CHAPTER 9

The Influence of Information-Based Initiatives and Negotiated Environmental Agreements on Technological Change

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9.1. Introduction and scope of the chapter

While it is accepted that inappropriate or indiscriminate design, use and disposal of a wide range of technologies are responsible for global as well as local environmental degradation, it is also widely recognized that fostering appropriate technological change is a necessary part of the solution. As will be discussed below, industry, agriculture and the service sector must have the willingness, opportunity, and capacity or capability to undertake technological changes. These changes could involve the adoption of already-proven technologies, or require incremental to radical innovation. In addition to process and product changes, changes in the organization of production and work also properly fit under the rubric of technological change.

In highly industrialized countries, the predominant response to environmental degradation has been to regulate maximum allowable emission and effluent levels, and concentration limits, in air water and soil directly, define acceptable levels and limits by reference to those achievable by application of certain technologies, such as best available technology (BAT), or require the adoption of specific technologies. There is a considerable literature on the effects of classical regulatory approaches on technological change, but little has been written on the effects of alternative or supplemental non-mandatory instruments, such as information-based initiatives and negotiated agreements, on technological change which are in a sense 'voluntary' on the part of industry. This chapter attempts to fill that void.

It is, however, important to be cognizant of the various effects that regulation might have on technological change because many so-called voluntary approaches occur against a backdrop of regulation and the success of some voluntary approaches are based on incentives that mimic regulation, such as civil liability (Ashford and Stone, 1991). The central questions are

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whether and to what extent more flexible approaches can be used to foster technological change, what kinds of technological changes are likely to be encouraged relative to classical regulatory approaches, and what are the necessary and sufficient conditions for those more flexible approaches to succeed? The core of such an enquiry requires an analysis of incentives and a behavioral model of firm behavior which explains the effect of incentives on the responding industrial sectors.

9.2. Technological change defined

Technological change is a general term that encompasses technological innovation, invention, diffusion, and technology transfer (Ashford and Caldart, 1996). Technological innovation is the first commercially successful application of a new technical idea. Sometimes the innovation is embodied in hardware and devices, sometimes in the organization of production and work, and sometimes in both. Innovation should be distinguished from invention, which is the development of a new technical idea, and from diffusion, which is the subsequent widespread adoption of an innovation by those who did not develop it. The distinction between innovation and diffusion is sometimes hard to draw, however, because innovations can rarely be adopted by new users without some modification. When modifications are extensive, i.e. when adoption requires significant adaptation, the result may be a new innovation. The term technology transfer is somewhat imprecise, sometimes referring to the diffusion of technology from government to industry, or from one industry or country to another. Although the term technology-forcing is most commonly used to mean the forcing of invention or innovation, it is also often used to mean the forcing of diffusion or technology transfer as well.

An innovation can be characterized by its type, by its significance, or by the activity from which it evolves. Innovation can be process-oriented or product-oriented. It can be modest and incremental or radical and revolutionary in nature. Innovation can be the result of an industry's main business activities or can evolve from the industry's efforts to comply with health, safety, or environmental demands. Regulatory instruments, economic incentives and voluntary initiatives, can affect any of these characteristics.

9.3. Historical evidence for the effects of regulation on technological change

The reductionist version of neoclassical economic theory predicts that since environmental regulation imposes non-productive investment by industry on pollution control, regulation can only be a drag on innovation, and hence on economic growth, because of the diversion of resources from R&D.[1] A more modern view currently in vogue is the so-called Porter hypothesis (Porter, 1991), which argues that regulations may actually stimulate growth and competitiveness. In fact, that suggestion and the empirical evidence that supports the hypothesis goes back to a series of publications from researchers at MIT beginning 12 years earlier (Ashford et al., 1979, 1985; Ashford and Heaton, 1983; Ashford, 1993), although Porter does not seem to be conscious of it (Jaffe et al., 1995).

