BUSINESS STRATEGY AND THE ENVIRONMENT, VOL. 6, 276–286 (1997)

THERE'S MONEY IN THE AIR: THE CFC BAN AND DUPONT'S REGULATORY STRATEGY

James Maxwell[1,2]* and Forrest Briscoe[1,2]
[1]Massachusetts Institute of Technology, MA, USA
[2]JSI Research & Training, Boston, MA, USA

DuPont, the world's dominant CFC producer, played a key role in the development of the Montreal Protocol on Ozone Depleting Substances. We argue that DuPont's pursuit of its economic interests, along with the political impact of the discovery of an ozone hole and the threat of domestic regulation, shaped the international regulatory regime for ozone-depleting substances. International regulation offered DuPont and a few other producers the possibility of new and more profitable chemical markets at a time when CFC production was losing its profitability and promising alternative chemicals had already been identified.

DuPont's organization and strategy were key to the successful leveraging of the Montreal process. For example, the Freon Division had close interaction with public officials and external groups, and benefited from the input of DuPont's external affairs department. This positioned DuPont to exploit the situation when regulatory discussions were stepped up.

From a public policy perspective, the Montreal process offers a valuable example of harnessing diversity in industry: some producers stood to gain more from the envisioned regulations than others. Such industry heterogeneity provides frequent opportunities for coalitions of 'the green and the greedy', such as that between DuPont and environmental interests. Methods to encourage potential industry winners into supporting environmental initiatives deserve further attention.

Bus. Strat. Env Vol. **6**, 276–286 (1997)

No. of Figures: 2. No. of Tables: 0.
No. of References: 33.

Revised 22 May 1997
Accepted 24 July 1997

INTRODUCTION

When public concern arises over the possible environmental effects of important industrial chemicals, the frequent response from industry is that change would be difficult. Alternatives may be lacking, and switching to them will surely prove expensive for society. This makes the last decade of international policy-making concerning chlorofluorocarbons (CFCs) extremely relevant. For the first time an entire class of valuable chlorinated chemicals, a billion-dollar-a-

*Correspondence to: James Maxwell, JSI Research and Training Institute Inc., 44 Farnsworth Street, BOSTON, MA 022101211, USA.

CCC 0964-4733/97/050276–11 $17.50

year product, is being phased out world-wide. Understanding how and why these changes took place provides insight into the likelihood of changes for other environmentally troubled chemicals.

The causes of change have been oversimplified by the participants. The diplomats cited a new global environmental consciousness. Mustafa Tolba, then head of United Nations Environmental Program, heralded 'the beginning of a new era of environmental statesmanship' (Tolba, 1987; Benedick, 1991). However, the corporations involved said they had merely 'followed the science', only acting on the issue once the scientific uncertainties had been reduced sufficiently.

In addition to both these factors, a review of the American and international policymaking towards CFCs reveals several other intertwined factors of importance. One critical aspect was the role of DuPont, the world's dominant producer, and other large chemical producers in the policymaking process. We argue that DuPont's pursuit of its economic interests, along with the political impact of perceptions of the science (the ozone hole) and the threat of domestic regulation, shaped the international regulatory regime for ozone-depleting substances. The Montreal process has been widely considered as offering an institutional blueprint for the responses that will be necessary for addressing other global environmental problems, such as climate change. We believe that the Montreal protocol process offers lessons for international environmental policymaking, but not those usually proposed.

DuPont confronts an emerging environmental issue

As with lycra and nylon, freon was one of DuPont's most successful products that had been produced for decades following its discovery at General Motors laboratories in the 1920s. Freon had offered clear-cut advantages over other early alternatives used in refrigeration because it was nontoxic and relatively inexpensive to produce. Over the years, its applications had extended from refrigeration to its use as a propellant in aerosol sprays, the cleaning of metals in the electronics industry, and use in foam blowing for insulation. By the mid 1970s, DuPont remained the dominant freon producer in the world, accounting for more than half of US and nearly a quarter of world production capacity. CFCs were a growing commodity chemical business in which DuPont's scale gave it a substantial competitive advantage over its rivals. Because of high transportation costs relative to the price of the product, production was regionally concentrated near large markets.

