: All Domestic Producers	Percent Change	Colorado Producers	Percent Change
1947	67		67	
1948	102	+52.0	102	+52.2
1949	177	+73.0	175	+71.5
1950	459	+159.0	452	+158.3
1951	766	+66	620	+37.2
1952	874	+14	743	+20.0
1953	1163	+33	940	+26.5
1954	1700	+46	1239	+31.8
1955	2784	+63	1483	+20.0
1956	5958	+114	1726	+16.4
1957	8482	+42	1966	+13.3
1958	12437	+46	2917	+48.3
1959	16239	+30	3278	+12.3
1960	17637	+8	3117	-5.0
1961	17348	-1	2951	-5.3
1962	17008	-1	2652	-10.0
1963	14217	-16	2134	-20.0
1964	11846	-16	1800	-16.0
1965	10442	-11	1290	-28.0
1966	9488	-9	1258	-2.4
1967	8425	-11	840	-33.2
1968	7337	-13	782	-7.0
1969	6184	-15	0	-100.0
1970	2521	-59	0	

Sources:

Atomic Energy Commission, Statistical Data of the Uranium Industry, (Grand Junction, Colorado: U.S. Atomic Energy Commission, January 1, 1972) page 9 ("AEC Concentrate Purchases by States").

the 1960's, the average price paid dropped to $8.02. In 1970, uranium was sold for $5.74 per pound. This was 60% less than the price it had commanded in 1953. (See Table 21)

The amount of public lands leased to private operators for uranium production also declined with the passage of time. For example, between 1948 and 1954, the number of leases issued by the Atomic Energy Commission to private producers increased from one to thirty-five. Mineral output on public lands during this time period increased by more than 1000% at an average annual rate of 74%. As the government realized that there was no longer a uranium shortage, these lands were gradually removed from production. Between 1954 and 1962, the number of government leases dropped from 35 to 6. The amount of ore obtained from public lands dropped 73% from 160,822 tons in 1954 to 42,891 tons in 1962. After 1962, all productive activity on these lands was halted. (See Table 22)

The sluggish uranium market in the 1960's and 1970's was in part due to delays in the diffusion of atomic reactors on a massive scale. Current levels of uranium commitments to utilities and power plant manufacturers falls far below both projected estimates of fuel needs and the productive potential of the industry.[98] The industry cannot hope to find relief from its slim volume of sales to commercial buyers in expanded trade with the government. Current projections put government reserves of uranium as adequate to meet defense needs for the next eleven years.[99]

The Relationship Between National Uranium Needs and Organizational Concern

Trends in the demand for uranium appear to be inversely associated with government and company concern. (See Figure 5) During the 1960's, there was a steady decline in the prices paid for the ore, the amounts of ore purchased by the government and the withdrawal of incentives to enhance production. This coincided with a doubling of government efforts to inspect uranium mines and punish operators who violated radiation codes.

To measure the strength and direction of the relationship between the need for uranium and the intensity of organizational concern, correlation coefficients were computed. Measures of government concern were the annual number of inspections and sanctions issued by government enforcement agents to mine operators. (See Chapter 5, Table 8) Measures of company concern consisted of the yearly expenditures for ventilation by the largest uranium mining companies in Colorado. (See Chapter 5, Table 16) Several measures of national uranium needs were explored. These included the annual price paid for each pound of uranium concentrate, the number of tons of ore purchased by the Atomic Energy Commission from Colorado producers and on a nation-wide basis, and the number of uranium mines that operated in Colorado each year. The best measure of uranium needs was the average price paid per pound of uranium concentrate between 1950 and 1970. The advantage of a price-per-pound measure lies in its ability to reflect both supply and demand. The remaining measures--levels of ore purchased by the Atomic Energy Commission and the number of operating mines--only reflect absolute levels of consumption. Information on these various

Table 21

The Average Price Paid For Uranium, 1948-1971

Year	Average price per pound uranium concentrate
1948	$ 7.14
1949	8.53
1950	9.11
1951	10.10
1952	11.28
1953	12.35
1954	12.27
1955	12.25
1956	11.51
1957	10.49
1958	9.45
1959	9.12
1960	8.75
1961	8.50
1962	8.15
1963	7.82
1964	8.00
1965	8.00
1966	8.00
1967	8.00
1968	8.00
1969	6.99
1970	5.74
1971	5.54

ources: Atomic Energy Commission, Statistical Data of the Uranium Industry, (Grand Junction, Colorado, January 1, 1972.) p.8 ("AEC Domestic Uranium Concentrate Purchases: 1948-1971")

Table 22

A Summary of Atomic Energy Commission Mineral Lease Production, 1948-1962

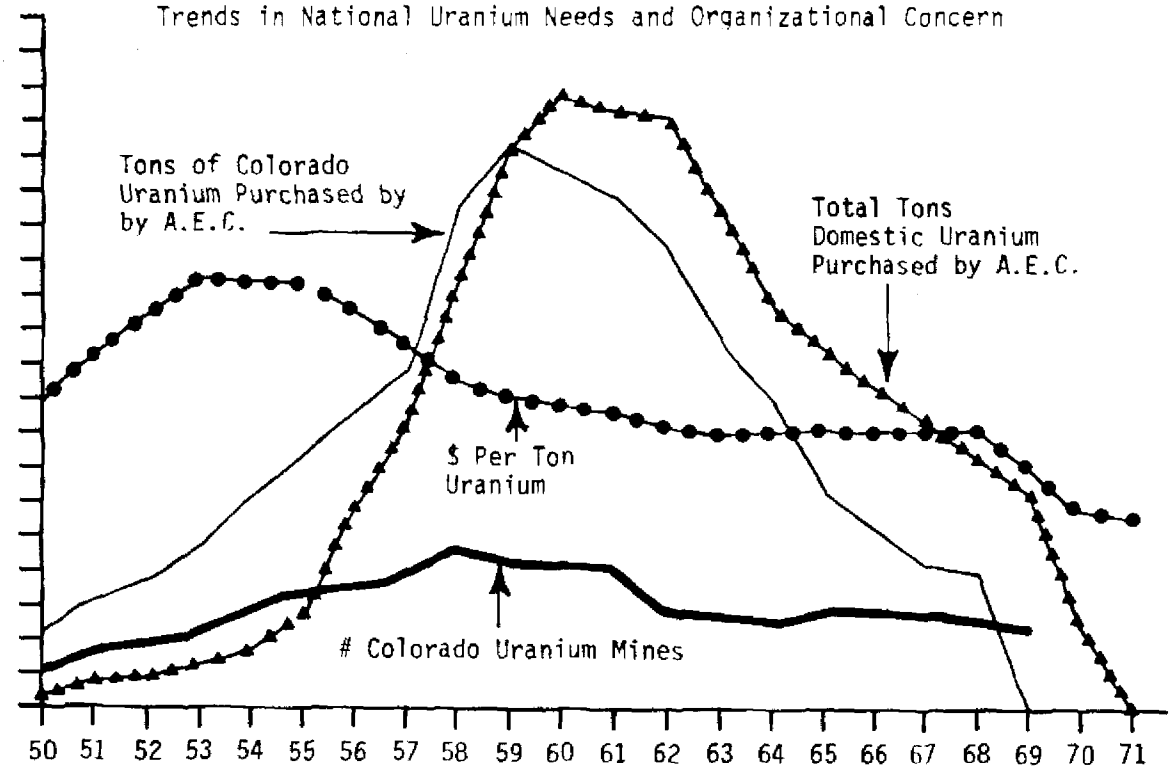
Year	Numbers of leases	Production (dry tons)	Percentage change
1948	1		
1949	8	12,109	+149
1950	12	30,261	+111
1951	17	64,146	+ 57
1952	30	101,050	+ 35
1953	35	136,780	+ 17
1954	35	160,822	- 13
1955	28	138,961	- 10
1956	22	125,048	- 20
1957	22	99,499	+ 21
1958	21	121,481	- 15
1959	16	102,157	- 4
1960	14	97,144	- 38
1961	11	59,625	- 28
1962	6	42,891	

