GREEN AND COMPETITIVE: ENDING THE STALEMATE.

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The need for regulation to protect the environment gets widespread but grudging acceptance: widespread because everyone wants a livable planet, grudging because of the lingering belief that environmental regulations erode competitiveness. The prevailing view is that there is an inherent and fixed trade-off: ecology versus the economy. On one side of the trade-off are the social benefits that arise from strict environmental standards. On the other are industry's private costs for prevention and cleanup -- costs that lead to higher prices and reduced competitiveness. With the argument framed this way, progress on environmental quality has become a kind of arm-wrestling match. One side pushes for tougher standards; the other tries to roll them back. The balance of power shifts one way or the other depending on the prevailing political winds.

This static view of environmental regulation, in which everything except regulation is held constant, is incorrect. If technology, products, processes, and customer needs were all fixed, the conclusion that regulation must raise costs would be inevitable. But companies operate in the real world of dynamic competition, not in the static world of much economic theory. They are constantly finding innovative solutions to pressures of all sorts -- from competitors, customers, and regulators.

Properly designed environmental standards can trigger innovations that lower the total cost of a product or improve its value. Such innovations allow companies to use a range of inputs more productively -- from raw materials to energy to labor -- thus offsetting the costs of improving environmental impact and ending the stalemate. Ultimately, this enhanced resource productivity makes companies more competitive, not less.

Consider how the Dutch flower industry has responded to its environmental problems. Intense cultivation of flowers in small areas was contaminating the soil and groundwater with pesticides, herbicides, and fertilizers. Facing increasingly strict regulation on the release of chemicals, the Dutch understood that the only effective way to address the problem would be to develop a closed-loop system. In advanced Dutch greenhouses, flowers now grow in water and rock wool, not in soil. This lowers the risk of infestation, reducing the need for fertilizers and pesticides, which are delivered in water that circulates and is reused.

The tightly monitored closed-loop system also reduces variation in growing conditions, thus improving product quality. Handling costs have gone down because the flowers are cultivated on specially designed platforms. In addressing the environmental problem, then, the Dutch have innovated in ways that have raised the productivity with which they use many of the resources involved in growing flowers. The net result is not only dramatically lower environmental impact but also lower costs, better product quality, and enhanced global competitiveness. (See the insert "Innovating to Be Competitive: The Dutch Flower Industry.")

This example illustrates why the debate about the relationship between competitiveness and the environment has been framed incorrectly. Policy makers, business leaders, and environmentalists have focused on the static cost impacts of environmental regulation and have ignored the more important offsetting productivity benefits from innovation. As a result, they have acted too often in ways that unnecessarily drive up costs and slow down progress on environmental issues. This static mind-set has thus created a self-fulfilling prophecy leading to ever more costly environmental regulation. Regulators tend to set regulations in ways that deter innovation. Companies, in turn, oppose and delay regulations instead of innovating to address them. The whole process has spawned an industry of litigators and consultants that drains resources away from real solutions.

POLLUTION = INEFFICIENCY

Are cases like the Dutch flower industry the exception rather than the rule? Is it naive to expect that reducing pollution will often enhance competitiveness? We think not, and the reason is that pollution often is a form of economic waste. When scrap, harmful substances, or energy forms are discharged into the environment as pollution, it is a sign that resources have been used incompletely, inefficiently, or ineffectively. Moreover, companies then have to perform additional activities that add cost but create no value for customers: for example, handling, storage, and disposal of discharges.

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The concept of resource productivity opens up a new way of looking at both the full systems costs and the value associated with any product. Resource inefficiencies are most obvious within a company in the form of incomplete material utilization and poor process controls, which result in unnecessary waste, defects, and stored materials. But there also are many other hidden costs buried in the life cycle of the product. Packaging discarded by distributors or customers, for example, wastes resources and adds costs. Customers bear additional costs when they use products that pollute or waste energy. Resources are lost when products that contain usable materials are discarded and when customers pay -- directly or indirectly -- for product disposal.

Environmental improvement efforts have traditionally overlooked these systems costs. Instead, they have focused on pollution control through better identification, processing, and disposal of discharges or waste -- costly approaches. In recent years, more advanced companies and regulators have embraced the concept of pollution prevention, sometimes called source reduction, which uses such methods as material substitution and closed-loop processes to limit pollution before it occurs.

But, although pollution prevention is an important step in the right direction, ultimately companies must learn to frame environmental improvement in terms of resource productivity. [1] Today managers and regulators focus on the actual costs of eliminating or treating pollution. They must shift their attention to include the opportunity costs of pollution -- wasted resources, wasted effort, and diminished product value to the customer. At the level of resource productivity, environmental improvement and competitiveness come together.

This new view of pollution as resource inefficiency evokes the quality revolution of the 1980s and its most powerful lessons. Today we have little trouble grasping the idea that innovation can improve quality while actually lowering cost. But as recently as fifteen years ago, managers believed there was a fixed trade-off. Improving quality was expensive because it could be achieved only through inspection and rework of the inevitable" defects that came off the line. What lay behind the old view was the assumption that both product design and production processes were fixed. As managers have rethought the quality issue, however, they have abandoned that old mind-set. Viewing defects as a sign of inefficient product and process design -- not as an inevitable byproduct of manufacturing -- was a breakthrough. Companies now strive to build quality into the entire process. The new mind-set unleashed the power of innovation to relax or eliminate what companies had previously accepted as fixed trade-offs.

