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THE EVOLUTION OF CRISES: CRISIS PRECURSORS

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Industrial crises, or organizationally based technological disasters that cause major harm to human life and/or the natural environment, may be triggered by industrial accidents, environmental pollution incidents, product injuries, or occupational hazards. While past explanations of crisis causes focusing on technological, organizational and interorganizational failures; as well as simultaneous failures of technological, organizational and societal systems provide us with a good understanding of immediate causes of events that trigger crises, the authors point out that we still lack an understanding of how preconditions for crises arise. Arguing that the precursor conditions of industrial crises are rooted in the historical development of organizations, and interactions between organizations and their environments, the authors attempt to determine why these precursors arise. Using an analysis of data on the Bhopal and the Three Mile Island crises, they trace the evolution of crisis precursor conditions, and present the patterns and logics of change in organizational and environmental variables observed in the two cases studied.

Industrial crises are organizationally based technological disasters that cause major harm to human life and/or the natural environment. Crises may be triggered by industrial accidents, environmental pollution incidents, product injuries, or occupational hazards. Examples of such crises include the Bhopal disaster, the Chernobyl Nuclear plant accident, and the Exxon Valdez oil spill. Past explanations of the causes of crises have focused upon technological failures (Perrow 1984), organizational and interorganizational failures (Turner 1976) and simultaneous failures of technological, organizational and societal systems (Shrivastava 1987). While these studies provide us with a good understanding of immediate causes of events that trigger crises, we still lack an understanding of how preconditions for crises arise.

The precursor conditions of industrial crises are rooted in the historical development of organizations, and in interactions between organizations and their environments. How and why these precursors arise is the focus of this study. In this paper, we trace the evolution of crisis precursor conditions and present the patterns and logics of change in organizational and environmental variables observed in two cases studied, the Bhopal and Three Mile Island crises (see also Miglani et al. 1990, Shrivastava et al. 1990).

BACKGROUND

Organizational attributes and environmental pressures develop over many years in concrete and symbiotic stages, and may ultimately result in crises. Organizations respond to environmental changes with short term orientation; their responses create internal contradictions that make them crisis-prone. Over a period of time, as slack in financial, technological, and human resources and safety related variables diminishes, organizational propensity for crisis increases. Under the right preconditions, accidents are triggered by seemingly innocuous failures in human, organizational and technological elements. Since the loss of slack also reduces the organizations' ability to contain and overcome the damage from the accidents, events which might have been minor may escalate into full blown crises.

Before proceeding, it is important to clarify the use of some terms in this study. The type of industrial crises studied here typically occur in organizations dealing with hazardous technologies, such as the manufacture and storage of chemicals and pharmaceuticals, nuclear power generation; or the transportation or disposal of hazardous substances and wastes. These organizations generally own the hazardous technologies. In most situations organizations are corporations (private or public sector) divided into administrative units or subsidiaries. The organization as a whole, and its component subsidiaries, operate in multifaceted environments characterized below.

When we are discussing the interaction of environmental and organizational variables, we include the interactions between the parent organization and its environment, the subsidiary or the division (where the accident occurs) and its environment, and finally the interaction between the parent and the subsidiary. Thus, the parent organization's environment affects the subsidiary through parent-subsidiary linkages.

Environmental Factors

The environment relevant for understanding precursors of crises has several components. The first is economic conditions at both the macro-economic level and within the industries in which the organization or its subsidiary operates. These conditions are important because they determine the overall economic opportunity available to companies, and consequently their motivations. Dynamism and competition within an industry squeezes company resources and creates pressure to cut costs. Changes in customer needs or preferences, and in technologies, creates confusion, increasing the likelihood of errors in the production and delivery of goods and services. Indirectly, economic pressures shape key resource allocation decisions which, in turn, affect levels of safety (Starbuck and Hedberg 1987).

Another key component of the environment is the political situation. Political concerns play an important role in obtaining licenses and permissions to operate hazardous technologies; and they shape governmental regulation of hazardous technologies, creating a network of rules within which corporations must operate. This regulatory infrastructure includes a system of detecting and policing the violation of rules, and punishing the guilty. These rules may facilitate or hinder development of new technologies (Goldschmidt 1982).