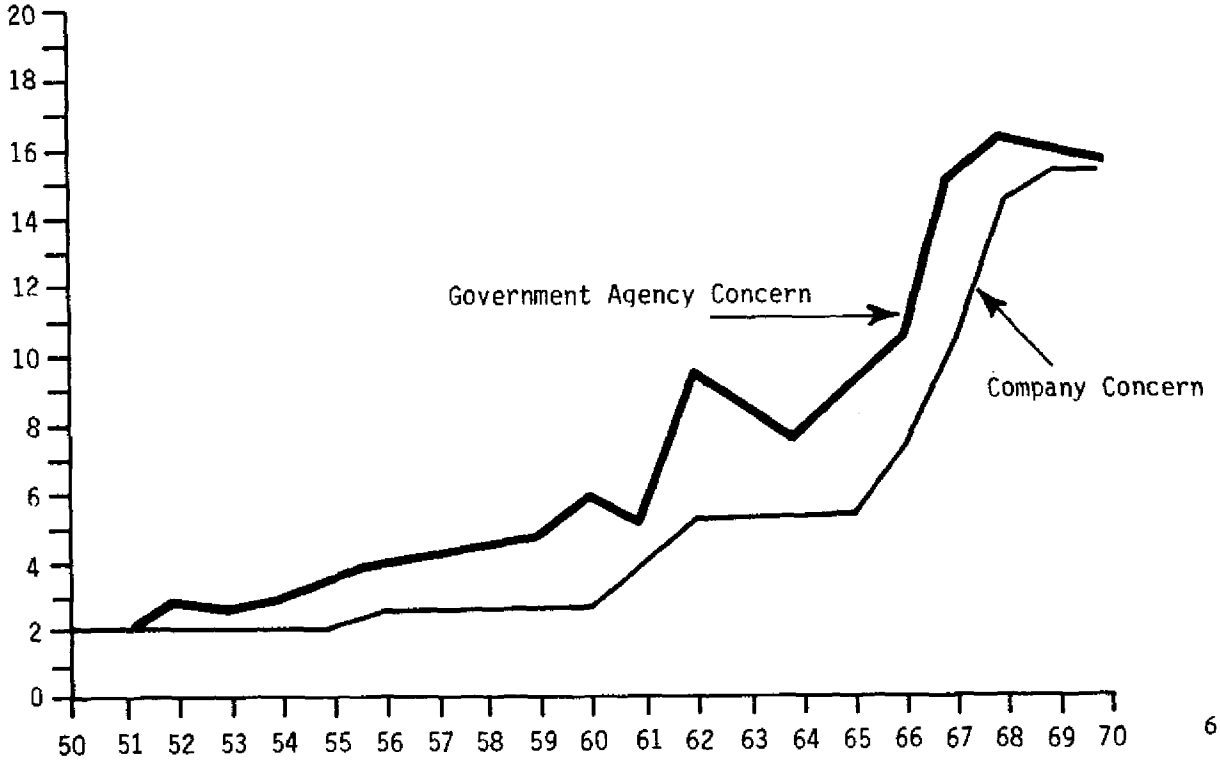
Sources:

Atomic Energy Commission, Summary of AEC Mineral Lease Production, (Obtained from Mr. Gilman Ritter, Grand Junction Office, Colorado, May 1973, Unpublished)

Figure 5

Trends in National Uranium Needs and Organizational Concern





measures of national needs is located in this chapter.

The analysis revealed that the relationship between uranium needs and organizational concern is a negative one for both companies and government agencies; but somewhat stronger for government agencies. The correlation coefficient for annual price per pound and government inspections was -0.779, while the r between price and company expenditures for ventilation was -0.737. (See Table 23) Thus, the relationships predicted were borne out.

HAZARD VISIBILITY

A second factor that appears to have influenced the level of concern demonstrated by companies and government agencies was the inconspicuousness of the hazard. Since radiation is invisible, scentless and intangible, those who campaigned against its danger often encountered reactions of disbelief. Public skepticism to the perils of radiation were reinforced by its elusiveness to measuring devices and its delay in manifesting evidence of bodily harm among the exposed population. Thus, it was expected that the concern of decision-makers would only be aroused with dramatic evidence that the hazard existed.

An analysis of trends in the visibility of the hazard and organizational "concern" suggests that this was indeed the case. The initiation of government regulations and company activities to reduce radiation coincided with the documentation of excessive deaths to United States miners due to radiation induced lung cancers. Perhaps more significantly, concern was aroused with the circulation of a series of newspaper articles on the plight of the uranium miners. In addition, concern was coterminous with expenditures to compensate afflicted miners and their families.

Trends in Hazard Visibility

Evidence of the hazard comes from the research efforts of the Public Health Service. Although medical research from Europe from the early twentieth century linked the incidence of lung cancers to mining uranium, the association was challenged by representatives of the domestic industry. Differences in the length of the working day and working conditions between the United States and European industries led many to argue that the two situations were incomparable. As a result, the Public Health Service initiated an investigation of health conditions in United States mines in 1950.

Three types of evidence eventually succeeded in arousing the concern of officials in government and business. One was a collection of lung

Table 23

Relationships Between National Uranium Needs and Organizational Concern

	Organizational concern shown by		
	Government Agencies		Companies
National uranium needs	No. Inspections	No. Sanctions	Dollars per ton for ventilation
Dollars per pound uranium	-0.779*	-0.731*	-0.737*
Tons Colorado ore purchased by A.E.C.	-0.352*	-0.215*	-0.488*
Tons domestic ore purchased by A.E.C.	-0.160*	-0.288*	-0.011*
Numbers of Colorado uranium mines	-0.113*	-0.127*	-0.220*

*Pearson correlation coefficients

cancer deaths among uranium miners. The second was a mounting tide of compensation claims filed by afflicted miners and their families and projections that the Colorado Workmen's Compensation Fund would be ultimately bankrupt by subsequent uranium miner claims. The third was a series of articles in the popular press that depicted the lung cancer risk confronting uranium miners and the pattern of official neglect.

Evidence of injury to United States miners accumulated gradually. During the 1950's, only a handful of lung cancer deaths occurred to miners who worked underground. Although health officials attached importance to each death in view of the European experience, the mortality experience of the uranium mining population during the 1950's did not arouse widespread concern. Only the New Mexico State Health Department and state mine inspector decided that the lives of miners were imperiled by exposure to radiation. As a result, in 1958, a program to control radiation was initiated in that state.

In 1960, the Public Health Service released information on the mortality experiences of their study group of miners from 1950 through December 31, 1959. This report showed that the incidence of lung cancer among men who had three or more years of uranium mining experience significantly exceeded the number expected among the population based on the mortality experience of a non-uranium mining control group. This announcement culminated in a meeting of the governors of uranium producing states in December of 1960 to discuss the problem. Subsequently, in 1961, Colorado initiated a formal program to reduce radiation.