Like defects, pollution often reveals flaws in the product design or production process. Efforts to eliminate pollution can therefore follow the same basic principles widely used in quality programs: Use inputs more efficiently, eliminate the need for hazardous, hard-to-handle materials, and eliminate unneeded activities. In a recent study of major process changes at ten manufacturers of printed circuit boards, for example, pollution-control personnel initiated thirteen of thirty-three major changes. Of the thirteen changes, twelve resulted in cost reduction, eight in quality improvements, and five in extension of production capabilities. [2] It is not surprising that total quality management (TQM) has become a source of ideas for pollution reduction that can create offsetting benefits. The Dow Chemical Company, for example, explicitly identified the link between quality improvement and environmental performance by using statistical-process control to reduce the variance in processes and to lower waste.

INNOVATION AND RESOURCE PRODUCTIVITY

To explore the central role of innovation and the connection between environmental improvement and resource productivity, we have been collaborating since 1991 with the Management Institute for Environment and Business (MEB) on a series of international case studies of industries and sectors significantly affected by environmental regulation: pulp and paper, paint and coatings, electronics manufacturing, refrigerators, dry cell batteries, and printing inks. (See Table 1) The data clearly show that the costs of addressing environmental regulations can be minimized, if not eliminated, through innovation that delivers other competitive benefits. We first observed the phenomenon in the course of our research for a study of national competitiveness, The Competitive Advantage of Nations (The Free Press, 1990).

Consider the chemical sector, where many believe that the ecology-economy trade-off is particularly steep. A study of activities to prevent waste generation at twenty-nine chemical plants found innovation offsets that enhanced resource productivity. Of 18 of of these waste prevention activities, only one resulted in a net cost increase. Of the seventy activities with documented changes in product yield, sixty-eight reported increases; the average for twenty initiatives documented with specific data was 7 percent. These innovation offsets were achieved with surprisingly low investments and very short

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payback times. One-quarter of the forty-eight initiatives with detailed capital cost information required no capital investment at all; of the thirty-eight initiatives with data on the payback period, nearly two-thirds recouped their initial investments in six months or less. The annual savings per dollar spent on source reduction averaged three dollars and forty-nine cents for the twenty-seven activities for whic h this information could be calculated. The study also found that the two main motivating factors for source reduction activities were waste disposal costs and environmental regulation.

Innovation in response to environmental regulation can fall into two broad categories. The first is new technologies and approaches that minimize the cost of dealing with pollution once it occurs. The key to these approaches often lies in taking the resources embodied in the pollution and converting them into something of value. Companies get smarter about how to process toxic materials and emissions into usable forms, recycle scrap, and improve secondary treatment. For example, at a Rhone-Poulenc plant in Chalampe, France, nylon by-products known as diacids used to be incinerated. Rhone-Poulenc invested 76 million francs and installed new equipment to recover and sell these diacids as additives for dyes and tanning and as coagulation agents. The new recovery process has generated annual revenues of about 20.1 million francs. New de-inking technologies developed by Massachusetts-based Thermo Electron Corporation, among others, are allowing more extensive use of recycled paper. Molten Metal Technology of Walth am, Massachusetts, has developed a cost-saving catalytic extraction method to process many types of hazardous waste.

The second and far more interesting and important type of innovation addresses the root causes of pollution by improving resource productivity in the first place. Innovation offsets can take many forms, including more efficient utilization of particular inputs, better product yields, and better products. (See the insert "Environmental Improvement Can Benefit Resource Productivity.") Consider the following examples.

Resource productivity improves when less costly materials are substituted or when existing ones are better utilized. Dow Chemical's California complex scrubs hydrochloric gas with caustic to produce a wide range of chemicals. The company used to store the wastewater in evaporation ponds. Regulation called for Dow to close the evaporation ponds by 1988. In 1987, under pressure to comply with the new law, the company redesigned its production process. It reduced the use of caustic soda, decreasing caustic waste by 6,000 tons per year and hydrochloric acid waste by eighty tons per year. Dow also found that it could capture a portion of the waste stream for reuse as a raw material in other parts of the plant. Although it cost only $250,000 to implement, the process gave Dow an annual savings of $2.4 million. [3]

3M also improved resource productivity. Forced to comply with new regulations to reduce solvent emissions by 90 percent, 3M found a way to avoid the use of solvents altogether by coating products with safer, water-based solutions. The company gained an early-mover advantage in product development over competitors, many of whom switched significantly later. The company also shortened its time to market because its water-based product did not have to go through the approval process for solvent-based coatings. [4]

3M found that innovations can improve process consistency, reduce downtime, and lower costs substantially. The company used to produce adhesives in batches that were then transferred to storage tanks. One bad batch could spoil the entire contents of a tank. Lost product, down-time, and expensive hazardous-waste disposal were the result. 3M developed a new technique to run rapid quality tests on new batches. It reduced hazardous wastes by 110 tons per year at almost no cost, yielding an annual savings of more than $200,000. [5]

Many chemical-production processes require an initial start-up period after production interruptions in order to stabilize output and bring it within specifications. During that time, only scrap material is produced. When regulations raised the cost of waste disposal, DuPont was motivated to install higher-quality monitoring equipment, which in turn reduced production interruptions and the associated production startups. DuPont lowered not only its waste generation but also cut the amount of time it wasn't producing anything. [6]

Process changes to reduce emissions and use resources more productively often result in higher yields. As a result of new environmental standards, Ciba-Geigy Corporation reexamined the waste-water streams at its dye plant in Tom's River, New Jersey. Engineers made two changes to the production process. First, they replaced sludge-creating iron with a less harmful chemical conversion agent. Second, they eliminated the release of a potentially toxic product into the wastewater stream. They not only reduced pollution but also increased process yields by 40 percent, realizing an annual cost savings of $740,000. Although that part of the plant was ultimately closed, the example illustrates the role of regulatory pressure in process innovation.