There is ample evidence that regulation, if properly designed and implemented, can prompt the kind of technological change that can significantly reduce human and environmental exposure to toxic substances. Prior work has developed models to explain the effects of regulation on technological change (Figure 9.1). The particulars of this model, the nature of the regulatory stimulus, the characteristics of the responding industrial sectors, and the resulting implications of the model for explaining technological responses to regulation and for designing innovative regulatory strategies, are discussed below. As we will see, the model is also useful for predicting the results of voluntary initiatives by industry.

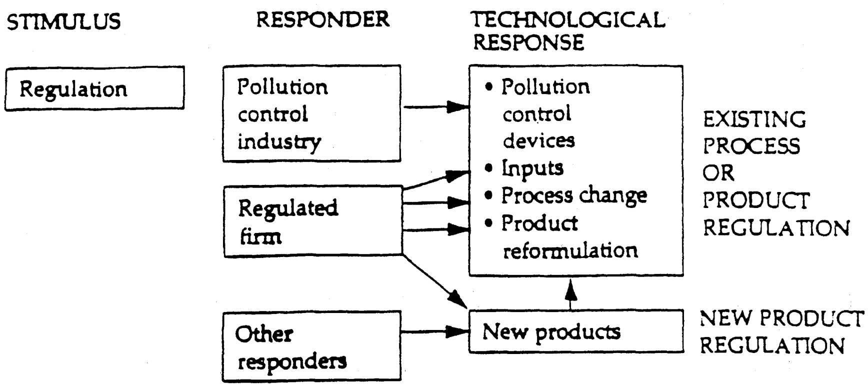

Figure 9.1. A model for regulation-induced technological change

9.3.1. *The regulatory stimulus*

Environmental, health and safety regulations affecting the industry that uses or produces a regulated chemical include controls on air and water quality, solid and hazardous waste, pesticides, food additives, pharmaceuticals, toxic substances, workplace health and safety, and consumer product safety. These regulations control different aspects of development or production; they change over time; and they are technology-forcing to different degrees. Furthermore, the internal structure of regulations may alter the general climate for innovation. Elements of that structure include the form of the regulation (product versus process regulation), the mode (performance versus specification standards), the time for compliance, the uncertainty, the stringency of the requirements, and the existence of other economic incentives that complement the regulatory signal.

The distinction between regulation of products and regulation of processes suggests yet a further distinction. New products differ from existing products, and production process components differ from unwanted by-products or pollutants. Regulations relying on detailed specification standards (which specify the technology to be installed) or on levels of control achievable by the best available technology may discourage innovation while prompting rapid diffusion of state-of-the-art technology. Although a phased in compliance schedule allows a timely industry response, it may prompt only incremental improvements in technology.

An industry's perception of the need to alter its technological course often precedes promulgation of a regulation. Most environmental regulations arise only after extended scrutiny of a potential problem by government, citizens, workers, and industry. Prior scrutiny often has greater effects on industry than formal rule making, because anticipation of regulation stimulates innovation. For example, formal regulation of PCBs occurred years after the government expressed initial concern. Aware of this concern, the original manufacturer and other chemical companies began to search for substitutes prior to regulation. Similarly, most firms in the asbestos products industry substantially complied with Occupational Safety and Health Administration asbestos regulation years before it was promulgated. This pre-regulation period can allow industry time to develop compliance technologies, process changes, or product substitutes while allowing leeway for it to adjust to ensure continued production or future commercial innovation.

The government's initial show of concern is often, however, an unreliable stimulus to technological change. Both technical uncertainties and application of political pressures may cause uncertainty regarding future regulatory requirements. Nevertheless, some regulatory uncertainty is frequently beneficial. Although excessive regulatory uncertainty may cause industry inaction, too much certainty will stimulate only minimum compliance technology. Similarly, excessively frequent changes to regulatory requirements may frustrate technological development. (Tunable economic instruments, such as pollution taxes, also provide inherently uncertain signals, although they may achieve better static efficiency employing off-the-shelf technology.)

