Regulation and Technical Innovation

By Nicholas A. Ashford and George R. Heaton

Environmental, health, and safety regulation and technological innovation are related concerns because: (1) past technological growth has resulted in problems that created the need for regulation; (2) regulation may affect the future rate and direction of technological innovation, thereby affecting economic growth; and (3) technological innovation is an important pathway to the solution of environmental, health, and safety problems.

The characteristics of regulation, the firm, and its technology principally determine how regulation affects technological change. Regulation is a complex stimulus. It may have different purposes, control different aspects of development or production, rely on different policy instruments, and have differing legal authority to "force" the development of new technology.

Informal government actions, which usually occur well in advance of formal rulemaking, also provide important signals to firms and often result in significant technological change. Uncertainty in the signals given the firm to meet environmental, health, and safety goals—particularly about the level of, and time frame for, compliance—may play a crucial part in the firm's response and may either stimulate or retard innovation. The uncertainty associated with regulation results from both industry and government action and may be a necessary consequence of the administrative flexibility in the U.S. political system.

It is useful for analytical purposes to separate the impacts of regulation into those affecting: (1) innovation for ordinary or "main business" purposes, and (2) abatement/compliance responses. In the first case, regulation affects a traditional, although slowly evolving, activity; whereas, in the second case, regulation demands technological changes which would not have been previously considered within the ordinary scope of business activity.

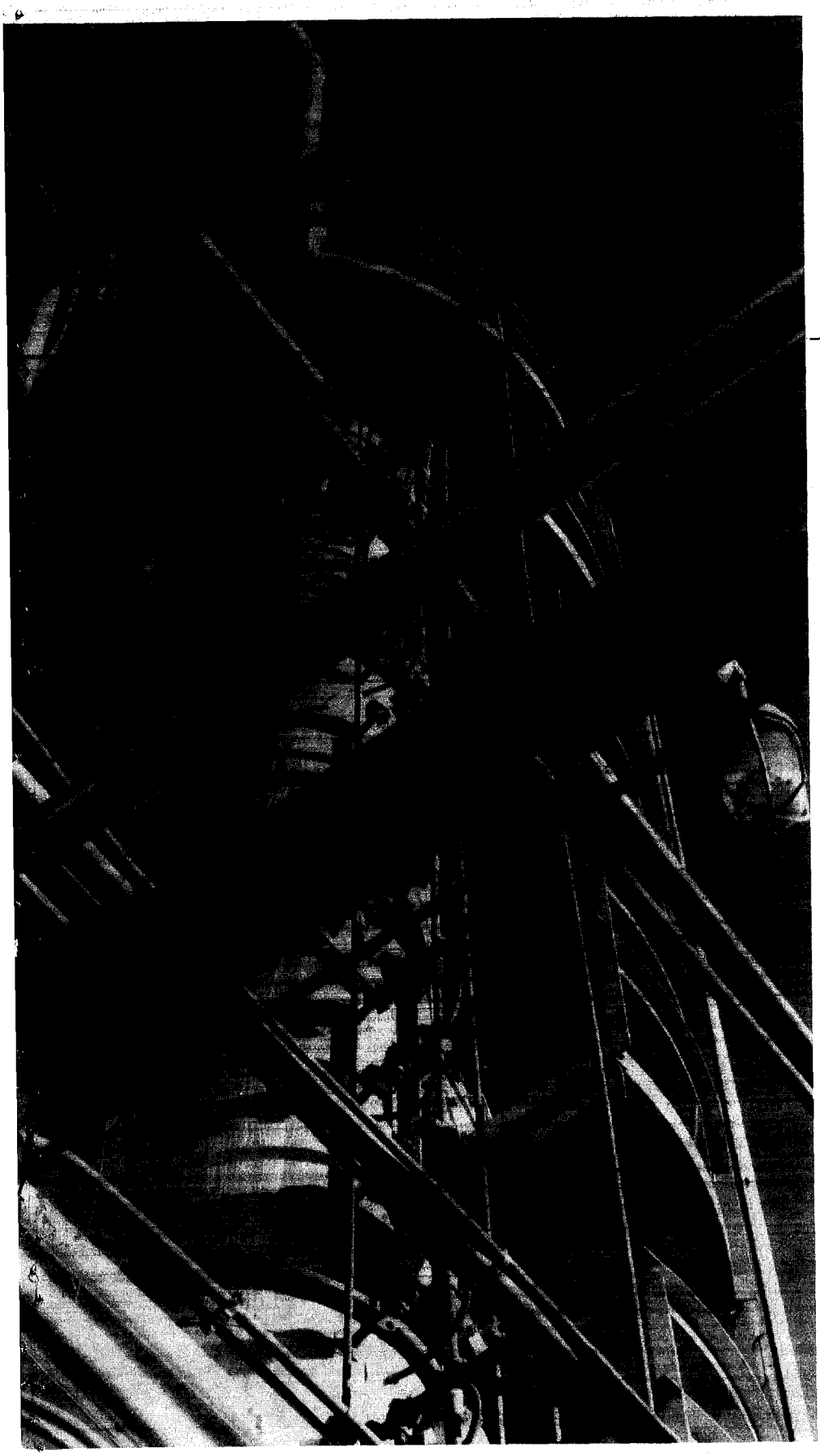
Regulation may cause changes in main business innovation by affecting profitability. Increased costs have been reported in the pharmaceutical industry, but the unusual character of both regulation and innovation in that sector may make its experience unique. The effect of cost increases on rates of return throughout industry has not been demonstrated. These costs may be passed on. Increased commercial risk may occur as a result of regulation; however, regulation may also decrease risk as compared to, for example, the threat of products liability suits. The number of new products in the pesticide and pharmaceutical industries has been shown to have decreased; however, it is neither clear that the level of significant innovations has declined, nor that the decline is attributable to regulation.