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Process innovations to comply with environmental regulation can even improve product consistency and quality. In 1990, the Montreal Protocol and the U.S. Clean Air Act required electronics companies to eliminate ozone-depleting chlorofluorocarbons (CFCs). Many companies used them as cleaning agents to remove residues that occur in the manufacture of printed circuit boards. Scientists at Raytheon confronted the regulatory challenge. Initially, they thought that complete elimination of CFCs would be impossible. After research, however, they found an alternate cleaning agent that could be reused in a closed-loop system. The new method improved average product quality -- which the old CFC-based cleaning agent had occasionally compromised -- while also lowering operating costs. Responding to the same regulation, other researchers identified applications that did not require any cleaning at all and developed so-called no-clean soldering technologies, which lowered operating costs without compromising quality. Witho ut environmental regulation, that innovation would not have happened.

Innovations to address environmental regulations can also lower product costs and boost resource productivity by reducing unnecessary packaging or simplifying designs. A 1991 law in Japan set standards to make products easier to recycle. Hitachi, along with other Japanese appliance producers, responded by redesigning products to reduce disassembly time. In the process, it cut back the number of parts in a washing machine by 16 percent and the number of parts in a vacuum cleaner by 30 percent. Fewer components made the products easier not only to disassemble but also to assemble in the first place. Regulation that requires such recyclable products can lower the user's disposal costs and lead to designs that allow a company to recover valuable materials more easily. Either the customer or the manufacturer who takes back used products reaps greater value.

Although such product innovations have been prompted by regulators instead of by customers, world demand is putting a higher value on resource-efficient products. Many companies are using innovations to command price premiums for "green" products and to open up new market segments. Because Germany adopted recycling standards earlier than most other countries, German companies have first-mover advantages in developing less packaging-intensive products, which are both lower in cost and sought after in the marketplace. In the United States, Cummins Engine Company's development of low-emissions diesel engines for such applications as trucks and buses -- innovation that U.S. environmental regulations spurred -- is allowing it to gain position in international markets where similar needs are growing.

These examples and many others like them do not prove that companies always can innovate to reduce environmental impact at low cost. However, they show that there are considerable opportunities to reduce pollution through innovations that redesign products, processes, and methods of operation. Such examples are common in spite of companies' resistance to environmental regulation and in spite of regulatory standards that often are hostile to innovative, resource-productive solutions. The fact that such examples are common carries an important message:

Today a new frame of reference for thinking about environmental improvement is urgently needed.

DO WE REALLY NEED REGULATION?

If innovation in response to environmental regulation can be profitable -- if a company can actually offset the cost of compliance through improving resource productivity -- why is regulation necessary at all? If such opportunities exist, wouldn't companies pursue them naturally and wouldn't regulation be unnecessary? That is like saying there will rarely be ten-dollar bills to be found on the ground because someone already will have picked them up.

Certainly, some companies do pursue such innovations without, or in advance of, regulation. In Germany and Scandinavia, where both companies and consumers are very attuned to environmental concerns, innovation is not uncommon. As companies and their customers adopt the resource productivity mind-set and as knowledge about innovative technologies grows, there may well be less need for regulation over time in the United States.

But the belief that companies will pick up on profitable opportunities without a regulatory push makes a false assumption about competitive reality -- namely, that all profitable opportunities for innovation have already been discovered, that all managers have perfect information about them, and that organizational incentives are aligned with innovating. In fact, in the real world, managers often have highly incomplete information and limited time and attention. Barriers to change are numerous. The Environmental Protection Agency's Green Lights program, which works with companies to promote energy-saving lighting, shows that many ten-dollar bills are still waiting to be picked up. In one audit, nearly 80 percent of

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the projects offered paybacks within two years or less, and yet the companies considering them had not taken action. [7] Only after companies joined the program and benefited from the EPA's information and cajoling were such highly profitable projects implemented.

We are now in a transitional phase of industrial history in which companies are still inexperienced in handling environmental issues creatively. Customers, too, are unaware that resource inefficiency means that they must pay for the cost of pollution. For example, they tend to see discarded packaging as free because there is no separate charge for it and no current lower-cost alternative. Because there is no direct way to recapture the value of the wasted resources that customers already have paid for, they imagine that discarding used products carries no cost penalty for them.

Regulation, although a different type than is currently practiced, is needed for six major reasons:

* To create pressure that motivates companies to innovate. Our broader research on competitiveness highlights the important role of outside pressure in overcoming organizational inertia and fostering creative thinking.