A third component of the environment pertinent to understanding industrial crises is the social context. Social goals, norms, attitudes, and values of the community determine the social legitimacy of technologies and their corporate development. Legitimacy is bestowed on technologies widely perceived as being in the public interest. Absence of such legitimacy can be the source of both public criticism and political pressures to discourage use.

Finally, the physical infrastructure that supports hazardous plants and facilities, including the supply of basic services such as, water, electricity, communications and transportation, also plays an important role in industrial crises. These services must be reliable and adequate, to enable the use of modern safety equipment and to avoid jeopardizing industrial safety. Community social infrastructure, in the form of adequate medical and public health services, civil defense services, fire control services, and a general awareness of hazards in the community, is fundamental to an ability to recover from industrial crises (Shrivastava 1987).

Organizational Factors

Organizational attributes of interest include those variables that influence levels of risk and safety of the organization. Several strategy related variables are salient here, including organizational resources, goals, and strategy. These variables set the strategic context within which safety decisions are made. Safety problems arise when resources are scarce and managerial attention is directed elsewhere due to the extant goals and strategies of the firm (Miller and Friesen 1984, Mitroff and Pauchant 1990). The second category of variables are operating characteristics such as the hazardous aspects of technologies used, interdependence and coupling between systems, size of plants, quality of human resources, and organizational policies and procedures. These variables jointly determine the risks inherent in the company's operations (Perrow 1984).

Variables that influence decision making such as top management ideology, decision processes, organizational structure and degree of centralization, CEO personality, and organizational culture are also important. Excessive bureaucratization prevents managers from discovering and acting upon safety problems (or the same result may occur because of internal conflicts, political behavior, or poor information systems).

The personalities and morality of top management, and particularly the CEO, are critical determinants of whether the firm adopts a socially responsible attitude toward public safety. Highly risk-taking CEOs may undertake risky projects and unduly tax the resources of the firm. Narcissistic managers may not care about the consequences to society of their actions, and are likely to have their firms engage in hazardous practices to make money. Firms run by detached CEOs become political hotbeds in which second level managers fight for power, oblivious to the larger and longer term consequences of their actions. CEO personalities and top management values also influence organizational culture. Culture determines organizational attitudes toward safety, product integrity, security and vigilance, maintenance, environmental protection, and worker health (Pauchant and Mitroff 1989, Weick 1988).

RELATIONAL PROPERTIES PROMOTING CRISES

The environmental, organizational and individual factors are not independent. They are related in many and complex ways, and it is the interrelationships which give rise to crisis-proneness of organizations. In tracing the precursors of crises, we have identified some of the relationships among these variables. These are explained below.

1. One of the most disturbing features of industrial crises is that once weakness in the organization has set in, any one of many seeds—societal, organizational and human, can have a predominating influence in inducing the crisis. Only one of the social factors or organizational policies has to be out of place to vastly increase the chances of a crises. We call this the "**weak link in the chain**" property.

2. Secondly, **failures are not independent but instead have common sources**; a single source can spawn multiple failures. This has profound implications for the system of checks and balances that is supposed to exist to prevent crises.

3. Another important property is **tight coupling within technological systems**. Modern technological systems are designed with high interdependence and tight coupling because these properties improve technical efficiency and provide connectivity between large subsystems. However, this same interdependence also may propagate errors through the system, with one technological failure triggering others, which in turn trigger further failures in a chain reaction (Perrow 1984).

Another pertinent aspect of this interdependence is the **mutual causality among organizational problems**. For example, structural deficits can erode resources, reduce vigilance, and cause human errors. In a reciprocal manner, human errors can reduce vigilance, erode resources and leave the firm too weak to adopt an appropriate structure. In other words, not only are there interdependencies, these interdependencies are robust and can give rise to each other.

4. **Organizational momentum and inertia** are other important properties of crises. Once organizations begin to evolve in certain directions, they have a tendency to unquestioningly continue down their chosen paths regardless of changed circumstances. The configuration of strategies, structures and resource allocations maintains organizational continuity and permanence (Miller and Friesen 1984). Change is resisted, even when hazards are identified, because there are so many reasons for avoiding a new direction. The firm may feel the change is unwarranted and too expensive to make; it may deny the need for change, and the consequences of not changing; or it may not have the knowledge to design effective change programs.