Since the initial demonstration of significant excesses of lung cancer among uranium miners, evidence has steadily mounted which supports this contention. As Table 24 shows, 97 deaths were attributed to lung cancer contracted in the course of mining uranium before a national regulation on radiation was issued in 1967. Of that number, 70 occurred in Colorado. On the basis of trends prior to 1967, an actuarial firm projected that the death toll in Colorado to uranium miners between 1967 and 1985 would amount to 1,150 miners. Since the total population in Colorado that has ever mined uranium at one time or other is estimated not to have exceeded 6,000, this fatality projection was alarming. By 1970 the total number of deaths attributed to lung cancer due to uranium mining had risen to 150. (See Table 24)

The compensation of afflicted miners entered the picture in 1958 when the first workmen's compensation award was issued posthumously to a victim of lung cancer who had mined uranium. His compensation included $1,332.51 to defray medical expenses and $500 to cover funeral costs. His widow received $11,466.[100] (See Table 25)

The issue of compensating miners stricken with lung cancer was received with interest previously denied to the issue of the hazard itself. Attention was devoted to the removal of legal barriers that stood in the way of compensating victims of slowly developing diseases,

Table 24

Numbers of Lung Cancer Deaths Contracted in the Course of Mining Uranium

Year	Deaths	Year	Deaths	Year	Deaths	Year	Deaths
1945	1	1952	0	1959	5	1966	16
1946	0	1953	1	1960	9	1967	13
1947	1	1954	1	1961	6	1968	10
1948	0	1955	2	1962	7	1969	15
1949	1	1956	2	1963	10	1970	15
1950	1	1957	3	1964	9		
1951	1	1958	5	1965	16	Total:	150

Sources:

Joint Committee on Atomic Energy, Radiation Exposure of Uranium Miners, 1967, p.193 ("Mortality Summary by State and Year"), and Joint Committee on Atomic Energy, Radiation Standards for Uranium Mining, 1969, p.313 ("Deaths of Uranium Miners, 1954-1968")

Table 25

Colorado Compensation Claims Filed and Awarded to Uranium Miners Who Contracted Lung Cancer

		Number of Cases			
Year	Filed	Awarded	Denied	Pending	Total Amount Awarded
1957	1	0	1	0	$ 0
1958	1	1	0	0	11,000
1959	0	0	0	0	0
1960	0	0	0	0	0
1961	0	0	0	0	0
1962	4	3	1	0	37,794
1963	3	1	2	0	14,867
1964	6	4	2	0	59,390
1965	6	6	0	0	74,808
1966	9	6	3	0	93,899
1967	11	8	1	2	120,075
1968	10	5	3	2	95,395
1969	11	6	2	3	101,403
1970	8	4	0	4	n.a.
1971	12	4	0	8	n.a.

Sources:

Compiled from Digest of Lung Cancer Cases and Supplemental Digest of Lung Cancer Cases and records of recent compensation claims at the Department of Labor and Employment, Division of Labor, Workmen's Compensation Section, 200 E. 9th Avenue, Denver, Colorado.

and to devising more equitable ways of financing such compensation awards. The former problem was tackled in a session of the Joint Committee on Atomic Energy in 1959. Noting that it was generally impossible for lung cancer victims to comply with the requirement of most state compensation statutes that a claim be filed within six months after injurious exposure, the Committee concluded that

> If radiation cases (were) to be properly compensated, there must be provision for the removal of technical and procedural bars which may operate to exclude meritorious cases in which symptoms of disease and disability may occur long after initial or final exposure to hazardous agents, as in radiation disease. If cases of radiation are to be protected, these statutes must be written so that a claim may be filed within a reasonable period after disability (or the necessity for treatment) has transpired, and additionally not until after the employee knows, or should know, the nature of his disease, and its relation to employment. If all cases are to be protected, there can be no limit other than this for the filing of claims. (101)

Since 1959, twenty-two states have enacted legislation which modified the time limit provision of state workmen's compensation statutes. This has facilitated the process of compensating victims of lung cancer.

The problem of financing compensation awards to lung cancer victims was handled by the industry itself. Initially, the burden of such awards was borne by the victim's terminal employer. However, since job turnover is very high in the uranium mining industry, and so many employers have gone out of business during the past two decades, this arrangement generated dissatisfaction. It was felt that financial penalties were unfairly inflicted on the surviving firms in the industry and that firms responsible for causing injurious radiation exposure were escaping punishment. To remedy these ills, an industry-wide fund was created to finance the compensation of diseased uranium miners.[102]

Although some of the uranium producing states have persisted in ignoring compensation claims filed by victims of lung cancer, the number of claims filed in Colorado has increased considerably. At the close of 1966, for example, 21 cases had been awarded. The cumulative cost of these compensations amounted to $292,224. (See Table 25)

Publicity on the problem only gained momentum in the months preceeding and following the promulgation of a standard on radiation levels in mines by Secretary of Labor Wirtz. Although a few articles appeared on the subject in the Denver Post in earlier years, they tended to be more suggestive than conclusive. For example, in 1957, a Denver Post story reported that scientists were studying the possibility of a connection between mine radioactivity and lung cancer.[103] A 1960 story spoke of the "hinted risk" confronting uranium miners,[104] and even in 1962 an article reported on official but "inconclusive" surveys indicating an increase in lung cancer among uranium miners.[105]

In 1967, however, the tenor of the articles changed. In early March of that year an article appeared with the definitive assertion that uranium miners were contracting lung cancer from the gas in uranium mines.[106] This was quickly reiterated in an April story on the subject along with staggering projections of the disease and death that lay in store for uranium miners by the year 1985.[107] Four days later the Joint Congressional Committee on Atomic Energy announced it was planning a hearing into the matter within a matter of weeks.[108] In the interim, articles appeared announcing the 50th death of a uranium miner because of lung cancer[109] and efforts by Senator Lee Metcalf to organize Westerners in Congress to join in sponsoring a bill to fight the dangers of mining uranium.[110]

Wirtz's actions in May of 1967 served to stimulate new commentary and at the close of 1967, 20 articles had appeared in the Denver Post on the risk confronting uranium miners and the implications of that risk for the mining industry of the state and the state insurance compensation fund. (See Table 26)

The Relationship Between Hazard Visibility and Organizational Concern

In the wake of mounting deaths, compensation claims and publicity about both, the problem of excess radiation resulting in lung cancer was clearly established in the eyes of the industry and the government. Inspections of uranium mines increased and more money was spent for ventilation equipment. (See Figure 6)

To measure the strength of the relationship between evidence of the hazard and the actions taken by the government and companies to control radiation in mines, correlation coefficients were computed between measures of hazard visibility and organizational concern. It was expected that greater evidence of the hazard would induce government agencies and companies to take actions to reduce radiation. Measures of government concern included the annual number of inspections and sanctions to uranium mine operators issued by the Colorado Bureau of Mines. This information is located in Table 8 in the previous chapter. Measures of company concern consisted of the yearly expenditures for ventilation, per ton of ore mined, by the largest uranium mining companies in Colorado. (See Chapter 5, Table 16) Measures of the visibility of the hazard included the annual number of deaths attributed to lung cancer among uranium miners, the annual number of claims filed by uranium miners who suffered from lung cancer effects, and the annual number of articles appearing in the Denver Post on the subject of lung cancer among uranium miners. (See Tables 24, 25 and 26 in this chapter)

The analysis between all measures of hazard visibility and organizational concern was positive and strong. Relationships, however, were somewhat stronger in the case of government agencies. The best measure of hazard visibility appeared to be the annual number of compensation