* To improve environmental quality in cases in which innovation and the resulting improvements in resource productivity do not completely offset the cost of compliance; or in which it takes time for learning effects to reduce the overall cost of innovative solutions.

* To alert and educate companies about likely resource inefficiencies and potential areas for technological improvement (although government cannot know better than companies how to address them).

* To raise the likelihood that product innovations and process innovations in general will be environmentally friendly.

* To create demand for environmental improvement until companies and customers are able to perceive and measure the resource inefficiencies of pollution better.

* To level the playing field during the transition period to innovation-based environmental solutions, ensuring that one company cannot gain position by avoiding environmental investments. Regulation provides a buffer for innovative companies until new technologies are proven and the effects of learning can reduce technological costs.

Those who believe that market forces alone will spur innovation may argue that total quality management programs were initiated without regulatory intervention. However, TQM came to the United States and Europe through a different kind of pressure. Decades earlier, TQM had been widely diffused in Japan -- the result of a whole host of government efforts to make product quality a national goal, including the creation of the Deming Prize. Only after Japanese companies had devastated them in the marketplace did Americans and Europeans embrace TQM.

THE COST OF THE STATIC MIND-SET

Regulators and companies should focus, then, on relaxing the trade-off between environmental protection and competitiveness by encouraging innovation and resource productivity. Yet the current adversarial climate drives up the costs of meeting environmental standards and circumscribes the innovation benefits, making the trade-off far steeper than it needs to be.

To begin with, the power struggle involved in setting and enforcing environmental regulations consumes enormous amounts of resources. A 1992 study by the Rand Institute for Civil Justice, for example, found that 88 percent of the money that insurers paid out between 1986 and 1989 on Superfund claims went to pay for legal and administrative costs, whereas only 12 percent was used for actual site cleanups. [8] The Superfund law may well be the most inefficient environmental law in the United States, but it is not the only cause of inefficiency. We believe that a substantial fraction of environmental spending as well as of the revenues of environmental products and services companies relates to the regulatory struggle itself and not to improving the environment.

One problem with the adversarial process is that it locks companies into static thinking and systematically pushes industry estimates of the costs of regulation upward. A classic example occurred during the debate in the United States on the 1970 Clean Air Act. Lee Iacocca, then executive vice president of the Ford Motor Company, predicted that compliance

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with the new regulations would require huge price increases for automobiles, force U.S. production to a halt by 1975, and severely damage the U.S. economy. The 1970 Clean Air Act was subsequently enacted, and lacocca's dire predictions turned out to be wrong. Similar stories are common.

Static thinking causes companies to fight environmental standards that actually could enhance their competitiveness. Most distillers of coal tar in the United States, for example, opposed 1991 regulations requiring substantial reductions in benzene emissions. At the time, the only solution was to cover the tar storage tanks with costly gas blankets. But the regulation spurred Aristech Chemical Corporation of Pittsburgh, Pennsylvania, to develop a way to remove benzene from tar in the first processing step, thereby eliminating the need for gas blankets. Instead of suffering a cost increase, Aristech saved itself $3.3 million.

Moreover, company mind-sets make the costs of addressing environmental regulations appear higher than they actually are. Many companies do not account for a learning curve, although the actual costs of compliance are likely to decline over time. A recent study in the pulp-and-paper sector, for example, found the actual costs of compliance to be four dollars to five dollars and fifty cents per ton, whereas original industry estimates had been as high as sixteen dollars and forty cents. [9] Similarly, the cost of compliance with a 1990 regulation controlling sulfur dioxide emissions is today only about half of what analysts initially predicted, and it is heading lower. With a focus on innovation and resource productivity, today's compliance costs represent an upper limit.

There is legitimate controversy over the benefits to society of specific environmental standards. Measuring the health and safety effects of cleaner air, for example, is the subject of ongoing scientific debate. Some believe that the risks of pollution have been overstated. But whatever the level of social benefits proves to be, the private costs to companies are still far higher than necessary.

GOOD REGULATION VERSUS BAD

In addition to being high-cost, the current system of environmental regulation in the United States often deters innovative solutions or renders them impossible. The problem with regulation is not its strictness. It is the way in which standards are written and the sheer inefficiency with which regulations are administered. Strict standards can and should promote resource productivity. The United States' regulatory process has squandered this potential, however, by concentrating on cleanup instead of prevention, mandating specific technologies, setting compliance deadlines that are unrealistically short, and subjecting companies to unnecessarily high levels of uncertainty.

The current system discourages risk taking and experimentation. Liability exposure and the government's inflexibility in enforcement, among other things, contribute to the problem. For example, a company that innovates and achieves 95 percent of target emissions reduction while also registering substantial offsetting cost reductions is still 5 percent out of compliance and subject to liability. On the other hand, regulators would reward it for adopting safe but expensive secondary treatment. (See the insert "Innovation-Friendly Regulation.")

Just as bad regulation can damage competitiveness, good regulation can enhance it. Consider the differences between the U.S. pulp-and-paper sector and the Scandinavian. Strict early U.S. regulations in the 1970s were imposed without adequate phase-in periods, forcing companies to adopt best available technologies quickly. At that time, the requirements invariably meant installing proven but costly end-of-pipe treatment systems. In Scandinavia, on the other hand, regulation permitted more flexible approaches, enabling companies to focus on the production process itself, not just on secondary treatment of wastes. Scandinavian companies developed innovative pulping and bleaching technologies that not only met emission requirements but also lowered operating costs. Even though the United States was the first to regulate, U.S. companies were unable to realize any first-mover advantages because U.S. regulations ignored a critical principle of good environmental regulation: Create maximum opportunity for innovation by letting industries discover how to solve their own problems.