Regulatory stringency is the most important factor influencing technological innovation. A regulation is stringent either because compliance requires a significant reduction in exposure to toxic substances, because compliance using existing technology is costly, or because compliance requires a significant technological change. Legislative policy considerations dictate different degrees of stringency. Some statutes require that standards be based predominantly on environmental, health, and safety concerns; some on existing technological capability; and others on the technology within reach of a vigorous research and development effort.

In the early 1970s most environmental, health, and safety regulations set standards at a level attainable by existing technology. The regulations reflected both a perceived limit to legislative authority and substantial industry influence over the drafting of standards. Some recent regulations, such as the technology-based standards for hazardous air pollutants under the 1990 amendments to the Clean Air Act, have tended toward greater stringency, but they still rely on existing technologies, although often those in minority or rare use. The effect of the agency's strategy on innovation is not confined to standard setting. Innovation waivers or variances, which stimulate innovation by allowing non-compliance with existing regulation while encouraging the development of a new technology, are affected by enforcement strategies as well. These are discussed under Negotiated Agreements (below). Finally, the degree to which the requirements of a regulation are strictly enforced may influence the willingness of an industrial sector to attempt to innovate.

9.3.2. Characteristics of the responding industrial sector

The industry responding to regulation may be the regulated industry, the pollution control industry, or another industry (see Figure 9.1). Regulation of existing chemical products or processes might elicit installation of a pollution control device, input substitution (the substitution of one input chemical for another), a manufacturing process change, or product reformulation. The regulated industry will likely develop new processes and change inputs; the pollution control industry will develop new control devices; and either the regulated industry or new entrants will develop reformulated or new products, depending on their inherent innovativeness in the product area. Regulation of new chemicals (such as pre-market screening), however, will simply affect the development of new products.

Past research on the innovation process in the absence of regulation has focused on the innovation dynamic in diverse industrial segments throughout the economy (Utterback, 1987). The model of the innovation process on which that research focused refers to a 'productive segment' (a single product line) in industry, defined by the nature of its technology. Automobile engine manufacture would be a productive segment, as would vinyl chloride monomer production, but neither the automobile industry nor the vinyl chloride industry would be a productive segment since they both encompass too many diverse technologies. Over time, the nature and rate of innovation in the segment will change. Initially, the segment creates a market niche by selling a new product, superior in performance to the old technology it replaces. The new technology is typically unrefined, and product change occurs rapidly as technology improves. Because of the rapid product change, the segment neglects process improvements in the early period. Later, however, as the product becomes better defined, more rapid process change occurs. In this middle period, the high rate of process change reflects the segment's need to compete on the basis of price rather than product performance. In the latter stages, both product and process change decline and the segment becomes static or rigid. At this point in its cycle, the segment may be vulnerable to invasion by new ideas or disruption by external forces such as regulation or an energy crisis that could cause a reversion to an earlier stage.

9.3.3. The explanation of technological responses to regulation and implications for the design of strategies

Review of the history of regulation on technological change confirms that product regulations tend to call forth product innovations, that pollutant regulations tend to elicit process innovations, and that the stringency and relative certainty of regulation are important determinants of technological innovation (Ashford et al., 1985). These observations are expected from the general innovation model described above. Responses to regulation will be influenced by the inherent innovativeness of the responding industrial sector, which in turn can be predicted from past patterns of innovation along either product or process dimensions. Further, as is discussed below, the responses of industry to information-based initiatives or negotiated agreements will likewise be more or less predictable.

The value of this theory of innovation is that it provides a rationale upon which an environmental or governmental authority may fashion a regulation or other strategy aimed at the industry most likely to achieve a desired environmental goal and by which the private sector can develop a more appropriate response to environmental problems. Consistently, the theory relies on the assumption that the strategy designer can determine the extent of an industry's innovative rigidity (or flexibility) and its likely response to incentives with reference to objectively determinable criteria.