Table 26

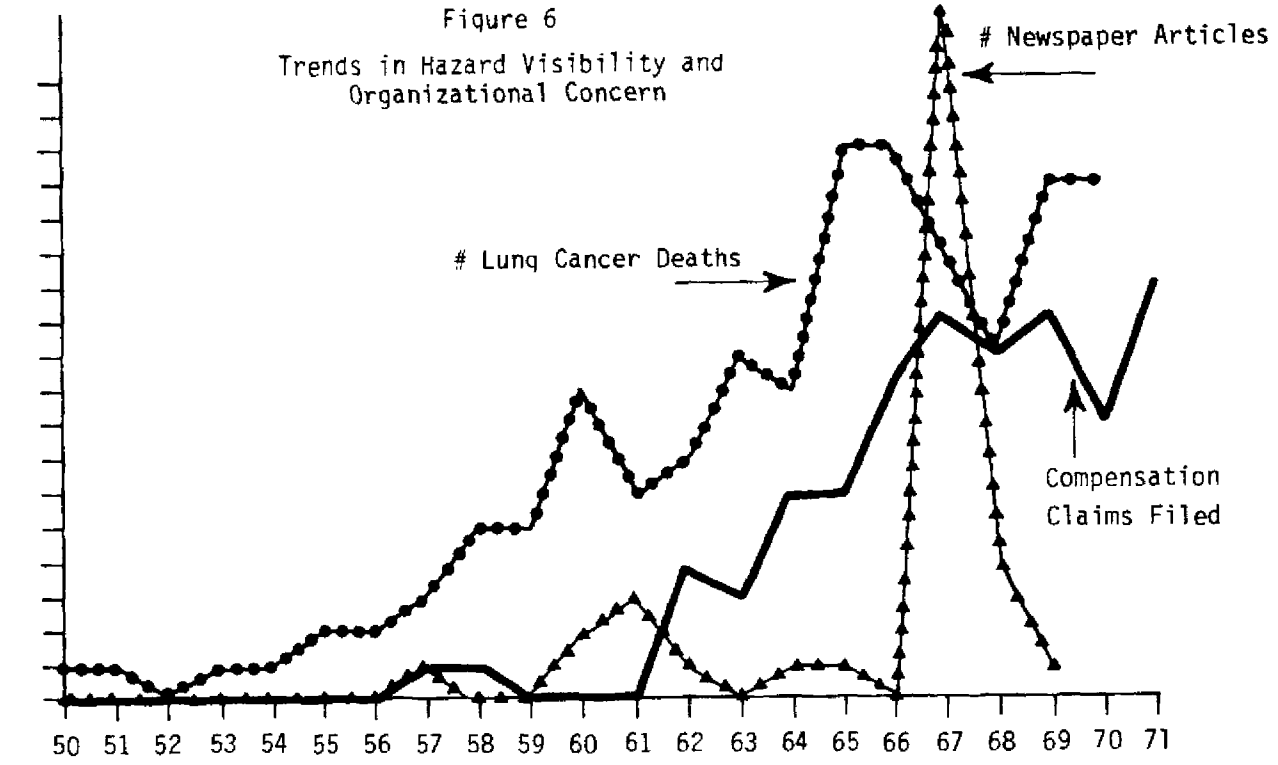
Number of Articles Appearing in the Denver Post on the Subject of Lung Cancer Among Uranium Miners

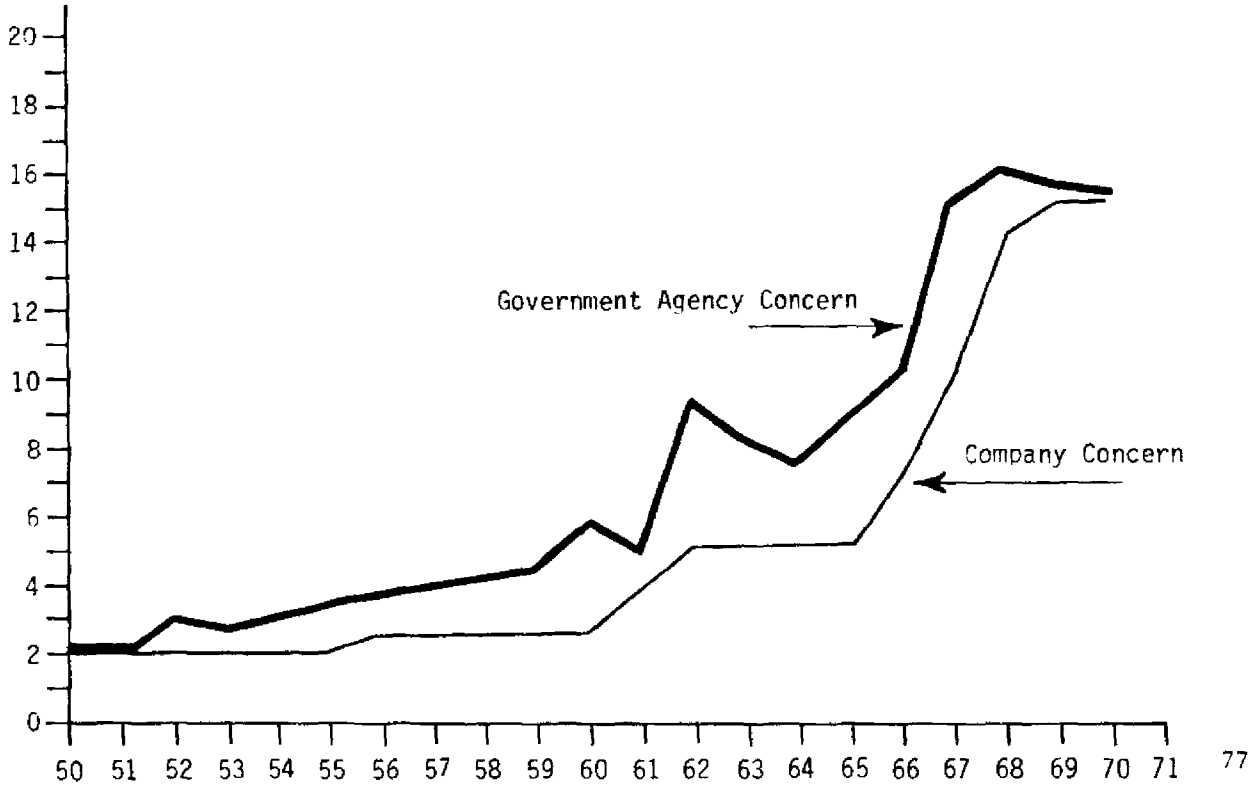
Year	Articles	Year	Articles
1950	0	1960	2
1951	0	1961	3
1952	0	1962	1
1953	0	1963	0
1954	0	1964	1
1955	0	1965	1
1956	0	1966	0
1957	1	1967	20
1958	0	1968	4
1959	0	1969	1

Source: The Denver Post, Morgue Clipping File, 1950-1969, (Topic Headings, "Cancer," and "Colorado Mining.")

Figure 6

Trends in Hazard Visibility and Organizational Concern





claims filed by uranium miners suffering from lung cancer. This suggests that the financial consequences of the hazard carried considerable weight in generating concern among government agencies and companies. (See Table 27)

INDUSTRY STRUCTURE

The structure of the uranium mining industry is also postulated to have affected the actions taken by government agencies and companies to reduce mine radiation. It was expected that to the extent that the industry became large-scale and stable it would and could more readily undertake the expenses of effecting adequate ventilation. At the same time, it was expected increased stability within the industry would make it easier for government regulators to keep track of the mining population; and, as a result, would produce a rise in government "concern" shown by successfully completed inspections.

Trends in Industry Structure

The supply and demand picture in the industry itself suggests that it became more stable and large-scale over time. The uranium industry can be shown to have passed through the three stages of supply and demand relationships posited by the economist, Alfred Marshall.[111] The three stages are: one, a momentary equilibrium, when supply is fixed; two, short-run equilibrium, when firms can produce more within given plants; and three, long-run equilibrium, when firms can abandon old plants, build new ones, and when old firms leave an industry and new ones enter it. In the case of uranium, the first stage resembles the late 1940's and early 1950's when uranium supplies were limited and demand was strong. Prices increased steadily until 1955. Phase II begins around 1956 when supplies are relatively abundant and demand begins to taper off. Prices drop at this time and stabilize at a lower level than those experienced under Phase I. The last stage emerges in the mid-1960's when supply is even more abundant and demand weak. Small, unproductive mines are closed down and the industry is gradually dominated by large, mature firms. The new price is far below the level of the monetary equilibrium price.