Unfortunately for the U.S. pulp-and-paper industry, a second principle of good regulation was also ignored: Foster continuous improvement; do not lock in on a particular technology or the status quo. The Swedish regulatory agency took a more effective approach. Whereas the United States mandated strict emissions goals and established very tight compliance deadlines, Sweden started out with looser standards but clearly communicated that tougher ones would follow. The results were predictable. U.S. companies installed secondary treatment systems and stopped there. Swedish

producers, anticipating stricter standards, continually incorporated innovative environmental technologies into their normal cycles of capacity replacement and innovation.

The innovation-friendly approach produced the residual effect of raising the competitiveness of the local equipment industry. Spurred by Scandinavian demand for sophisticated process improvements, local pulp-and-paper-equipment suppliers, such as Sunds Defibrator and Kamyr, ultimately made major international gains in selling innovative pulping and bleaching equipment.

Eventually, the Scandinavian pulp-and-paper industry was able to reap innovation offsets that went beyond those directly stemming from regulatory pressures. By the early 1990s, producers realized that growing public awareness of the environmental problems associated with pulp-mill effluents was creating a niche market. For a time, Scandinavian companies with totally chlorine-free paper were able to command significant price premiums and serve a rapidly growing market segment of environmentally informed customers.

IMPLICATIONS FOR COMPANIES

Certainly, misguided regulatory approaches have imposed a heavy burden on companies. But managers who have responded by digging in their heels to oppose all regulation have been shortsighted as well. It is no secret that Japanese and German automobile makers developed lighter and more fuel-efficient cars in response to new fuel consumption standards, while the less competitive U.S. car industry fought such standards and hoped they would go away. The U.S. car industry eventually realized that it would face extinction if it did not learn to compete through innovation. But clinging to the static mind-set too long cost billions of dollars and many thousands of jobs.

To avoid making the same mistakes, managers must start to recognize environmental improvement as an economic and competitive opportunity, not as an annoying cost or an inevitable threat. Instead of clinging to a perspective focused on regulatory compliance, companies need to ask questions such as What are we wasting? and How could we enhance customer value? The early movers -- the companies that can see the opportunity first and embrace innovation-based solutions -- will reap major competitive benefits, just as the German and Japanese car makers did. (See the insert "The New Environmentalists.")

At this stage, for most companies, environmental issues are still the province of outsiders and specialists. That is not surprising. Any new management issue tends to go through a predictable life cycle. When it first arises, companies hire outside experts to help them navigate. When practice becomes more developed, internal specialists take over. Only after a field becomes mature do companies integrate it into the ongoing role of line management.

Many companies have delegated the analysis of environmental problems and the development of solutions to outside lawyers and environmental consultants. Such experts in the adversarial regulatory process, who are not deeply familiar with the company's overall technology and operations, inevitably focus on compliance rather than innovation. They invariably favor end-of-pipe solutions. Many consultants, in fact, are associated with vendors who sell such technologies. Some companies are in the second phase, in which environmental issues are assigned to internal specialists. But these specialists -- for example, legal, governmental-affairs, or environmental departments -- lack full profit responsibility and are separate from the line organization. Again, the result is almost always narrow, incremental solutions.

If the sorts of process and product redesigns needed for true innovation are even to be considered, much less implemented, environmental strategies must become an issue for general management. Environmental impact must be embedded in the overall process of improving productivity and competitiveness. The resource-productivity model, rather than the pollution-control model, must govern decision making.

How can managers accelerate their companies' progress toward a more competitive environmental approach? First, they can measure their direct and indirect environmental impacts. One of the major reasons that companies are not very innovative about environmental problems is ignorance. A large producer of organic chemicals, for example, hired a consultant to explore waste reduction opportunities in its 40 waste streams. A careful audit uncovered 497 different waste streams -- the company had been wrong by a factor of more than ten. [10] Our research indicates that the act of measurement alone leads to enormous opportunities to improve productivity.

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Companies that adopt the resource-productivity framework and go beyond currently regulated areas will reap the greatest benefits. Companies should inventory all unused, emitted, or discarded resources or packaging. Within the company, some poorly utilized resources will be held within plants, some discharged, and some put in dumpsters. Indirect resource inefficiencies will occur at the level of suppliers, channels, and customers. At the customer level, resource inefficiencies show up in the use of the product, in discarded packaging, and in resources left in the used-up product.

Second, managers can learn to recognize the opportunity cost of underutilized resources. Few companies have analyzed the true cost of toxicity, waste, and what they discard, much less the second-order impacts that waste and discharges have on other activities. Fewer still look beyond the out-of-pocket costs of dealing with pollution to the opportunity cost of the resources they waste or the productivity they forgo.

There are scarcely any companies that think about customer value and the opportunity cost of wasted resources at the customer level.

Many companies do not even track environmental spending carefully, and conventional accounting systems are ill equipped to measure underutilized resources. Companies evaluate environmental projects as discrete, stand-alone investments. Straightforward waste- or discharge-reduction investments are screened using high hurdle rates that presume the investments are risky -- leaving ten-dollar bills on the ground. Better information and evaluation methods will help managers reduce environmental impact while improving resource productivity.