5. Another aspect of the relationship between precursors of crises deals with **contradictions and conflicts** inherent in organizational and technological systems. Contradictions refer to the competing and irreconcilable demands on a system that create conflicts in its operation. Pressures from multiple sources and constituencies are present in every technological and

organizational system by virtue of their design. For example, we design technological systems to satisfy competing demands of low cost but high safety, or high flexibility but tight control. Similarly, corporations are expected to satisfy the demands of stockholders to maximize profits, and yet simultaneously to minimize dangers to environment, consumer and worker health (Shrivastava 1991a, 1991b)

Organizational and technological contradictions arise out of diverse considerations, only some of which dominate management decision making at particular stages of an organization's evolution. Similarly, they have different effects on safety and crisis proneness at different stages of crisis evolution. Table 1 shows how attributes such as, size, complexity, automated controls, safety backup, stakeholders, habituation to risk, location, and regulations have contradictory influences on organizational performance.

EVOLUTION OF INDUSTRIAL CRISES

Table 2 depicts the stages through which the environment evolves, and how the organization responds to each of those stages. The stages begin several years before the actual crises. The environment evolves through the stages of munificence, crunch and uncertainty, while the corresponding organizational responses are bullish expansion, cutbacks and confusion. Environmental stages of munificence and crunch may be repeated more than once, as it happened in the case of Union Carbide. Each such cycle progressively weakens the organization, increasing the chances of an accident.

First Stage of Environmental Evolution: Munificence

The roots of crisis in both Bhopal and Three Mile Island can be traced back to periods of environmental munificence. Environmental munificence refers to a stage of organizational development in which the economic, social, and political environments offer many opportunities for growth and gains; it is characterized by economic growth and prosperity. This economic expansion is accompanied by a liberalization of social and political attitudes toward risk and regulation. Growth and risk taking are rewarded; organizations are encouraged to take bolder decisions. Most segments of the society align themselves in favor of this growth. Within this environment, fear of risk is minimized, doing is viewed as better than not doing, bigger and faster as better than smaller and slower, and newer technologies as better than older ones. Along with other segments of the society, the regulatory system

Table 1. Contradictory Demands on Design and Operation of Industrial Systems

Demands during Design Phase	Demands during Operating Phase
Size	
Economics of scale considerations require that industrial units be large. Thus, designers tend toward designing larger systems.	Large size and large number of parts and subsystems make it difficult to control the damage caused by the failure of the system.
Larger size of industrial systems increases the role of communications in managing the system.	The larger size of the system also, at the same time makes it more difficult to achieve better communication between its units.
Complexity	
Economic considerations, as well as professional ethos of designers move them toward designing complex, integrated units.	Operators have limited cognitive ability, which is unable to handle system complexity. Organizations simplify operations by artificially fragmenting work, making the unit failure-prone. This also makes it difficult to control failures and makes the system crisis prone.
Automatic control systems	
In order to manage system complexity, designers build them with automatic controls.	But automation decreases operator involvement, making it difficult for workers to understand system complexity. Thus they will be less likely to successfully control or recover from a failure once a failure occurs.
Large backup systems	
Large systems are designed with more expensive backup systems.	But because of their large costs and their passive role on a day-to-day basis, they are the best candidates for neglect and elimination during economic downturns in an organization.
Organizational stakeholders	
Stakeholders demand and reward novelty and functional designs.	Stakeholders demand and reward financial efficiency, which leads to cost-cutting and neglect/elimination of backup systems.
Human habituation to risky systems	
System designers rely on operator and other plant personnel sensitivity to system malfunctions to detect and correct system problems.	Operators and other plant personnel are the first to get desensitized to minor and/or gradually escalating system faults.
Location	
Systems risks require that potentially dangerous units be set up in areas away from densely populated areas	Availability of skilled manpower, proximity to raw materials and/or customers require plants to be set up near populated areas.
Regulatory	
New technologies and designs require tight state regulation and control.	The state has inadequate knowledge to successfully regulate technologies.
During recessionary periods, when organizations are most likely to cut back in crucial areas, state should increase its supervision and control of organizations.	During recessionary times, even the state is strapped for funds and reduces its regulatory function.
	Also, during recessionary times, the state relies on organizational initiatives to emerge out of recession. During these times, the organizations demand and get freedom from state control.