Regulation may increase the number of technically successful innovations that fail because of environmental, health, or safety concerns. On the other hand, regulation may reduce the number of products that would have ultimately failed for environmental, health, or safety reasons by discouraging their development. Even if failures do increase, there will be a compensating effect from increased safety, health, or environmental quality. Moreover, any change in the failure rate is likely to be a transitional, rather than a permanent, effect.

Because regulation can increase market risk, it changes the nature of investment opportunities. Increased risk may deter investment, especially in low-volume products. New applications for demonstrably safe technologies may be preferred to investments in environmentally unproven products and processes. Regulation is also likely to direct resources away from conventional R&D activities into compliance. To the extent that R&D diversion exists, it may tend to reduce main business innovation. There is substantial evidence of a change in corporate R&D, including overall decreases in some industries and a shift from basic to applied research. Whether this results from other factors or from regulation is not clear. Moreover, marginal decreases in R&D have not been shown to lead to a corresponding decrease in innovative output.

Some research has shown that the change in R&D patterns may actually

Dr. Nicholas Ashford is an Associate Professor of Technology and Policy and Assistant Director of the Center for Policy Alternatives at the Massachusetts Institute of Technology. He developed a methodology for decisionmaking in chemicals regulation for EPA and the U. S. Council on Environmental Quality. Dr. George Heaton, a research associate at the Center for Policy Alternatives, has been involved in various research efforts concerning the design of regulatory policy and its relationship to technology.



result in more overall innovation, especially in areas "ancillary" to compliance efforts. This phenomenon may occur predominantly in industries which were relatively uninnovative before regulation, but which have responded creatively to regulation. In addition, R&D induced by regulation can often lead to general process improvements. Although these benefits (e.g., greater output, smaller energy costs) do not usually outweigh the cost of compliance, they offset compliance costs to some extent. Finally, new organizational structures and skill mixes have been found in firms as a result of regulation. This can rechannel firm creativity.

Because regulation has different impacts on differently situated firms, it tends to change industry structure. Regulation creates barriers to entry when compliance measures are expensive and subject to economies of scale. On the other hand, many new entrants have solved regulatory problems that established firms were not successfully addressing. In addition, because regulation can increase the need to compete and the difficulty of survival in the market, it may lead to more innovation by established firms.

Regulation obviously encourages technological change for compliance purposes. However, these changes will not necessarily be new or novel technologies; indeed, regulation often prompts compliance through new uses or diffusion of existing technologies. In regulated industries (in contrast to the pollution control industry), the adoption of compliance measures may result in health and safety benefits only, with little or no benefit to the firm. On the other hand, even though most compliance technologies appear to be developed within the regulated firm for its own use, many compliance technologies are also saleable. In some industries, the relationship between suppliers and producers has been altered by regulation, with suppliers often developing innovative compliance technology. It should be recognized that the division of industry into regulated segments and the pollution control industry

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may not be a real one, especially in the chemical industry. There, the regulated firm and the creator of new compliance technology are often one and the same.

Over a period of two years the MIT Center for Policy Alternatives conducted a National Science Foundation-sponsored study of the effects of environmental, health, and safety regulation on technological change in the U.S. chemical industry.