In 1974, two events occurred that would leave a lasting imprint on DuPont's policies toward this highly versatile product. The first was a scientific discovery. In the early 1970s the British scientist James Lovelock, who had invented an instrument for measuring trace amounts of CFCs in the atmosphere, determined that nearly all of the CFCs released to that date (around one billion pounds) were still in the atmosphere. Two chemists at the University of California at Irvine, sought to understand the effects of such a large accumulation of CFCs in the atmosphere, and suggested a theory that the chlorine released from CFCs could cause significant reductions in the stratospheric ozone layer. In a paper published in *Nature* (Molina and Rowland, 1974), they postulated that CFCs tended to migrate to the stratosphere where they underwent a series of complex chemical reactions that converted ozone into oxygen. As chlorine was a catalyst, a single chlorine atom could destroy large numbers of ozone molecules. If these chemical reactions led to a breakdown in the earth's protective shield then dangerous levels of ultraviolet radiation could penetrate to the earth's surface, harming human health and the environment.

A second key event occurring in 1974 was the appointment of Irving Shapiro as the chairman and chief executive officer of DuPont. Shapiro, a lawyer and the first nonmember of the DuPont family to serve as chairman, brought a new, more proactive strategy towards business–government relationships and environmental issues. Shapiro described his experience in governmental relationships as one of the primary reasons for his selection:

> I think the DuPont board at that time was very alert and wise in anticipating the conditions that were developing in the country and in saying 'We need a different kind of leadership. We want a leadership that understands government and the political conditions in the country and can address itself to some of those issues.'

Shapiro considered the chemical industry's traditional strategy of public resistance and lobbying against environmental legislation to be counterproductive. He believed that industry needed to work with government to devise policies that served both public and private interests. In his first year of office, DuPont's new chairman confronted calls for a ban on the aerosol uses of one of DuPont's hallmark products, CFCs.

Under the auspices of the Chemical Manufacturers Association, DuPont initiated a research program by academic investigators to obtain factual

Bus. Strat. Env, Vol. **6**, 276–286 (1997)

evidence to sustain or dismiss the theory. Together with other companies in the chemical industry, DuPont contributed some $3–5 million towards a multiyear research program. While this research was undertaken, DuPont sought to persuade members of Congress and the regulatory agencies that it was safe to delay any regulatory actions for 2–3 years until the scientific uncertainties could be resolved (Dotto and Schiff, 1978). At the same time, DuPont officials pledged that they would cease production of the suspect chemical 'if credible research demonstrated a significant threat to health or the environment' (Lubkin, 1975).

Notwithstanding this pledge, DuPont officials warned of the economic costs of precipitous regulatory action (anon, 1975a). A DuPont spokesmen estimated that industry directly relevant to CFCs contributed more than $8 billion to the US economy each year, employing more than 200,000 Americans (anon, 1975b). In DuPont's view, any restrictions on CFCs were both unwarranted because of the scientific uncertainties prevailing at the time and impractical because of the substantial costs they would impose upon the US economy as a whole.

Despite a well financed public relations campaign, DuPont waged a losing struggle to defend CFCs against scientists and environmental groups who wished to curtail their use. During 1975, a federal interagency task force recommended steps to restrict the use of CFCs if a National Academy of Sciences study were to confirm the task force's assessment (IMOS, 1975). Congressional hearings followed in which legislation was proposed banning the use of CFCs in aerosols. Bills to regulate CFCs were introduced in a dozen states; Oregon banned the use of CFCs in aerosols. New York State required companies to label aerosols products when they contained CFCs.