A look at the early uranium mining industry shows it to have been composed of small companies, partnerships, families and individuals. The preponderance of small producers is attributed to the enticing benefits the Atomic Energy Commission offered to those who mined uranium. Bonuses were offered to defray the initial costs of production and subsidized transportation was available to miners in remote areas for hauling ore.

Table 27

Relationships Between Hazard Visibility and Organizational Concern

	Organizational concern shown by		
	Government agencies		Companies
Hazard visibility	No. Inspections	No. Sanctions	Dollars per ton for ventilation
Annual number lung cancer deaths	0.851*	0.858*	0.757*
Annual number compensation claims filed	0.945*	0.873*	0.890*
Annual number articles in Denver Post	0.532*	0.420*	0.435*

*Pearson correlation coefficients

The government guaranteed the purchase of uranium at a generous price. For those who lacked the capital to purchase mineral lands, leasing arrangements were available with both the government and the large mining companies. Prior to 1960, all of the mines owned by Colorado's largest uranium producer, Union Carbide, were operated by private, independent miners through contract agreements.[112] Until 1962, the Atomic Energy Commission leased public lands to private operators. Motivated by government subsidies, small entrepreneurs flocked to uranium mines. The industry acquired a speculative, pioneering character. As one interviewee put it, "In the early days, there was a uranium prospector under every tree."[113] Thus, in 1951, 40% of the 98 mines that operated in Colorado were owned by small producers. Large companies owned another 40% of the operating mines and the remaining 20% were owned by the Atomic Energy Commission. (See Table 28)

Changes in the structure of the industry began during the late 1950's. The price paid for uranium declined and the bonus system was later terminated. In 1962 the Atomic Energy Commission removed a large supply of land formerly available to the small prospector. The stretch-out program and the decline in government purchasing after 1962 were fatal developments for many operators. In 1960, only 32% of the 352 mines that operated in Colorado were owned by small companies, families or individuals. Government leased lands had diminished to only a fraction of the mines that operated, (5%). The remainder of the industry was owned by the large companies having both mining and milling facilities. This accounted for 63% of the mines that operated in 1960. (See Table 28)

In the ensuing lean years, survival favored the integrated companies with both mining and milling facilities. In 1966 these few companies produced 79% of the domestic uranium and controlled 94% of the ore reserves in the nation.[114] Since 1965, the newest faces to appear on the uranium scene have been the large oil companies. At least 18 oil companies have invested heavily in producing and processing uranium. Although the petroleum industry only accounted for one-sixth of uranium production in 1970, it held 45% of all known uranium reserves. The large oil companies were also making more than half of the new discoveries in uranium at the time.[115]

By 1970, the overwhelming advantage of the large companies in Colorado was clear. Of the 139 mines listed as operating that year, approximately 72% were owned by companies with assets in excess of one million dollars. Sixty-six percent were owned by companies with assets in excess of one billion dollars. Union Carbide held a lion's share of the industry. It owned 56% of the operating mines in Colorado. (See Table 28)

Attempts to quantify changes in the structure of the industry in the sample over time, however, were only partially successful. The Colorado sample of mines is over represented with mines owned by large companies during the early 1950's. This bias reflects the greater availability of records on mines of this latter type at the Colorado Bureau of Mines.

Table 28

The Composition of the Uranium Mining Industry, 1950-1970

Year	Percentage of mines owned by			
	A.E.C.	Small companies	Large companies	Union Carbide Corp.*
1950	20.0	40.0	40.0	30.0
1951	18.5	39.2	42.3	31.0
1952	17.0	38.4	44.6	32.0
1953	15.5	37.6	46.9	33.0
1954	14.0	36.8	49.2	34.0
1955	12.5	36.0	51.5	35.0
1956	11.0	35.2	53.8	36.0
1957	9.5	34.4	56.1	37.0
1958	8.0	33.6	58.4	38.0
1959	6.5	32.8	60.7	39.0
1960	5.0	32.0	63.0	40.0
1961	3.3	31.6	63.9	41.6
1962	1.7	31.2	64.8	43.2
1963	0	30.8	65.7	44.8
1964	0	30.4	66.6	46.4
1965	0	30.0	67.5	48.0
1966	0	29.6	68.4	49.6
1967	0	29.2	69.3	51.2
1968	0	28.8	70.2	52.8
1969	0	28.4	71.1	54.4
1970	0	28.0	72.0	56.0

*Colorado's largest producer

Sources:

Compiled from Bureau of Mines, Report for the Years 1950-1951, August 15, 1952 (List of Operating Mines in Various Counties in Colorado) pp.51-101

Bureau of Mines, Annual Report for the Year 1960, May 1, 1961 (List of Mineral Operations) pp.61-87

Colorado Bureau of Mines, A Summary of Mineral Industry Activities in Colorado 1970, May 1, 1971 (Mineral Operations by County) pp.62-86

(Exact counts of operators were made for the years 1950, 1960 and 1970 with the abovementioned sources and records maintained at the Colorado Bureau of Mines, 1845 Sherman Street, Denver, Colorado; Figures for other years were extrapolated.)

Large companies regularly filed annual reports summarizing the activities of all their mining properties. This was in addition to information recorded by the state mining inspectors. It was thus generally possible to piece together a complete picture of such mining operations over time. Mines owned by individuals or families, on the other hand, were often never covered in the record, or, if covered at all, only haphazardly so. Thus, for lack or incompleteness of information, mines owned by small companies, partnerships or individuals were disproportionately excluded from the sample. As a result, the sample group fails to show trends suggesting the decline of importance of small operators relative to large over time. (See Table 29)

However, there is limited evidence from the sample that changes in the structure of the industry did occur.

There has been a gradual rise in the number of large Colorado mines. Although the average number of men employed in the sample between 1950 and 1969 was relatively constant and extremely small, e.g., 1.29, there was a slight increase in the number of larger mines during the 1960's. In 1956, the first mine employing fifty-one men or more began to operate. In 1962, it was joined by another. At the conclusion of the study period, 7.1% of the mines sampled employed 16 men or more. (See Table 30)

Colorado mines also tended to become more productive with passing time. Although the majority of mines produced less than 250 tons per month throughout the study period, a greater proportion yielded 500 tons or more during the 1960's. Between 1950 and 1969, approximately 5.4% of the 1581 mines sampled in the decade produced 500 tons or more on a monthly basis. In the next decade, the proportion of mines in this production category was 12.3%. (See Table 31)

The Relationship Between Industry Structure and Organizational Concern

Thus, it appears that the uranium industry gradually came to be composed of mature, stable and large firms. Concurrently, government agencies were better able to keep track of the mining population and firms were better equipped to undertake the expenses of effecting adequate ventilation. Inspections of uranium mines increased and more money was spent for ventilation equipment. (See Figure 7)

To test the implications of this transformation in the structure of the industry for the onset and intensity of organizational concern, correlation coefficients were computed between measures of industry structure and organizational concern. Industry structure was assessed in terms of the annual percentage of mines owned by large companies, the percentage of mines owned by Union Carbide in particular; the percentage of mines producing more than 500 tons on a monthly basis; and the percentage of mines employing more than 16 men. This information is contained in various tables in this chapter. Once again, measures of organizational concern included the annual

Table 29

Annual Percentage of Mines Owned by Small, Large and Government Producers in the Sample of Colorado Mines, 1950-1969

Year	Percentage of mines owned by			
	A.E.C.	Small companies	Large companies	Union Carbide Corp.
1950	30	6.7	63.3	43.3
1951	27.6	10.3	62.1	48.3
1952	25.2	13.6	61.2	36.9
1953	19.7	22.0	58.3	34.6
1954	22.6	26.0	51.4	32.9
1955	21.8	35.8	42.4	26.7
1956	16.0	30.2	53.8	35.4
1957	11.0	31.7	57.3	39.4
1958	9.4	31.2	59.4	37.2
1959	7.7	31.2	61.2	39.2
1960	6.9	29.4	63.7	39.7
1961	4.1	31.1	64.8	37.0
1962	2.4	33.3	64.3	31.7
1963	0.0	35.6	63.9	28.2
1964	0.0	46.0	54.0	16.7
1965	0.0	37.4	61.5	26.4
1966	0.0	28.0	71.1	35.8
1967	0.0	25.7	73.8	41.0
1968	0.0	24.8	75.2	52.8
1969	0.0	29.1	69.3	48.8

Source:
The sample of Colorado uranium mines.