Third, companies should create a bias in favor of innovation-based, productivity-enhancing solutions. They should trace their own and their customers' discharges, scrap, emissions, and disposal activities back into company activities to gain insight about beneficial product design, packaging, raw material, or process changes. We have been struck by the power of certain systems solutions: Groups of activities may be reconfigured, or substitutions in inputs or packaging may enhance utilization and potential for recovery. Approaches that focus on treatment of discrete discharges should be sent back to the organization for rethinking.

Current reward systems are as anti-innovation as regulatory policies. At the plant level, companies reward output but ignore environmental costs and wasted resources. The punishment for an innovative, economically efficient solution that falls short of expectations is often far greater than the reward for a costly but "successful" one.

Finally, companies must become more proactive in defining new types of relationships with both regulators and environmentalists. Businesses need a new mind-set. How can companies argue shrilly that regulations harm competitiveness and then expect regulators and environmentalists to be flexible and trusting as those same companies request time to pursue innovative solutions?

THE WORLD ECONOMYN IN TRANSITION

It is time for the reality of modern competition to inform our thinking about the relationship between competitiveness and the environment. Traditionally, nations were competitive if their companies had access to the lowest cost inputs -- capital, labor, energy, and raw materials. In industries relying on natural resources, for example, the competitive companies and countries were those with abundant local supplies. Because technology changed slowly, a comparative advantage in inputs was enough for success.

Today globalization is making the notion of comparative advantage obsolete. Companies can source low-cost inputs anywhere, and new, rapidly emerging technologies can offset disadvantages in the cost of inputs. Facing high labor costs at home, for example, a company can automate away the need for unskilled labor. Facing a shortage of a raw material, a company can find an alternative raw material or create a synthetic one. To overcome high space costs, Japanese companies pioneered just-in-time production and avoided storing inventory on the factory floor.

It is no longer enough simply to have resources. Using resources productively is what makes for competitiveness today. Companies can improve resource productivity by producing existing products more efficiently or by making products that are more valuable to customers -- products customers are willing to pay more for. Increasingly, the nations and companies that are most competitive are not those with access to the lowest-cost inputs but those that employ the most advanced technology and methods in using their inputs. Because technology is constantly changing, the new paradigm of

global competitiveness requires the ability to innovate rapidly.

This new paradigm has profound implications for the debate about environmental policy -- about how to approach it, how to regulate, and how strict regulation should be. The new paradigm has brought environmental improvement and competitiveness together. It is important to use resources productively, whether those resources are natural and physical or human and capital. Environmental progress demands that companies innovate to raise resource productivity -- and that is precisely what the new challenges of global competition demand. Resisting innovation that reduces pollution, as the U.S. car industry did in the 1970s, will lead not only to environmental damage but also to the loss of competitiveness in the global economy. Developing countries that stick with resource-wasting methods and forgo environmental standards because they are "too expensive" will remain uncompetitive, relegating themselves to poverty.

How an industry responds to environmental problems may, in fact, be a leading indicator of its overall competitiveness. Environmental regulation does not lead inevitably to innovation and competitiveness or to higher productivity for all companies. Only those companies that innovate successfully will win. A truly competitive industry is more likely to take up a new standard as a challenge and respond to it with innovation. An uncompetitive industry, on the other hand, may not be oriented toward innovation and thus may be tempted to fight all regulation.

It is not at all surprising that the debate pitting the environment against competitiveness has developed as it has. Indeed, economically destructive struggles over redistribution are the norm in many areas of public policy. But now is the time for a paradigm shift to carry us forward into the next century. International competition has changed dramatically over the last few decades. Senior managers who grew up at a time when environmental regulation was synonymous with litigation will see increasing evidence that environmental improvement is good business. Successful environmentalists, regulatory agencies, and companies will reject old trade-offs and build on the underlying economic logic that links the environment, resource productivity, innovation, and competitiveness.

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FOOTNOTES

(1.) One of the pioneering efforts to see environmental improvement this way is Joel Makower's The E-Factor: The Bottom-Line Approach to Environmentally Responsible Business (New York: Times Books, 1993).

(2.) Andrew King, "Improved Manufacturing Resulting from Learning from Waste: Causes, Importance, and Enabling Conditions," working paper, Stern School of Business, New York University, New York, 1994.

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(9.) Norman Bonson, Neil McCubbin, and John B. Sprague, "Kraft Mill Effluents in Ontario," report prepared for the Technical Advisory Committee, Pulp and Paper Sector of MISA, Ontario Ministry of the Environment, Toronto, March 29, 1988, p. 166.

(10.) Parkinson, p. 30.