The study involved both the construction of a model of the effects of regulation on compliance technology and an investigation of the characteristics of regulation, the technologies employed by the regulated or responding firms, and the resulting technological responses. Data were obtained from interviews with about 50 firms subjected to the principal regulations on lead, mercury, PCB's, and vinyl chloride.

The study concluded that the character of the technology in use is a major factor determining the response to regulation. Most firms in a given industrial segment responded very similarly. Moreover, their response was often what would have been expected, given the history of innovation in the segment. We therefore concluded that compliance responses to regulation are usually predictable.

On the other hand, there were some surprises. Particularly when regulation precipitated "crisis" conditions, industry responded creatively, changing its historical patterns. Sometimes innovative responses arose from firms outside of the regulated group. The responding firms saw the development of compliance technology as a way to capture new markets.

Most compliance technologies used were actually modifications, or sometimes even simple adoptions, of existing technologies rather than new ideas. Very few radically new technologies arose in response to regulation and very few required much development time. There are significant exceptions to this pattern, however, especially in the case of recent regulations concerned more directly with chemical process technology or product safety.

Perhaps our most important findings concerned systemic changes in the innovation process and the ancillary responses traceable to regulation. The principal systemic change observed was the establishment of environmental or regulatory affairs units in 65 percent of the firms in our sample. The environmental affairs units maintained liaison with regulatory agencies and often established in-firm environmental safety standards and review procedures for new and existing products and processes. Thus they are likely to provide a continuing incentive for safer products and processes. We also saw a change in personnel skill-mixes as a result of regulation. For example, regulation has greatly increased the need for analytical chemists. Companies often reported that the addition of such new skills allowed them to find more and better uses for their products.

Ancillary or "spin-off" changes were evident as well. These changes occurred as a result of the need to comply with regulation but were not necessary in order to meet regulatory requirements. Twenty percent of the firms interviewed remembered or readily admitted to the existence of ancillary improvements, but we believe that more would have been revealed had we interviewed several persons in each firm. Many ancillary changes arose when companies took advantage of the opportunity created by regulation-related changes to institute other changes—long-desired but postponed. Thus, we saw regulation accelerating new developments. Other ancillary changes arose directly out of compliance R&D—for example, several new catalysts for petroleum refining were developed as part of the effort to switch to lead-free gasoline. Although these ancillary responses were often unforeseen at the time compliance efforts began, our experience shows that they are not rare events.

In the past, the chemical industry has been resilient in its response to significant regulatory efforts. It has reached or surpassed the technological requirements of regulation. In part, this is because the previous standards imposed appear to have been based on present technological feasibility or best available technology. But, in addition, the industry has been able to accelerate the development of new process technology needed for compliance—for example new polymerization techniques for vinyl chloride. There is strong evidence that regulation can change the overall character of product and process innovation in the industry, providing that the regulations are stringent enough and properly designed.

The industry might well be viewed as being in a transition period between a past history of little emphasis on environmental and health concern and a future pattern of much greater activity. This is evidenced by increasing managerial attention to these issues via both the formal establishment of environmental affairs units and shifting emphasis in the nature of chemical product design and production.

The newer regulatory efforts, especially those concerned with workplace hazards, consumer products, and new activities by EPA under the Toxic Substances Control Act, may be particularly important for innovation both in compliance technology and in process or product redesign. This is to be contrasted with past efforts at air and water quality control, which focused on single pollutants as emissions or effluents at the end of the production process.

The most important effect of regulation on technological innovation may be its potential for restructuring the nature of industrial production. Over the longer term, industry may adiust to environmental, health, and safety demands with changes in the nature of production that will be more basic and can be accomplished with far less disturbance.

Regulations should be designed to elicit the best possible technological response from the industry. The past pattern of basing standards on existing technology must be altered by promulgating regulations which are "technology forcing." In addition, the overall stimulus for change must be made strong enough to effect a shift in the general management approach to all possible hazards associated with production. The adoption of generic regulations or regulation of classes of chemicals would provide a stronger impetus for change than a substance-by-substance approach.

In the past, one of the impediments to the design of "technology forcing" regulations has been the fact that the agencies have relied on the regulated industries as the source of their information about the potential for technological change. Accordingly, compliance has been largely the adoption of "off the shelf" technology and has resulted in less protection of health and the environment than might have actually been possible. Our research suggests that important changes in technology can be encouraged by regulation. This will be the case especially if, in the future, both the agencies and the industry develop an appreciation for the complexities of the regulation-technological change relationship. The regulatory agencies should be aware of the fact that it is possible to design regulations to stimulate the development of new technologies whose performance exceeds the expectations of both industry and government. □