The marketplace, however, moved even more swiftly than the political system (Dotto and Schiff, 1975, pp. 165–166; anon, 1975c). In 1975, Johnson Wax, a major consumer products company, announced at a news conference, which was heavily attended by national media, its intention to phase out the use of CFCs as aerosol propellants. Other large consumer products companies followed its example, placing as much as 25% of DuPont's CFC business at risk. With demand for CFCs in aerosols falling off in response to consumer pressures, federal agencies proposed a phaseout of nonessential use of CFCs in aerosols. The speed of marketplace and regulatory developments prevented DuPont from commercializing a less ozone-depleting alternative. A DuPont spokesmen cautioned that this schedule 'leaves us without a short-term replacement for aerosol products'.

These market and regulatory developments had long term consequences for the profitability of DuPont's CFC business. The fall in US demand for aerosols led to manufacturing overcapacity and undermined DuPont's and other US producers ability to raise prices and improve profit margins. The pressure on prices was so great that prices in real terms remained constant for more than a decade (Figure 1). DuPont implemented measures to reduce its manufacturing costs, but they proved inadequate to restore the business' underlying profitability. In contrast European producers, such as Imperial Chemical Industries (ICI) and ATOCHEM, continued to market CFCs for use in aerosols as their governments rejected the American approach to regulation. The unilateral action to ban the use of CFCs in aerosols had cost DuPont and other US manufacturers an estimated 20% of the global market. This led to a world-wide shift in the production of CFCs (Figure 2).

While DuPont was losing the marketplace and political struggle to defend CFCs, Shapiro assumed a proactive stance on major pieces of environmental legislation. In 1976, he had instructed senior vice-president Richard Heckert to collaborate with the Congress and the EPA in drafting versions of the Toxic Substances Control Act. The law required, among other things, extensive testing, at corporate expense, of any new chemical product before it was sold. According to Shapiro, the bill was 'a lot better than it would have been if the industry had simply said, as sometimes happens, we'll fight it to the death' (Shapiro, 1986). In 1980, DuPont boldly split from the position of the Chemical Manufacturers Association, and similarly endorsed Congressman Jim Florio's version of the superfund law, which required companies to assume financial responsibility for cleaning up abandoned hazardous waste sites. DuPont actively supported progressive environmental legislation, even while resisting specific regulations directed at a variety of its products.

Following a National Academy of Sciences report predicting ozone depletion of 16%, the EPA in 1980 proposed to extend regulations from aerosols to other uses, and eventually to ban the substances altogether (DuPont, 1989). To resist the EPA's latest regulatory initiative, DuPont helped to organize a trade association known as the Alliance for Responsible CFC Policy with other major producers and users. However, public interest and media attention had waned following the elimination of CFCs in aerosols. An industry-sponsored lobbying organization was no longer necessary to discourage further regulation. The declining public interest and continued uncertainty in the science did not diminish the fact that

Bus. Strat. Env, Vol. **6**, 276–286 (1997)