Table 30

Percentages of Mines by Size of Work Force, 1950-1969

Year	Percentages of mines employing men that number	
	1-15	16 or more
1950	100.0	00.0
1951	96.6	3.4
1952	97.1	2.9
1953	99.2	0.8
1954	98.6	1.4
1955	96.9	3.0
1956	96.7	3.3
1957	96.0	4.1
1958	97.4	2.6
1959	95.8	4.2
1960	95.4	4.6
1961	94.5	5.2
1962	95.2	4.8
1963	94.9	5.1
1964	95.9	3.4
1965	94.5	5.5
1966	95.8	4.1
1967	96.7	3.3
1968	94.4	5.6
1969	92.9	7.1

Source:
The sample of Colorado uranium mines.

Table 31

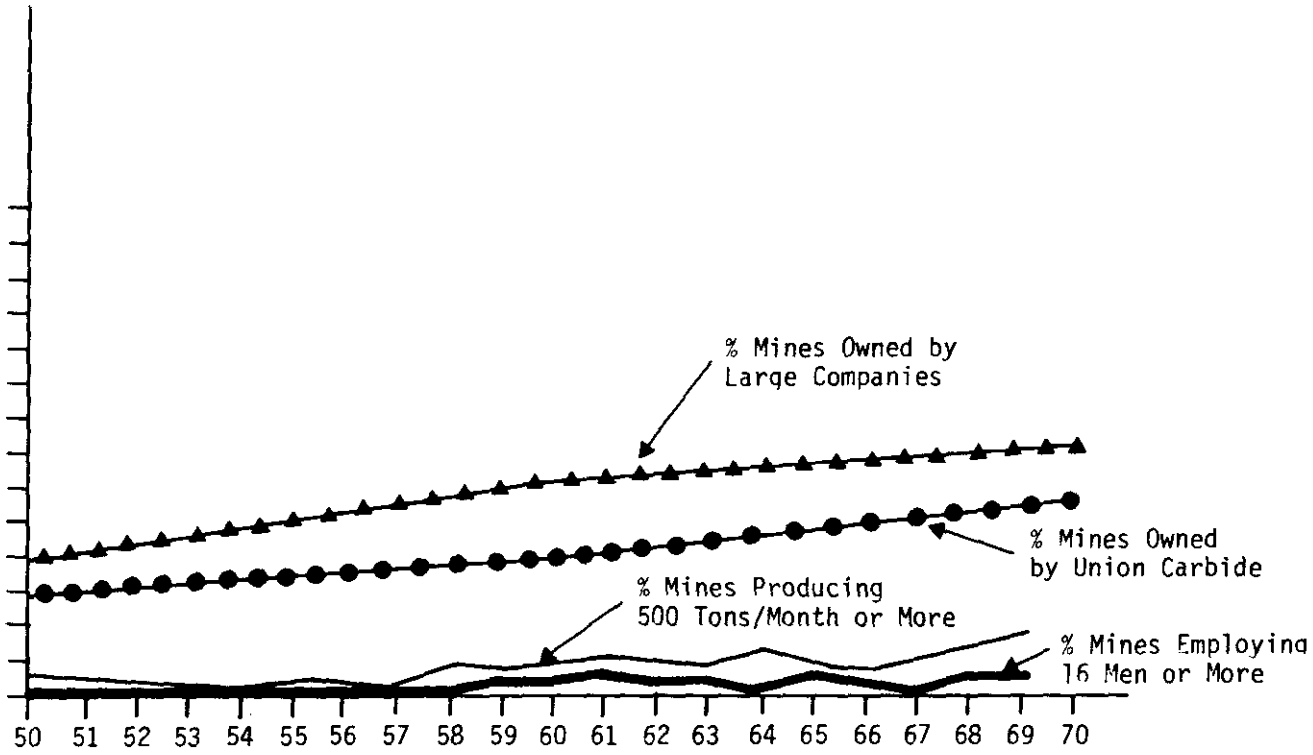
Percentage of Mines by Tons of Ore Produced, 1950-1969

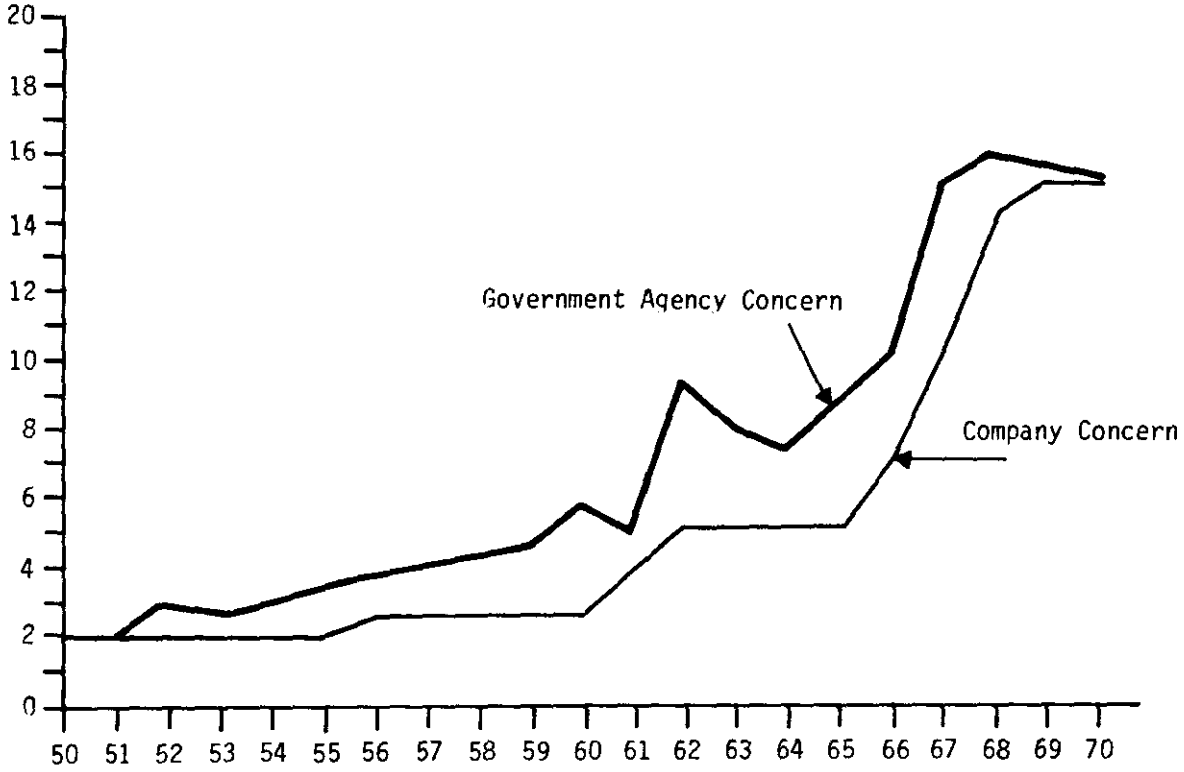
Year	Percentages of mines producing on a monthly basis tonnage equal to	
	0 - 500	500 or more
1950	90.0	6.7
1951	94.8	5.1
1952	97.1	2.9
1953	97.6	2.4
1954	96.6	3.5
1955	94.5	5.4
1956	94.9	5.2
1957	96.0	4.1
1958	91.0	9.0
1959	90.4	9.7
1960	88.5	11.5
1961	87.4	12.6
1962	88.8	11.2
1963	89.8	10.2
1964	87.9	12.0
1965	89.0	10.9
1966	90.8	9.2
1967	89.0	10.9
1968	84.5	15.6
1969	81.1	18.9

Source:
The sample of Colorado uranium mines.