9.4. Information-based approaches

Information-based approaches can be voluntary, such as eco-labelling or certain kinds of eco-audits, or they can require the firm to report emissions, effluents and sudden/accidental releases to the environment, or to disclosing the exposure of workers to toxic substances. To the extent that there is high demand for green products in a certain country, one might well expect product innovation from a producer in a certain product niche, providing that producer has the capability to engage in product innovation. Where the established product is unsafe, or undesirable from an environmental perspective, and not worthy of an eco-label, a new entrant with a superior product may very well displace a well-established, but non-innovative product firm. To the extent that a firm's product not only has to be safe, but has to be manufactured safely and its inputs be environmentally acceptable to earn an eco-label, process innovation, or at least modification, may occur, and input substitutions from existing alternatives may be fostered. Unfortunately, most eco-labelling schemes start with the firm, given its inputs, and ignore manufacturing processes, concentrating instead on product use and disposal.

Eco-audits can serve the purpose of making the firm more aware of its environmental problems and, if the firm is capable, search for technological alternatives in inputs and manufacturing process to produce the same product in a more environmentally friendly way, or reformulate its product, providing it is in the firm's economic or reputational interest to do so. The eco-audit alone will not drive the firm to either innovate or to adopt technology in use elsewhere, unless there are significant economic costs associated with polluting that can be avoided or benefits to changing production (such as recovering valuable material in pollution streams). To the extent that eco-auditing schemes require the firm to submit a plan to remediate its pollution and to follow up with action, there could be significant technological change. This is mostly not the case.

Right-to-know requirements for the reporting of emissions, effluents and sudden/accidental releases to the environment or the disclosure of the exposure of workers to toxic substances by a firm could prompt significant demands from the community or workforce to control pollution, providing they have timely access to the reported information. In the United States, industry reporting requirements have lead to easy, but important changes in production practices, usually under the description of house-keeping or maintenance changes. Where loss of valuable starting material or final product is discovered by the reporting requirements, some process changes may be stimulated.

Whether its interest in pollution prevention comes in response to legal requirements or as a result of voluntary risk reduction efforts, a firm must have access to information about pollution prevention technologies if it is to adopt or adapt them. Environmental agencies have had a mixed history in making such information available through information dissemination, demonstration projects and technical assistance to firms.

Beyond simply sharing information on particular technologies, the agencies could help promote pollution prevention by helping firms to think about their technological options in a more formal and systematic fashion. In order to facilitate pollution prevention or the shift to clean (or cleaner) technologies, options for technological change must be articulated and evaluated according to multivariate criteria, including economic, environmental and health/safety factors. The identification of these options and their comparison against the technology in use is called technology options analysis (TOA) (see Ashford, 1994).

At first blush, it might appear that TOA is nothing more than a collection of multivariate impact assessments for existing industrial technology and alternative options. However, it is possible to bypass extensive cost, environmental, health and safety, and other analyses or modelling by performing comparative analyses of these factors (such as comparative technological performance and relative risk and ecological assessment). Comparative analyses are much easier to do than analyses requiring absolute quantification of variables, are likely to be less sensitive to initial assumptions than, for example, cost–benefit analysis, and will enable easier identification of win–win options. Thus, while encompassing a greater number of technological options than simple technology assessment (TA), the actual analysis would be easier and probably more believable.

TOAs can identify technologies used in a majority of firms that might be diffused into greater use, or technologies that might be transferred from one industrial sector to another. In addition, opportunities for technology development, that is, innovation) can be identified. Government might merely require the firms or industries to undertake a TOA. On the other hand, government might either force or assist in the adoption or development of new technologies. If government takes on the role of merely assessing (through TA) new technologies that industry itself decided to put forward, it may miss the opportunity to encourage superior technological options. In this case, only by requiring or undertaking TOAs itself is government likely to facilitate major technological change. Both industry and government have to be sufficiently technologically literate to ensure that the TOAs are sophisticated and comprehensive. Once superior existing technologies or technologies within easy reach of development are identified, the firm may be motivated to change out of both economic self-interest and in order to avoid possible future liability resulting from the failure to adopt less polluting or safer technology.