Table 1

Environmental Regulation Has Competitive Implications

Sector/Industry	Environmental Issues
Pulp and paper	Dioxin released by bleaching with chlorine
Paint and coatings	Volatile organic compounds (VOCs) in solvents
Electronics manufacturing	Volatile organic compounds (VOCs) in agents
Refrigerators	Chlorofluorocarbons (CFCs) used as refrigerants Energy usage
	Disposal
Dry cell batteries	Cadmium, mercury, lead, nickel, cobalt, lithium, and zinc release in landfills or to the air (after incineration)
Printing inks	VOCs in petroleum inks
Sector/Industry	**Innovative Solutions**
Pulp and paper	Improved cooking and washing processes

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	Elimination of chlorine by using oxygan, ozone, or peroxide for bleaching
	Closed-loop processes (still problematic)
Paint and coatings	New paint formulations (low-solvent-content paints, water-bome paints)
	Improved application techniques
	Powder or radiation-cured coatings
Electronics manufacturing	Semiaqueous, terpene-based cleaning agents
	Closed-loop systems
	No-clean soldering where possible
Refrigerators	Alternative refrigerants (propane-isobutane mix)
	Thicker insulation
	Better gaskets
	Improved compresson
Dry cell batteries	Rechargeable batteries of nickel-hydride (for some applications)
	Rechargeable lithium batteries (now being developed)
Printing inks	Water-based inks and soy inks

Sector/Industry	Innovation Offsets
Pulp and paper	Lower operating costs through greater use of by-product energy sources
	25% initial price premium for chlorine-free paper
Paint and coatings	Price premium for solvent-free paints
	Improved coatings quality in some segments
	Worker safety benefits
	Higher coatings-transfer efficiency
	Reduced coating costs through

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	materials savings
Electronics manufacturing	Increase in cleaning quality and thus in product quaity 30% to 80%reduction in cleaning costs, often for one-year pay-back periods Elimination of an unnecessary production step
Refrigerators	10% better energy efficiency at same cost 5% to 10% initial price premium for "green" refrigerator
Dry cell batteries	Nearly twice as efficient at same cost
	Expected to be price Competitive in the near future Higher energy efficiency
Printing inks	Higher efficiency, brighter colors, and better printability (depending on application)

Innovating to Be Competitive: The Dutch Flower Industry

The Dutch flower industry is responsible for about 65 percent of world exports of cut flowers -- an astonishing figure given that the most important production inputs in the flower business would seem to be land and climate. Anyone who has been to the Netherlands knows its disadvantages on both counts. The Dutch have to reclaim land from the sea, and the weather is notoriously problematic.

How can the Dutch be the world's leaders in the flower business when they lack comparative advantage in the traditional sense? The answer, among other reasons, is that they have innovated at every step in the value chain, creating technology and highly specialized inputs that enhance resource productivity and offset the country's natural disadvantages.

In selling and distribution, for example, the Netherlands has five auction houses custom designed for the flower business. Carts of flowers are automatically towed on computer-guided paths into the auction room. The buying process occurs in a few seconds. Buyers sit in an amphitheater, and the price on the auction clock moves down until the first buyer signals electronically. That buyer's code is attached to the cart, which is routed to the company's shipping and handling area. Within a few minutes, the flowers are on a truck to regional markets or in a specialized, precooled container on their way to nearby Schiphol airport. Good airports and highway systems may be plentiful elsewhere, too. But the Netherlands' innovative, specialized infrastructure is a competitive advantage. It leads to very high productivity. It is so successful that growers from other countries actually fly flowers there to be processed, sold, and re-exported.

Paradoxically, having a shortage of general-purpose or more basic inputs can sometimes be turned into an advantage. If land were readily available and the climate more favorable, the Dutch would have competed the same way other countries did. Instead they were forced to innovate, developing a high-tech system of year-round greenhouse cultivation. The Dutch continually improve the unique, specialized technology that creates high resource productivity and underpins their competitiveness.

In contrast, an abundance of labor and natural resources or a lack of environmental pressure may lead a country's companies to spend the national resources unproductively.

Competing based on cheap inputs, which could be used with less productivity, was sufficient in a more insular, less global

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economy. Today, when emerging nations with even cheaper labor and raw materials are part of the global economy, the old strategy is unsustainable.

Environmental Improvement Can Benefit Resource Productivity

Process Benefits

* materials savings resulting from more complete processing, substitution, reuse, or recycling of production inputs

* increases in process yields

* less downtime through more careful monitoring and maintenance

* better utilization of by-products

* conversion of waste into valuable forms

* lower energy consumption during the production process

* reduced material storage and handling costs

* savings from safer workplace conditions

* elimination or reduction of the cost of activities involved in discharges or waste handling, transportation, and disposal

* improvements in the product as a by-product of process changes (such as better process control)

Product Benefits

* higher quality, more consistent products

* lower product costs (for instance, from material substitution)

* lower packaging costs

* more efficient resource use by products

* safer products

* lower net costs of product disposal to customers

* higher product resale and scrap value

Innovation-Friendly Regulation

Regulation, properly conceived, need not drive up costs. The following principles of regulatory design will promote innovation, resource productivity, and competitiveness:

Focus on outcomes, not technologies. Past regulations have often prescribed particular remediation technologies, such as catalysts or scrubbers for air pollution. The phrases "best available technology" (BAT) and "best available control technology" (BACT) are deeply rooted in U.S. practice and imply that one technology is best, discouraging innovation.

Enact strict rather than lax regulation. Companies can handle lax regulation incrementally, often with end-of-pipe or secondary treatment solutions. Regulation, therefore, needs to be stringent enough to promote real innovation.

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Regulate as close to the end user as practical, while encouraging upstream solutions. This will normally allow more flexibility for innovation in the end product and in all the production and distribution stages. Avoiding pollution entirely or, second best, mitigating it early in the value chain is almost always less costly than late-stage remediation or cleanup.