Figure 7

Trends in Industry Structure and Organizational Concern





number of inspections and sanctions issued by government enforcement agents and the number of dollars, per ton of ore mined, expended by the major Colorado producers for ventilation.

The analysis showed that scale and stability were directly related to the demonstration of concern by both companies and government agencies. The relationship between industry structure and concern by government agencies was stronger. The best measures of industry structure were proportions of mines owned by large producers in general. This suggests that the ownership profile of the industry was more significant than characteristics of mines themselves, as in the cases of size and productivity in arousing concern among government agencies and companies. The findings in this analysis tend to support the hypothesized relationships between industry structure and organizational concern. (See Table 32)

OFFICIAL CONCERN

The last historical factor postulated to have affected the response of enforcement agencies and companies to excess radiation in mines was federal level policy. Official guidance was believed to be critical in directing local caretaking agencies on the proper response to the problem. Thus, it was hypothesized that federal involvement in the regulation and supervision of radiation would be associated with a stringent control process. On the other hand, the absence of official, federal policies on the problem, would undermine radiation control. Faced with a vacuum of federal involvement, local enforcement agencies would inherit a problem for which they often lacked technical expertise, personnel, and statutory responsibility.

Trends in Official Concern

A look at information on federal agency concern suggests that little policy guidance was offered. There was a dearth of interest in the problem of excess radiation among the legislative and executive branches until well after the documentation of excess lung cancers among uranium miners. For example, a review of bills introduced into both Houses of Congress from the 81st Congress to the 91st Congress, shows that no legislation pertaining to the health of uranium miners was introduced until the first session of the 90th Congress in 1967. (See Table 33) In that year, no fewer than five bills were introduced; three in the Senate and two in the House of Representatives. All of the bills dealt with the issue of compensating miners afflicted with lung cancer.[116]

Two other bills on the subject of the health of uranium miners were introduced into the House of Representatives in 1969. They also handled

Table 32

Relationships Between Industry Structure
and Organizational Concern

	Organizational concern shown by		
	Government agencies		Companies
Industry structure	No. Inspections	No. Sanctions	Dollars per ton for ventilation
Percentage of mines owned by large companies	0.849*	0.797*	0.742*
Percentage of mines owned by Union Carbide	0.958*	0.895*	0.899*
Number of mines employing 16 men or more	0.662*	0.560*	0.636*
Percentage of mines producing 500 tons or more	0.809*	0.665*	0.806*

*Pearson correlation coefficients

Table 33

Bills Introduced into Both Houses of Congress Relating to the Health and Safety of Uranium Miners From the 81st Congress to the 91st Congress, 1949-1970

Congress	Year	Senate Bills	House of Representatives Bills
81	49	0	0
81	50	0	0
82	51	0	0
82	52	0	0
83	53	0	0
83	54	0	0
84	55	0	0
84	56	0	0
85	57	0	0
85	58	0	0
86	59	0	0
86	60	0	0
87	61	0	0
87	62	0	0
88	63	0	0
88	64	0	0
89	65	0	0
89	66	0	0
90	67	S 2782; S 2686; S 1927	HR 14558; HR 16302
90	68	0	0
91	69	0	HR 7606; HR 11476
91	70	0	0

Sources: Compiled from Congressional Index, Commerce Clearinghouse, 81 Congressional Session through 91 Congressional Session

the question of compensating uranium miners suffering from lung cancer.

None of the bills introduced to the 90th or 91st Congress were translated into public law. They did succeed, however, in generating public debate and interest in the problem. For example, on April 21, 1967, the Joint Committee on Atomic Energy announced that a series of public hearings would be held on the subject of radiation exposure of uranium miners. The ensuing hearings were conducted by the Joint Committee's Subcommittee on Research, Development and Radiation. It occupied eleven days over a four month period. More than fifty persons appeared before the committee as witnesses, and sixteen submitted statements for the record. In addition, a wealth of material, correspondence, reports and papers were presented. The proceedings of the Hearings were compiled in a two volume document that is 1373 pages long. In the words of Joint Committee Chairman Pastore and Price, "This two-part record constitutes the most comprehensive collection of information ever amassed concerning the exposure of human beings to radiation incident to the mining of uranium."[117]

On March 17 and 18, 1969, additional hearings were held before the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy. The sessions were also on the topic of exposure of uranium miners to lung cancer. The proceedings of this set of hearings amounted to 411 pages.[118]

Thus, it is obvious that the interests of the legislative branch of government and the health and safety of uranium miners was aroused in the last part of the 1960's. Prior to this time, however, there was a dearth of legislative guidance concerning the protection of miners who were exposed to radioactive material in the course of their employment.

The interests of the executive branch of government in the problem was also extremely modest. For the most part, federal agency interest coincided with that of the legislature. In both cases, 1967 was the peak year of concern. Unlike the legislature, however, federal agencies have shown fairly consistent interest in the subject of procuring uranium throughout the two decades under study.

To assess the attention devoted to the subject of the health of uranium miners among federal agencies, a content analysis was conducted of the Federal Register between 1950 and 1969. For each year, the index of the Federal Register was scanned for reference to uranium mining. All references were then traced in the body of the Federal Register and the number of lines devoted to the subject of uranium were counted and recorded.

As Table 34 shows, the bulk of interest in uranium shown by federal agencies had dealt with the subject of procurement. During the 1950's Federal Register entries on uranium exclusively detailed modifications in the incentive program launched in 1948 by the Atomic Energy Commission to secure uranium reserves. In 1961, the first entry (85 lines) on the subject of the health aspects of mining uranium appeared. In it, the

Table 34

A Content Analysis of the Federal Register
1950-1969

Year	Total number of pages Federal Register	Ratio lines: pages on subject uranium mining (procurement and health and safety)	Ratio lines: pages on subject uranium health and safety
1950	9,562	.0028	0
1951	13,175	.082	0
1952	11,896	.0016	0
1953	8,912	.0089	0
1954	9,910	.044	0
1955	10,196	.0025	0
1956	10,528	.029	0
1957	11,156	.033	0
1958	10,579	.018	0
1959	11,116	.0086	0
1960	14,479	0	0
1961	12,792	.0066	.0066
1962	13,226	.018	0
1963	14,842	.0033	.0033
1964	19,304	0	0
1965	17,142	.043	0
1966	16,850	.014	0
1967	21,087	.064	.035
1968	20,072	.027	0
1969	20,466	.011	.0039

Sources:
Compiled from the Federal Register, National Archives and Records Service of the General Services Administration, 1950-1969

Federal Radiation Council, created in 1959 to furnish advice on radiation to the president, solicited comments on the protection of miners employed in uranium mines. In 1963, 50 lines of the Federal Register dealt with the subject of protecting uranium miners from radiation exposure. In 1967, however, 749 lines of the Federal Register dealt with the problem of radiation exposure to uranium miners. This included the promulgation by Secretary of the Labor, Willard Wirtz, lowering radiation standards in the nation's uranium mines. It was the first federal law designed to safeguard the health of uranium miners. In 1969, 80 more lines were devoted to this subject. They were isolated from a larger, general law on health and safety standards in all types of underground mines. (See Table 34)