9.5. Negotiated agreements with government

Negotiated agreements with government differ from other so-called voluntary approaches in that they may be motivated by a desire on the part of industry to facilitate the achievement of legislated or mandatory environmental goals by introducing flexibility and cost-effective compliance measures, to negotiate specific levels of compliance fulfilling more general legislative mandates, or to negotiate legal definitions of best available technology and other technology-based requirements. (For a detailed analysis of U.S. negotiated agreements in both the environmental and occupational health areas, see Caldart and Ashford, 1999.)

Negotiated agreements may be divided into (1) negotiated regulation (either preceding formal regulation or as a substitute for formal regulation), including emission and effluent levels, and concentration limits in air, water and soil, and (2) technology-based standards, such as Best Available Technology (BAT); and negotiated compliance (implementing regulation or informal agreements), including the means and timetable for coming into compliance with emission, effluent, concentration, or product content requirements; and negotiation in the context of an enforcement action in which the firm is out of legal compliance (for example, encouraging cleaner production through the leveraging of penalty reductions).

Negotiated regulation between government and industry over emission and effluent levels, and concentration limits in air, water and soil will, in general, not encourage innovation, relative to classical regulation, unless the negotiating industry thinks it can use its possible superior pollution control or prevention technology to thwart domestic or foreign competition. The history of the effects of regulation on technological change indicate that only stringent regulation stimulates innovation, and usually firms negotiate regulatory limits to reduce their possible stringency. On the other hand, where acceptable limits are based on the performance of a particular technology (like BAT), and where a particular firm is able to negotiate industry-wide standards based on it's own technology, it may be motivated to innovate a superior technology which it can subsequently license or use to dominate the market.

Negotiated compliance between government and a specific firm over the means and timetable for coming into compliance with emission, effluent, concentration, or product content requirements has the potential to stimulate innovation, particularly process innovation, but is more likely to encourage the adoption of superior, off-the-shelf technology. In the United States this has been done either through negotiating specific terms in a facility permit or through innovation waivers. The individual state-based negotiated permits have been inadequate to bring the states into compliance with many federal requirements, resulting in criticism that states have been too lenient and lax about imposing emission limitations. Thus, innovation is unlikely to be fostered, and only a modicum of superior technology diffusion is likely to have occurred.

9.5.1. Innovation waivers

Various environmental laws have had provisions allowing the Environmental Protection Agency to issue innovation waivers, to allow a firms additional time to develop innovative approaches to compliance (Ashford et al., 1985). Similarly, variances have been available under the Occupational Safety and Health Act to employers seeking additional time to develop a new approach to worker protection. These provisions have rarely been used, however, both because industry has been unsure of their application has thus been wary of risking non-compliance, and because the agencies have not encouraged their use.

Innovation waivers are incentive devices built into environmental regulations. Generally, the waivers extend deadlines by which industry must meet emission or effluent limitations. Development of an innovative idea into an operational reality often requires trial periods and substantial time, during which a firm can incur penalties from violations of emissions or effluent standards. The innovation waiver exempts industry from penalties during trial periods and offers it the prospect of cost savings derived from a superior technology (the 1977 amendments to the Clean Air Act and the Clean water Act both provide for innovation waivers).

Innovation waivers apply mostly to process change, are expressly innovation-forcing, and do not promote diffusion. The agency will seldom use a waiver mechanism for promoting radical process innovation because of the long time generally necessary to develop the innovation. The agency, however, might well encourage both incremental process innovation and acceleration of radical innovation already underway. Success will require EPA to give early, clear, and certain signals to the developer, minimizing the risk of his technology being found unacceptable. Furthermore, good faith efforts resulting in significant, though not complete, achievement of the pollution reduction goal should be rewarded by fail-soft strategies, using appropriate and adjustable economic sanctions, industry is to be persuaded to take a technical and legal risk. One can make a case for risk sharing between government and industry in the interest of fostering innovative solutions.

9.5.2. Encouraging pollution prevention innovation and diffusion in enforcement settlements (see Becher and Ashford, 1995)

The settlement of an enforcement action often offers the agency an excellent opportunity to promote pollution prevention, rather than conventional end-of-pipe control technology. The firm's attention has been commanded, and a need for creative (and less costly) approaches to compliance may well have become apparent. EPA has sought to capitalize on this opportunity by encouraging the use of Supplemental Environmental Projects to promote pollution prevention.