Employ phase-in periods. Ample but well-defined phase-in periods tied to industry-capital-investment cycles will allow companies to develop innovative resource-saving technologies rather than force them to implement expensive solutions hastily, merely patching over problems. California imposed such short compliance deadlines on its wood-furniture industry that many manufacturers chose to leave the state rather than add costly control equipment.

Use market incentives. Market incentives such as pollution charges and deposit-refund schemes draw attention to resource inefficiencies. In addition, tradable permits provide continuing incentives for innovation and encourage creative use of technologies that exceed current standards.

Harmonize or converge regulations in associated fields. Liability exposure in the United States leads companies to stick to safe, BAT approaches, and inconsistent regulation on alternative technologies deters beneficial innovation. For example, one way to eliminate refrigerator cooling agents suspected of damaging the ozone layer involves replacing them with small amounts of propane and butane. But narrowly conceived safety regulations covering these gases seem to have impeded development of the new technology in the United States, while several leading European companies are already marketing the new products.

Develop regulations in sync with other countries or slightly ahead of them. It is important to minimize possible competitive disadvantages relative to foreign companies that are not yet subject to the same standard. Developing regulations slightly ahead of other countries will also maximize export potential in the pollution-control sector by raising incentives for innovation. When standards in the United States lead world developments, domestic companies get opportunities for valuable early-mover advantages. How-ever, if standards are too far ahead of, or too different in character from, those that are likely to apply to foreign competitors, industry may innovate in the wrong directions.

Make the regulatory process more stable and predictable. The regulatory process is as important as the standards. If standards and phase-in periods are set and accepted early enough and if regulators commit to keeping standards in place for, say, five years, industry can lock in and tackle root-cause solutions instead of hedging against the next twist or turn in government philosophy.

Require industry participation in setting standards from the beginning. U.S. regulation differs sharply from European in its adversarial approach. Industry should help in designing phase-in periods, the content of regulations, and the most effective regulatory process. A predetermined set of information requests and interactions with industry representatives should be a mandatory part of the regulatory process. Both industry and regulators must work toward a climate of trust because industry needs to provide genuinely useful information and regulators need to take industry input seriously.

Develop strong technical capabilities among regulators. Regulators must understand an industry’s economics and what drives its competitiveness. Better information exchange will help avoid costly gaming in which ill-informed companies use an array of lawyers and consultants to try to stall the poorly designed regulations of ill-informed regulators.

Minimize the time and resources consumed in the regulatory process itself Time delays in granting permits are usually costly for companies. Self-regulation with periodic inspections would be more efficient than requiring formal approvals. Potential and actual litigation creates uncertainty and consumes resources. Mandatory arbitration procedures or rigid arbitration steps before litigation would lower costs and encourage innovation.

For an extended discussion of the ways in which environmental regulation should change, see Michael E. Porter and Claas van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship," Journal of Economic Perspectives 9, no. 4 (fall 1995).

The New Environmentalists

Environmentalists can foster innovation and resource productivity by speaking out for the right kind of regulatory standards and by educating the public to demand innovative environmental solutions. The German section of

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Greenpeace, for example, noted in 1992 that a mixture of propane and butane was safer for cooling refrigerators than the then-prevalent cooling agents--hydrofluorocarbons or hydrochlorofluorocarbons--that were proposed as replacements for chlorofluorocarbons. Greenpeace for the first time in its history began endorsing a commercial product. It actually ran an advertising campaign for a refrigerator designed by Foron, a small refrigerator maker on the verge of bankruptcy. The action was greatly leveraged by extensive media coverage and has been a major reason behind the ensuing demand for Foron-built propane-butane refrigerators and the switch that the established refrigerator producers in Germany later made to the same technology.

Environmental organizations can support industry by becoming sources of information about best practices that may not be well known outside of a few pioneering companies. When it realized that German magazine publishers and readers alike were unaware of the much improved quality of chlorine-free paper, Greenpeace Germany issued a magazine printed on chlorine-free paper. It closely resembled the leading German political weekly, Der Spiegel, and it encouraged readers to demand that publishers switch to chlorine-free paper. Shortly after, Der Spiegel and several other large magazines did indeed switch. Other environmental organizations could shift some resources away from litigation to focus instead on funding and disseminating research on innovations that address environmental problems.

Among U.S. environmental groups, the Environmental Defense Fund (EDF) has been an innovator in its willingness to promote market-based regulatory systems and to work directly with industry. It supported the sulfur-dioxide trading system that allows companies either to reduce their own emissions or to buy emissions allowances from companies that have managed to exceed their reduction quotas at lower cost. The EDF-McDonald's Waste Reduction Task Force, formed in 1990, led to a substantial redesign of McDonald's packaging, including the elimination of the polystyrene-foam clamshell. EDF is now working with General Motors on plans to remove heavily polluting cars from the road and with Johnson & Johnson, McDonald's, NationsBank, The Prudential Insurance Company of America, Time Warner, and Duke University to promote the use of recycled paper.

Source: Benjamin C. Bonifant and Ian Ratciffe, "Competitive Implications of Environmental Regulation in the Pulp and Paper Industry," working paper, Management Institute for Environment and Business, Washington, D.C., 1994.