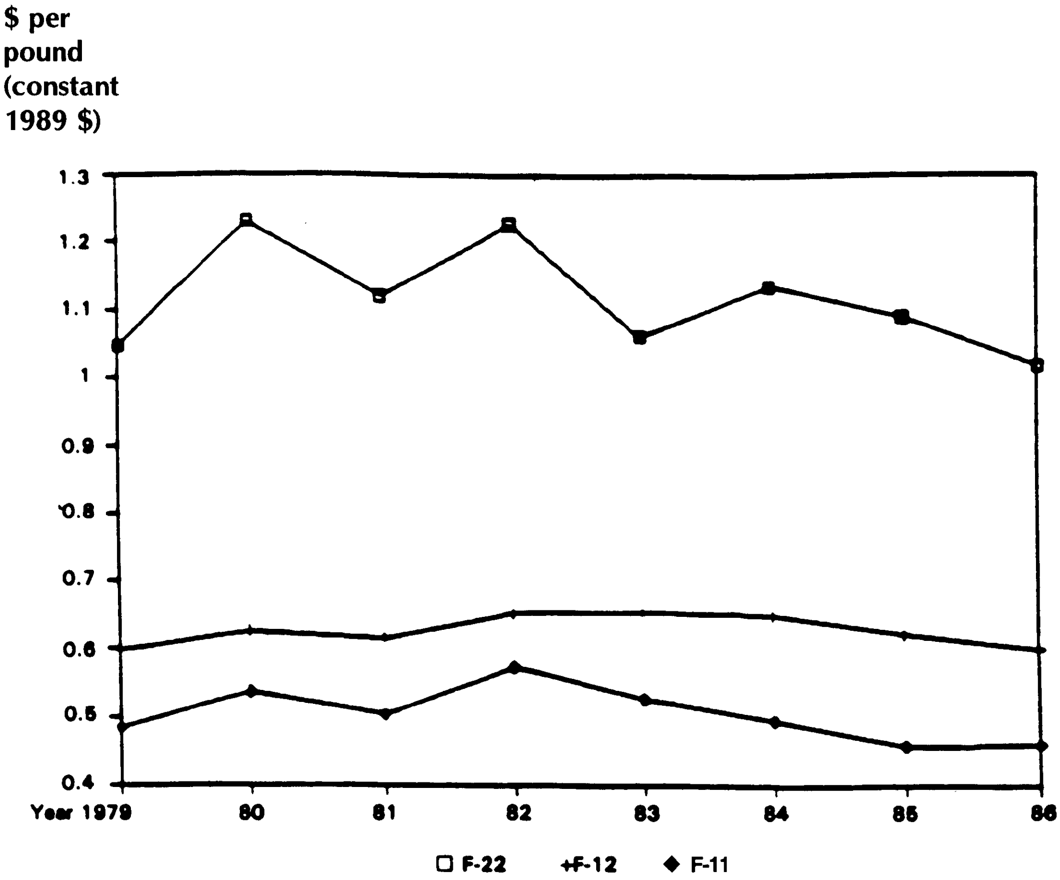

Figure 1. Average value of CFCs. The figures are the average unit values calculated from rounded figures. Prices have been deflated using the yearly average producer price index (US International Trade Commission, ????).

DuPont's freon business had paid a heavy price for responding to public concerns about the threat of ozone depletion in the 1970s. Worse yet, from DuPont's perspective, regulatory policy had not been based upon the scientific facts in this case, but on public perceptions that had been grossly distorted by environmental activists.

Shifting policy: Abandonment of a multibillion dollar product

During the early 1980s, the pressures for extending regulation of CFCs to other applications diminished as the scientific case against CFCs was undermined by scientific reports by the National Academy of Sciences. The reports suggested that ozone depletion was in the range of 2–4% rather than the 10–15% previously believed (National Academy of Sciences, 1982 and 1983). At the same time, the Reagan administration was unsympathetic to the expanded scope of regulation advocated by some EPA staff and environmentalists.

Given the state of scientific knowledge and the changing political circumstances, DuPont withdrew financial support for its research program on alternative chemicals. By the late 1970s, DuPont scientists had identified a number of replacements for the then-existing CFCs, but they all proved either too toxic or too costly. As long as existing chemicals were available, customers would resist a switch to higher priced alternatives. As Richard Heckert later wrote: 'the substitutes could never hope to compete because they were more expensive.... Such were the market realities at the beginning of the 1980s.' According to DuPont, the market rather than corporate policy dictated a change in research and development priorities away from the commercialization of substitutes.