Table 2. A Model of Evolution of Crises

Environmental Stages	Organizational Responses
Munificence	Bullish Expansion
Crunch	Cut Backs
Uncertainty	Confusion
	Triggering Event

also reorients itself toward expansion, diluting its regulatory and control functions to encourage growth.

These environmental characteristics preceded both the Bhopal and TMI crises. In the case of Union Carbide, the early and mid-1970s saw the demand for pesticides in Third World countries increase at a more rapid rate than in the United States. This was particularly true for India, where the growth in the pesticides market was sponsored by the Indian government itself, as a part of their program to improve public health and boost agricultural productivity. Encouraged by the government's buying program, many companies entered the production of pesticides. Increasing pesticides sales in the Third World in general, and in India in particular, were a part of Union Carbide's overall long-term strategy.

Similarly, in the TMI case, demand for power increased at a seven to eight percent annual rate during the 1960s and early 1970s, while prices for power were falling. Utility companies kept increasing their installed capacities, while simultaneously expanding the size of their power plants. Operating as regulated monopolies, which ensured them a minimum rate of return, their stocks were favored by investors.

Within the power industry, nuclear power was particularly favored. Promoted as a technology of the future, with abundant raw materials and extremely low cost of power generation, utility companies scrambled to set up new nuclear power plants. Adoption of nuclear power technology was equated with progressiveness, and progressive companies like General Public Utilities Corporation moved aggressively to adopt the new technology. GPUC established a target of 50 percent installed capacity from nuclear power by the end of seventies.

In the munificence stage, the political environment is facilitative and provides encouragement to business interests. There are few regulations that place limitations on firm operations. Licenses and permissions are easily available. In Bhopal, the Government of India not only invited Union

Carbide to enter this industry and gave the necessary licenses, but also provided subsidies for taxes, electricity, water supply and land. A few years later, against the recommendation of local authorities, the Central government gave permission to expand the Bhopal plant to manufacture MIC. It also bent over backwards to accommodate the company's demands by giving it special permission to control 51 percent of equity in the Indian Company.

Similarly, in the case of TMI, the government generously licensed nuclear power plants, with the number of licenses increasing until 1973. Throughout the fifties, sixties, and early seventies, the Atomic Energy Commission was responsible for both promotion as well as regulation of commercial nuclear power plants. However, as the Kemeny Commission noted after Three Mile Island, the focus on promotion far exceeded the focus on regulation (Kemeny 1979).

The social environment also supports the development of specific hazardous technologies in the munificence stage. These technologies are widely viewed as being in the public interest, and acceptable solutions to larger and intractable social problems. Thus, in the Bhopal case, pesticides were touted as a solution to the country's vexing problem of poor public health, and perennial food shortages. In the TMI case, nuclear energy was viewed as the solution to the energy problem, and a release from the threats posed by the OPEC oil embargoes. Nuclear power was enthusiastically endorsed by the government, utility industry, and the scientific establishment, as "the energy too cheap to be metered."

The environmental munificence stage precedes the crisis by at least five to ten years. By the time the crisis occurs few signs of munificence are apparent or even remembered.

The Onset of Crisis Proneness

Companies often react to environmental munificence with optimism, expanding operations, making new and risky investments, and pursuing aggressive growth. In this stage the organization expands with a gay abandon, characterized by capital investments into existing businesses, entry into new domains of business where they may have little experience, and employment expansion. Organizations try to capture fleeting but significant opportunities. The expansion is often rushed and risky, done under conditions of more than normal time pressures and less than normal information to support decision making. This is the first stage of evolution of crisis proneness.

Union Carbide's decision to establish the Bhopal plant was made during the seventies when the Indian government was emphasizing growth of the agricultural sector. Carbide was the only major chemical company that rushed to exploit the emerging opportunity, and they made little consideration of regulations, infrastructure availability, and safety management problems. Similarly, in the United States GPUC took several major decisions to enter and expand into nuclear power during the sixties, when the utility industry was growing very rapidly and attitudes toward nuclear power were very favorable in the social and political domains.