The Relationship Between Official Concern and Organizational Concern

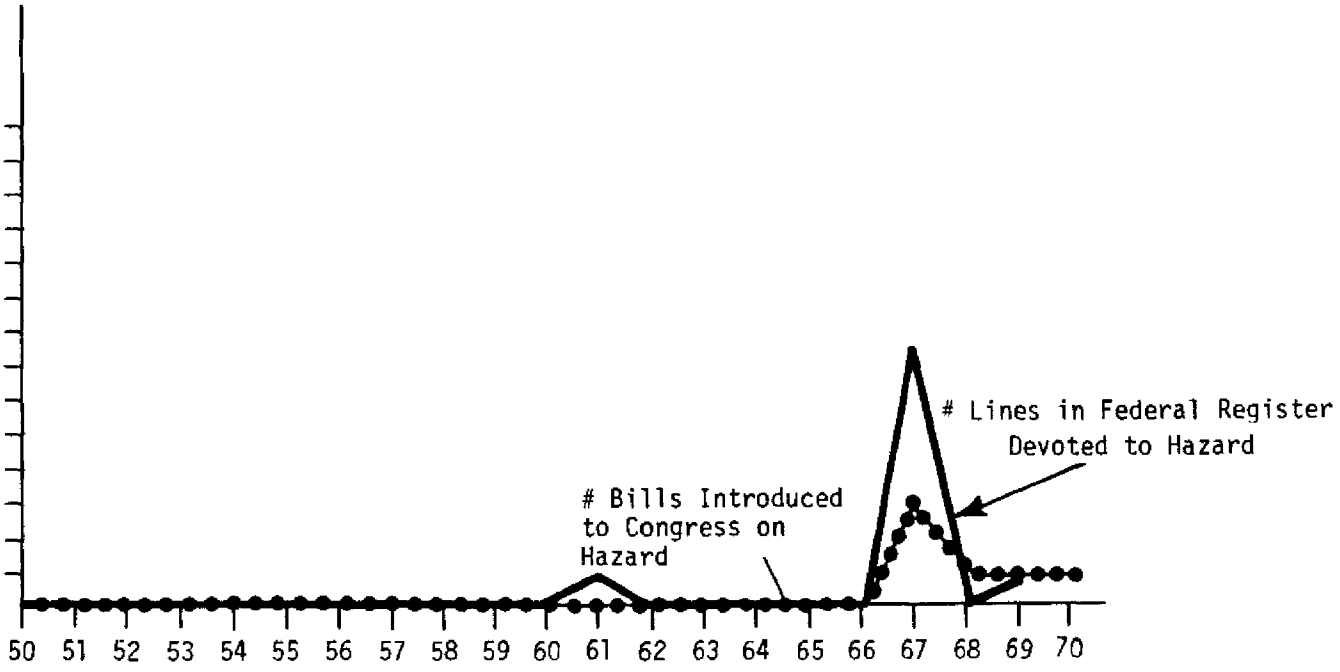
To examine whether trends in official concern were related to the actions of enforcement agencies and companies to control radiation, correlation coefficients were computed. Official concern was gauged by the annual number of bills introduced into both Houses of Congress relating to the health of uranium miners and the number of lines of the Federal Register devoted to the subject on a yearly basis. (See Tables 33 and 34) Organizational concern was measured by the annual number of inspections and sanctions made by the Colorado Bureau of Mines and the expenditures for ventilation made by the largest Colorado companies. (See Tables 8 and 16, Chapter 5) These relationships are graphically portrayed in Figure 8.

The relationships predicted between official and organizational concern are only partially supported by the evidence at hand. Only very weak associations were found between the attention devoted to the hazard in the Federal Register and inspections and company expenditures. Correlation coefficients between these variables were 0.476 and 0.378, respectively. No doubt, this is due to the extremely small number of lines on this subject in the Federal Register during the twenty year study period.

Correlation coefficients between the number of bills introduced into Congress on health and safety matters and organizational concern were somewhat stronger. For example, the r between Congressional bills and inspections is 0.698, and the r between Congressional bills and company expenditures for ventilation is 0.651. Despite this improvement, however, it appears that the role of federal policies in the control process was considerably weaker than that of the previously discussed factors of national uranium needs, hazard visibility, and industry structure. (See Table 35)

Figure 8

Trends in Official Concern and Organizational Concern



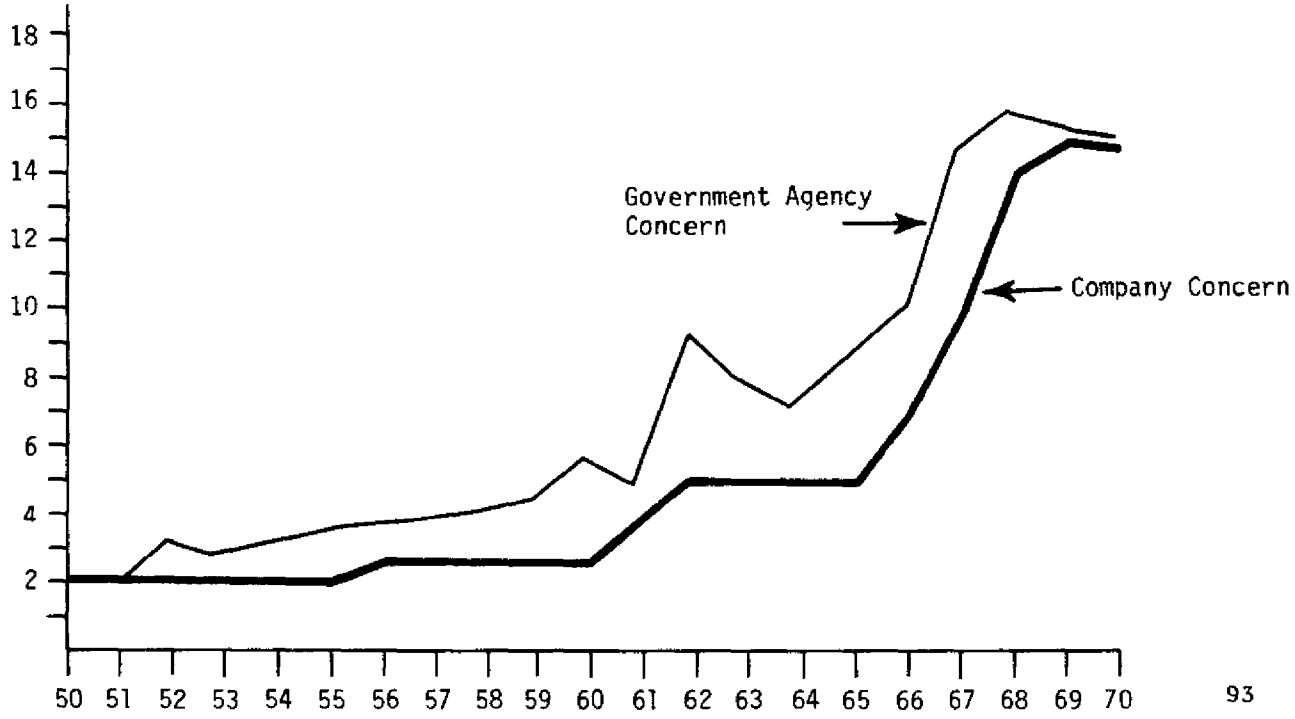


Table 35

Relationships Between Official Concern and Organizational Concern

	Organizational concern shown by		
	Government agencies		Companies
Official concern	No. Inspections	No. Sanctions	Dollars per ton for ventilation
Numbers of Bills introduced into Congress devoted to the health of miners	0.698*	0.465*	0.651*
Numbers of lines of Federal Register devoted to the helath of miners	0.476*	0.383*	0.378*

*Pearson correlation coefficients