British scientists' discovery of the Antarctic ozone hole in the spring of 1985 dramatically transformed the science and the politics of the ozone issue. Scientists had predicted a gradual lowering of stratospheric ozone levels over a long period of time as chlorine built up in the atmosphere; they had not expected either the rate or the magnitude of the

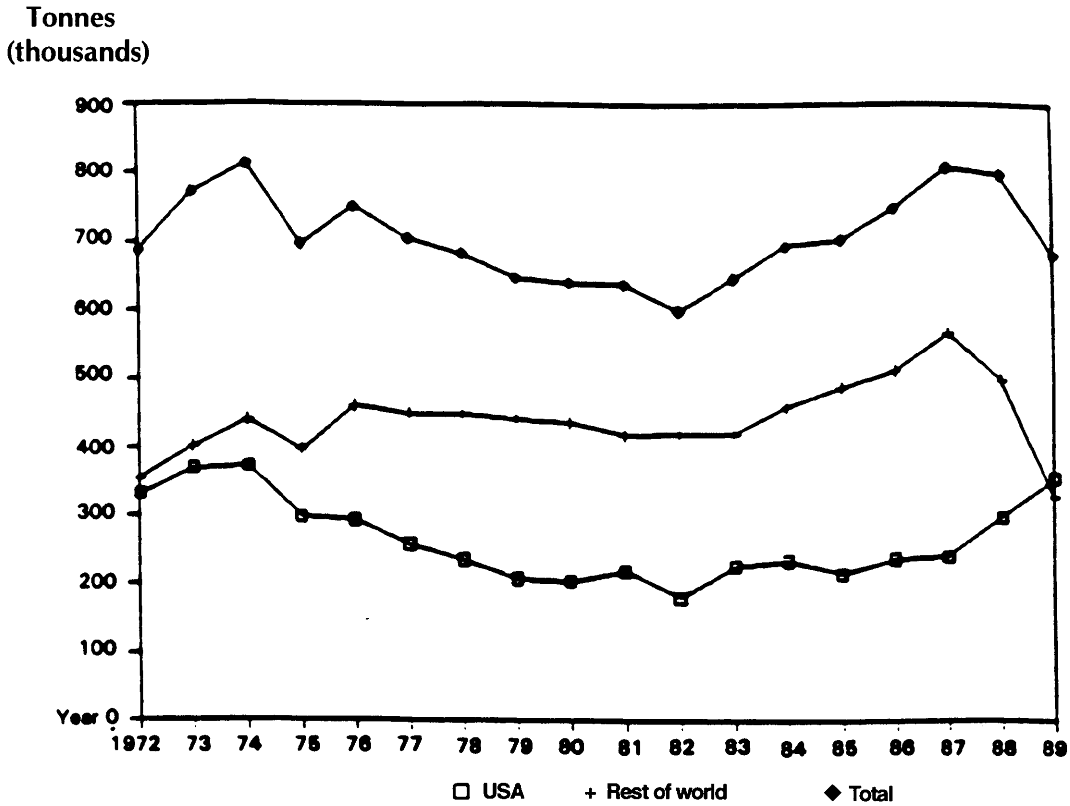

Figure 2. Production of CFCs 11 and 12. Data for the rest of the world are estimated by subtracting the US data (US International Trade Commission) from the world total (Chemical Manufacturers' Association, 1990).

depletion discovered over Antarctica. A debate raged within the scientific community as to whether industrial sources of chlorine or natural phenomena were responsible for the ozone hole occurring each spring.

The policy stalemate was broken, even while the scientific debate intensified. In the spring of 1986, environmental groups called for immediate reduction in the production and use of CFCs to ensure that society's experiment with the global climate did not cause dangerous levels of ultraviolet radiation to reach the earth's surface. David Doniger of the Natural Resource Defense Council warned that immediate cuts were necessary or that 'we would be facing an emergency that will make Chernobyl look like a trash fire at the county dump'. Lee Thomas, then recently appointed EPA administrator, stated that society could no longer afford to experiment with the world's atmospheric systems (Thomas, 1986). The frightening image of a 'hole' suddenly drew the media and public attention which a 'decreasing trend' never could have (Doos, 1994; Glantz, 1995). The hole was a political trigger even if it was not a scientific one.