The inherently risky nature of the first stage leads to the embedding of pathogens in organizational systems. "Pathogens" here refers to minor organizational, technological, policies and procedural, and human factor errors that are at the root of accidents. This medical metaphor captures well the development of large scale failures in organizations. Pathogens remain dormant in an organism, until by chance they are aroused, after which they attack the organism and become the source of illness.

Similarly, organizational pathogens in the form of inherently unsafe technologies, inadequate safety and protection equipment, inadequate policies and procedures and poor human resource practices get embedded in technological plants and organizational systems. Pathogens get embedded in the organization several years before the actual crisis occurs, and over the years cumulate. Initially they remain dormant, and often unnoticed, because the hectic pace of organizational activities in the bullish expansion stage is good cover for embedding of pathogens. Thus, organizations acquire hidden but explosive characteristics, that at a future date may directly contribute to crises.

An example of seeding of pathogens is provided by Union Carbide's strategic steps to ensure its own viability in the progressively competitive environment of the late 1970s. In 1975, Union Carbide decided to reduce the cost of manufacturing pesticides by making raw materials including MIC. In this environment of economic crunch, the design of the MIC plant was guided more by cost considerations than by safety considerations. Large scale storage of MIC in underground tanks was selected over no storage of MIC or storage of limited quantities in small drums. To ease maintenance, a design modification was made in the headers leading to the storage tanks, making it possible for water to enter the tanks more easily. These choices were inherently more risky and years later made it possible for the accident to occur.

At GPUC, pathogens were embedded when the company decided to adopt different designs for the control rooms for the two reactors at Three

Mile Island. This decision was a source of confusion for some of the operators, who had been trained and were experienced in the operation of Unit No. 1, but then were transferred to the unfamiliar Unit No. 2.

Second Stage of Environmental Evolution: Crunch

The second stage is initiated by sudden discontinuity in the economic environment. Economic opportunities dwindle rapidly, or even bottom out overnight. Coupled with decline in demand is an increase in competition within the industry. Crunch may be precipitated by a natural decline in demand for industry products, political events, governmental action, foreign competition, or a combination of these forces. Severe economic pressures on organizations ensue, and may even threaten their survival, forcing them to conserve resources, tighten their belts and cut costs. The period of environmental crunch precedes crisis by three to six years. This stage broadly sets forces into action that in the next few years will progressively and inexorably push the organization into greater degrees of crisis proneness.

In the Union Carbide case, the economic crunch occurred twice at the corporate level: during the mid-seventies with oil shocks and consequent recessions in the US economy, and again in the early eighties. On both those occasions, the company was forced to make cutbacks and realign its business portfolio. It sold off assets, cut back work force and pared down expenditures. At the Bhopal plant, economic crunch was exemplified by decline in the demand for pesticides from late seventies to the early eighties. It was triggered by the reduction of pesticides needed for government programs and poor monsoons that precluded wide scale use of pesticides in agriculture. Simultaneously, competition within the industry increased with the advent of many small pesticide formulators who successfully catered to regional markets.

In the TMI case economic crunch on the nuclear industry was caused by a general decline in the economy and the energy industry. After the oil embargo of 1973, the U.S. economy entered a period of recession. Demand for energy dropped in the 1974-77 period, making the plants under construction unneeded. Simultaneously, the costs of raw materials increased and utility companies had to incur additional expenditures in order to comply with government regulations. Sharp increases in the cost of new nuclear power plants made nuclear power less competitive than had been projected originally (Hyman 1983).

During the economic crunch period, the political and regulatory environment changes from being facilitative to being restrictive. New and economically burdensome regulations are enacted, and more effective policing systems are established. Industrial licenses and government permissions become more difficult to obtain.

In India, many environmental protection laws were enacted in the mid to late 1970s. Government's attitude towards multinational corporations also became more restrictive during this period. For example, both Coca Cola and IBM were thrown out of India for not agreeing to dilute their equity below government mandated limits. The crunch stage of the TMI regulatory environment was started with the transfer of regulatory power from the Atomic Energy Commission to the newly created Nuclear Regulatory Commission in 1974. NRC was created with the specific mandate of regulating the development of nuclear energy. Advent of the Carter Administration in 1976, with its luke warm attitude toward nuclear power, further dampened enthusiasm for nuclear power in the political establishment. The effects of more stringent regulations are evident in the cost of nuclear regulation, which jumped from under $25 million per year in and before 1965, to over $200 million per year in and after 1977.