Firms found in violation of EPA regulations can take advantage of two relatively new EPA policies that invite the inclusion of pollution prevention in enforcement settlements. Companies that have done so reduced or eliminated an environmental problem at the source and enhanced their prospects for future compliance. Many companies received a penalty reduction for their efforts, typically one dollar reduced for every two dollars expended. In order to increase the number of successful cases, the EPA Office of Enforcement commissioned the Massachusetts Institute of Technology to examine the agency's experience in promoting pollution prevention through its enforcement programmes.

In June 1989, the EPA Office of Enforcement issued a Pollution Prevention Action Plan that articulated the agency's strategy for promoting pollution prevention in enforcement. The enforcement settlement process was the primary target. Roughly 90% of firms cited with noncriminal violations of federal environmental statutes resolved the matter through a negotiated settlement with one of 10 regional offices of EPA rather than administrative proceedings in court. In the settlement process, EPA and company attorneys agree on a penalty and a set of conditions designed to achieve and maintain compliance. EPA has little statutory or regulatory authority to require firms to implement pollution prevention; the regulated community can choose how it will comply with federal requirements. Once an enforcement action is initiated, however, a window of opportunity for pollution prevention opens because the means of achieving compliance are subject to agreement by the agency and violator.

The principal mechanisms for including pollution prevention in enforcement settlements were articulated in two EPA policy statements. In 1991, EPA issued its *Policy on the Use of Supplemental Environmental Projects (SEPs) in Enforcement Settlements* (internal memo dated February 12, 1991). SEPs are environmentally beneficial activities negotiated into the terms of a settlement with EPA. The SEP policy authorized EPA to reduce the assessed penalty in exchange for the execution of a SEP. There were five categories of SEPs: pollution prevention, pollution reduction, environmental restoration, environmental auditing, and public awareness. In Fiscal Year 1992, EPA negotiated 222 SEPs, excluding the 187 negotiated by the Office of Mobile Sources. Twenty-eight percent involved pollution prevention. For a description of an updated SEP policy, see EPA Supplemental Environmental Projects Policy, 29 Environmental Reporter (BNA) 78–79 (1998) and Caldart and Ashford, 1999.

Also in 1991, EPA issued its *Interim EPA Policy on the Inclusion of Pollution Prevention and Recycling Provisions in Enforcement Settlements* (internal memo dated February 25, 1991), which provides specific guidelines for including pollution prevention in a settlement as either a SEP or a method of compliance. The Interim Policy gives agency negotiators flexibility to extend compliance schedules when pollution preventions is used as the means of compliance, especially if innovative technology is involved.

EPA can enhance and expand these activities. The research centered on case study analysis of nine SEPs and one enforcement settlement that used pollution prevention as the compliance method. In all 10 instances, a pollution prevention project was successfully negotiated into the terms of a legal settlement between the EPA and the firm. These settlements included chemical substitutions, process changes, or closed-loop recycling activities and were drawn from the universe of judicial and administrative enforcement actions negotiated by EPA up to and including fiscal year 1992.

Of the 10 case studies, five were reporting violations under Emergency Planning and Community Right-to-Know Act (EPCRA), Section 313 (i.e. Form R, Toxics Release Inventory data reporting; two stemmed from Clean Water Act violations; one from a Clean Air Act violation; and one from Resource Conservation and Recovery Act violation). The predominance in the study sample of EPCRA cases, that is, those involving failure to report toxic emissions on a Form R, reflects the relatively large number of pollution prevention SEPs in the larger sample population that were negotiated in EPCRA 313 settlements.

The technological changes undertaken by firms can be categorized by pollution prevention projects according to the locus and innovativeness of the change. The majority of technological changes made by case study firms are diffusion driven. A smaller number can be considered incremental innovations, and only one case can be considered a major innovation. There is a fairly even distribution of technological changes across the spectrum of primary, secondary, and ancillary processes.[2] If a random case study selection process had been used, the sample would have been more heavily weighted toward diffusion-driven changes to ancillary production processes. The larger universe of EPA settlements containing pollution prevention consisted mostly of adopting off-the-shelf cleaning technologies. This suggests there are unexploited opportunities in enforcement for stimulating innovative technological changes. This would require changing attitudes and levels of knowledge on the part of both the firm and EPA.