DuPont officials showed sensitivity to both the political and scientific dimensions of the ozone depletion issue. Through the CMA, DuPont had helped to develop a reliable reporting system for the production of CFCs. Based upon this data, DuPont scientists realized that the pattern of CFC use was changing. By the mid-1980s, the growth in refrigeration, mobile air conditioning, and CFC foams had more than offset the earlier declines in CFC use that had been caused by the aerosol ban in the US. Growth rates of several percentage points per year were expected to continue indefinitely.

In June 1986, Joe Steed, a chemical physicist and environmental manager for the Freon division, and Mac McFarland, an atmospheric scientist hired in the early 1980s, began a systematic evaluation of the science given increasing production levels. Using models and assumptions similar to those employed in a 1985 report by the World Meteorological Organization, they concluded that the growth in CFC production would cause significant reductions in ozone. This would occur under almost all the scenarios tested. At the same time, EPA officials were publicly claiming that the only way to stop chlorine accumulation in the atmosphere was an immediate 85% reduction in CFC production. Aware of the changing political climate, Steed and Kevin Fay, the director of the Alliance for Responsible CFC policy, believed that strict domestic regulation was inevitable unless industry took decisive action to prevent it.

The internal DuPont assessment concluded that future production levels should be limited to their existing levels. Senior management concurred with the assessment (Reinhardt, 1989). Observers from outside the industry might have considered the proposed cutbacks as a method of shoring up prices for a poorly performing product. Nevertheless, DuPont and other producers realized that a global freeze was a first step in a transition to alternative chemicals. Customers in growing markets would not remain loyal to products if the supply was potentially unavailable. For DuPont and other producers, an international regulatory regime that capped production implied an eventual phaseout of ozone-depleting chemicals and an orderly transition to alternatives. DuPont's decision to support international regulation was the critical moment in the more than decade long ozone depletion controversy.

Underlying this decision, DuPont officials had understood the commercial implications of phasing out CFCs and shifting to alternatives. Since the late 1970s, CFC 11 and 12 had not been highly profitable; DuPont had been forced to offer substantial volume discounts to large customers. In contrast, the substitutes would demand higher prices as they were inherently more expensive to produce. The development of each of the substitutes required sophisticated chemical engineering processes and capital investments of hundreds of millions of dollars. They would be marketed as specialty rather than commodity chemicals where the leading international firms could foresee substantial competitive advantages. Like other specialty chemical products, they would be characterized by low volume and high prices and profit margins would be higher because of less competition. DuPont's decision to support a CFC ban was based on the belief that it could obtain a significant competitive advantage through the sales of new chemical substitutes because of its proven research and development capabilities to develop chemicals, its (limited) progress already made in developing substitutes, and the potential for higher profits in selling new specialty chemicals. Although some observers have speculated on the relevance of patent expiration to the decision to support a CFC ban, DuPont officials reported no such influence.

The new chemical substitutes were projected to sell for 5–10 times the costs of CFC 11 and 12. The only constraint for the availability of substitutes was thus a world-wide market for higher priced materials, which depended on government intervention for itscreation. User industry resistance to such price increases would be reduced by the fact that CFCs comprised only a small percentage of the total cost of any new refrigerator or air conditioning system. The principal concern of industry was to phase in any transition so that it was consistent with the introduction of new products and did not cause obsolescence among existing equipment (Rothenburg and Maxwell, in press). The international regulatory regime had the potential to transform one of DuPont's mature and only marginally profitable businesses into a more lucrative one.