During the crunch stage, industries and technologies that may have been previously enjoyed social support are subjected to critical evaluation. This is often spurred by the inability of these industries to meet the exaggerated social expectations engendered during the munificence period. In India, as in many third world countries, the use of chemical pesticides came under criticism because they caused deaths and poisoning of many users. Moreover, the failure of the "green revolution" (agriculture using chemical fertilizers, pesticides, and irrigation), to make a dent on the food shortage problem led to the erosion of support for this modern form of agriculture.

In the TMI case, social movements of the 1960s created an attitude favoring environmental protection, use of human scale technologies, and public safety. In addition, the social sentiment against nuclear weapons spilled over to the nuclear power generation industry, further dampening residual enthusiasm. The several accidents that occurred in the nuclear industry only served to further compound the antipathy.

Organizational Response: Cutbacks

This stage refers to a period in which the organization cuts back on expenses in a attempt to remain competitive and profitable. Organizations respond to a crunch with radical actions that help maintain organization's viability. They often engage in aggressive resource conservation and cost cutting, and may even divest themselves of unprofitable operations. The crunch mentality is one of "belt tightening;" with safety consequences of measures rarely examined or acknowledged.

Cuts affect both production activities and support services. However, service activities (including maintenance, slack, extra supervision and surveillance, and personnel) get cut first and deepest. Cutbacks in personnel has two effects, both of which increase crisis proneness. First, reductions in the number of personnel in safety and maintenance functions reduces vigilance over hazards and can compromise the overall safety level. Second, personnel cutbacks create a sense of job insecurity that demoralizes the work force and reduces their loyalty to the firm.

Cutbacks that are consequential in causing crises can begin from one to three years before the crisis, initiating steady and cumulative erosion of the safety and integrity of production processes and products. At Bhopal the number of plant operators was reduced from eight in 1980 to four in 1984, at the time of the accident; materials costs were cut by recycling refrigerants from the MIC tanks to other parts of the plant; and the frequency of plant maintenance and operational safety surveys were reduced.

Cutbacks were implemented at MetEd and GPUC in 1972, after numerous cost over runs were discovered during a period of scarce funds for expansion. In 1974 employee strength was reduced by 403, and hundreds of jobs were redesigned, ostensibly to improve productivity. More importantly, further indirect cutbacks occurred in 1978 and 1979, when Unit No. 2 was put into operation without a proportionate increase in manpower. Just before the accident, the plant manager at Three Mile Island complained of inadequate staffing and poor morale among employees .

Third Stage of Environmental Evolution: Uncertainty

This stage is characterized by extreme and ubiquitous uncertainty in economic, technological, social, and political spheres; and continuous fluctuation in economic performance of industries and organizations. Industry demand for products is volatile. The heavy competition characteristic of the earlier phase is replaced by a shake-out of firms; many small firms may exit the industry. Technological uncertainty is prompted by minor accidents that reduce people's faith in the technology. There are concomitant fluctuations in social and political environments.

Early 1980s was a period of high uncertainty for the entire chemical industry, and particularly for Union Carbide Corporation. The company was facing strong global competition in a maturing chemical industry. Recent lack luster performance had prompted the company to overhaul its business portfolio and divest itself of many low profit chemical subsidiaries. The agricultural products business of Union Carbide's Indian subsidiary also faced high uncertainty.

The Bhopal plant had nine different factory managers in charge during its 14 year life. Some of these managers had been posted at the plant for less than a year. Others came from businesses totally unrelated to the production of chemicals, with no experience or background in the chemical industry. Frequent changes of factory managers created instability and discontinuity in management oversight. This weakness affected almost all parts of the plant, from morale of workers, to communications with headquarters, to implementation of safety policies.