Representatives from all nine of the SEP case study firms indicated support for the SEP policy. The firms were glad to have had the option to implement a pollution prevention project in exchange for some penalty reduction. The SEPs took some of the sting out of the enforcement process but did not eliminate the significant economic and psychological impacts of associated with being found out of compliance. Several companies stated that SEPs help to recognize their efforts to make improvements.

The flexibility offered by the two EPA policies should be used more aggressively to enhance not only pollution prevention, but also the development of new pollution prevention technologies and adoption of existing innovative technologies. Several of the cases demonstrated that this can be done, though not without determination and creativity on the part of both the agency and the firm.

9.6. Conclusion

Regulation, information-based initiatives, and negotiated environmental agreements can all influence technological change. Changes could involve either the adoption of already-proven technologies, or incremental to radical innovation in inputs, processes, final products, and the organization of production and work. In order for optimal changes to occur in industry, agriculture, transportation, energy systems, and the service sector, firms must have the willingness, opportunity, and capacity or capability to undertake those changes.

The capability to change depends on both the inherent innovativeness of the firm and available economic resources. The outcomes of various strategies will necessarily differ, depending on whether they create incentives which encourage firms to investigate heretofore unrecognized problems related to worker health, safety, and the environment and to act on information the firm already has (as a result of being required to report emissions, effluents, and waste; by seeking to earn a product eco-label; by undertaking eco-audits, or by negotiating the means and timetable for coming into compliance), to search for information outside the firm regarding already-existing solutions, thus encouraging the diffusion of technology from other firms or industries (as a result of performing technology options analysis), or to undertaken incremental technological innovation, or more radical innovation if they can (as a result of applying for innovation waivers, negotiating compliance levels or technology-based standards with regulatory agencies, or negotiating pollution prevention or cleaner/safer technology agreements with regulatory authorities). The policy designer would be well advised to think about what kind of technological change is needed to address a worker health, safety, or environmental problem and who is in the best position to deliver it. Sometimes it must be acknowledged that the firms creating the problems are not capable of providing the needed or best solutions, either because they do not have the requisite information, they do not have the requisite know-how, or because the lack of economic resources prevent their investing in technology development.

In the first case, strategies which disseminate information or stimulate information searches is needed. In the second case, a deliberate strategy of encouraging displacement or radical transformation of the dominant technology requires a new entrant (an outsider) to solve a particular worker health, safety, or environmental problem. In the latter case, financial assistance and incentives could help. What is important to realize is that the instruments and initiatives chosen should reflect the recognition that different policy instruments will elicit different kinds of responses, sometimes from different actors. Strategic approaches should be fashioned in such a way as to encourage the best possible technological change from the actors in the best position to bring it about. As a result, a dynamic eco-efficiency, rather than static eco-efficiency might be achieved.

Notes

1. For a recent review of this perspective, see Jaffe et al. (1995).
2. The distinction between primary, secondary, and ancillary manufacturingt/production process is an important one for innovation. An example in the context of casting and plating metal screws makes the point. The primary process is the casting of the screw. The secondary process is electroplating. The ancillary process is cleaning or degreasing the screw using organic solvents. If the environmental problems facing the firm is created by the latter activity, it might be relatively easy for the firm to search for and find an alternative, non-polluting cleaning process, and no innovation would be required. If the electroplating is the process that needs to be modified, at least a new process might have to be brought into the firm – usually by the diffusion of alternative plating technology – but the firm would be uncomfortable about changing a proven method and taking a chance on altering the appearance of its product, even if it is a separate operation. The most resistance could be expected by demands on the primary process. Here innovation might be necessary and the firm is not likely to invest in developing an entirely new casting process in order to reduce a regulatory fine.

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