Environmental uncertainty for GPUC was a consequence of the general condition of the U.S. economy. Buffeted by fluctuating oil prices in 1975-80 period, a world wide recession, and strong foreign competition, the U.S. economy faced major uncertainties. The energy sector of the economy was particularly sensitive to these changes because of its dependence on petroleum. In addition, increasing scrutiny by regulatory agencies at various governmental levels caused delays in the licensing and approval of nuclear plants.

The period of environmental uncertainty begins two or three years before the crisis; the volatility is sustained through out the crisis and even after it is over. Often regulatory induced and voluntary changes forced by the crisis restructure the environment to reduce this volatility. Haphazard responses to uncertainty make organizations crisis prone. Uncertainty fosters indecision, reluctance to act, delays in investment, cutbacks, and risky behavior in organizations. Organizations are fraught with indecision and vacillating about safety issues. They make more errors, and errors go undetected because of lack of vigilance. Several near-miss accidents may occur during this stage. Eventually crises are triggered by simultaneously and interacting failures in human, organizational and technological elements.

Confusion and Crisis Triggering Event

Environmental uncertainty complicates decision making. When there is no uncertainty, decisions are clear cut; however, when faced with uncertainty, the process is likely to take longer and organizations may be tempted to try to achieve mutually inconsistent objectives. It is under such circumstances that a failure in any single one of the supporting systems can cause a crises. These failures, which we call "crisis triggering" events, mark the end of precursor conditions and the beginning of crisis. They occur over a period of hours or days, but initiate a crisis which may last for several months or even years. They are caused by simultaneous and interacting failures in human, organizational, and technological elements.

Once the crisis triggering event takes place, the already weakened organization is unable to control the consequences. As a result, the event escalates into a full-blown crisis. The organizations in which they originate face a crisis of survival. They are closely scrutinized by the media and government agencies, come under critical attack from their stakeholders, and are often sued for damages. Financial and reputational damages resulting from such incidents are often sufficient to drive firms into bankruptcy.

In Bhopal, human failures included misjudgments by managers in allowing the use of defective storage tanks; human error (or sabotage by a worker) in pipe washing operations that allowed a large quantity of water to enter the storage tank; and the use of poorly qualified and trained workers in a sophisticated, hazardous facility. Organizational policy failures included faulty maintenance procedures that allowed four safety devices to be inoperative simultaneously; cost cutting measures, such as the removal of coolant from storage tank refrigerator and elimination of maintenance workers from second shift operation; and poor implementation of safety policies. Technological failures included poorly maintained equipment with leaking valves, broken gauges, and lack of safety equipment; design modification in the vendor system that eased maintenance but allowed water another path of entry into the storage tank, and storage of large quantities of impure MIC.

At Three Mile Island, organizational failures included reducing the levels of manpower in the absence of adequate understanding of nuclear power and poor human resources policies while the technological failure included failure of backup emergency systems poorly maintained backup systems.

CONCLUSIONS

This study describes precursors of crises as they evolve in interaction between organizations and their environments over a long period of time. Organizations do not experience crises without any advance warning: even sudden accidents have long historical patterns of strategic behaviors and failures. Precursors of crisis may precede the triggering event by as long as ten years. These precursors are a function of environmental changes and organizational responses to them.

Focusing on precursors of crises opens up new vistas for exploration. Past studies have explained crises by focusing on the triggering event and its immediate antecedents. By going back to sources that lead up to triggering events, this study identifies a new set of explanatory variables.

Although this was an exploratory study, it has some important practical implications. If we can identify crisis precursors early, we should be able to anticipate failures in large, complex, hazardous systems by studying their organizational histories. If managers observe boom-bust-confusion cycles, which are typical of crisis proneness, they may be able to interpret them as early warning signals and take preventive actions early in their evolution, quite possibly averting serious crises.

The evolutionary model presented here is based on a study of two crisis cases. Given the rarity of industrial crises, this model does not easily lend itself to validation through large samples. Rather than seeking generalizability, future studies of industrial crisis precursors instead should attempt to refine the model by identifying new variables relevant to explaining crisis precursors, describing nuances in relationships between variables, and establishing limits to the applicability of the model. This study has broadly articulated the logic of failures in the precrisis period. For this to become a diagnostically useful tool, further research is needed to refine the evolutionary model.

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