DuPont officials capitalized on this shift in strategy because the political wisdom of Shapiro had been institutionalized at the company. DuPont officials collaborated with officials of the user groups through the Alliance for Responsible CFC Policy to enlist their support for this shift in strategy. In fact, DuPont waited for the Alliance's own announcement before publicly revealing its own policy shift in September 1986 (Environmental Data Services, 1986). Joe Steed had also sought to inform and persuade other major chemical producers through the CMA to follow DuPont's lead. European chemical producers, however, remained suspicious of DuPont's announcement, fearing that its action was prompted by technical breakthroughs in substitutes development. The European chemical industry reluctantly accepted DuPont's argument for constraints on global CFC production, but only at levels that allowed for some continued growth in output (European Fluorocarbon Technical Committee, 1987). Both DuPont and European producers shared the same long term economic interests. Indeed, long term economic interests were one of the primary reasons that DuPont sought, and European chemical industry would ultimately accept, international regulation that helped to create a market for substitutes.

With industry having conceded that substitutes could be developed within 5 years, the case for phasing out CFCs was greatly strengthened. The EPA and environmental groups pushed for a complete phaseout of ozone-depleting chemicals within a decade. DuPont officials preferred a 20–30 year transition to the 10 year period advocated by the EPA. DuPont ultimately supported the Montreal protocol which mandated a 50% reduction in production by the year 2000. DuPont officials favoured an international regulatory regime – which had been watered down through comprise – to the alternative of stricter domestic regulation that would mandate a more rapid phaseout. Nevertheless, DuPont still publicly espoused the position that the science justified a limit but not an immediate reduction in the production of fully halogenated CFCs. According to DuPont officials, scientific evidence suggested that there was no imminent hazard to the environment from CFCs at the then current emissions levels; serious problems would arise as the continued growth in consumption led to further accumulations of chlorine in the atmosphere. DuPont's support for the protocol had also depended on US officials' ability to assure that the European-based producers could not gain a competitive advantage through any provisions of the international treaty (Maxwell and Weiner, 1993).

Almost immediately following the signing of the Montreal protocol in September 1987, the scientific case against CFCs hardened. Measurements from aircraft in the US-led Antarctic Airborne Ozone experiments detected the presence of chlorine monoxide, providing strong evidence linking chlorinated compounds with ozone loss (anon, 1987). The scientific results demonstrated definitively the link between chlorine and the hole. The Ozone Trends Panel report published in March 1988 provided still further confirmation of this link (Watson *et al.*, 1988). Even more importantly, the panel concluded that unexpectedly large depletions at middle/high northern latitudes during winter had been revealed. These data showed a 1.7–3% decrease of ozone in the northern hemisphere and up to a 6% depletion in the winter. The traditional models had predicted ozone losses in the long term, but it was clear that ozone depletion was already occurring over the northern hemisphere. The depletion was unbounded and unexplained at this time.

DuPont had monitored these scientific developments closely. In fact, McFarland had been the only industry member of the Ozone Trends Panel. As soon as the study was released publicly, McFarland and Steed recommended to the director of the Freon division that CFC production be curtailed. CFC production would need to be all but eliminated to restore the environmental quality of the stratosphere.

Within less than a week, DuPont's senior management accepted the recommendation and announced a plan to phase out their CFC production entirely. A Harvard Business School case study had described this decision-point as 'very sharp' – the critical turning point for DuPont. However, the decision was already clear for management at that point because of 1986 activities, during which DuPont had moved decidedly towards CFC substitutes. DuPont had already realized that its future lay there rather than with the old compounds, and this decision merely accelerated the phase-out process that had been initiated 2 years earlier.

DuPont claimed the decision to halt production of CFCs was science driven. In Congressional testimony, Dwight Bedsole described DuPont's decision-making process: 'Not one time that week did anyone discuss what effect this decision could have on the financial end of the business.' Richard Heckert, DuPont's chairman at the time, recalled a similar chain of events: 'Our determination to act on scientific evidence rather than on speculation exposed us to some criticism along the way, but as soon as hard evidence did appear, we didn't hesitate to act.' However, DuPont officials were aware of the political consequences of the Ozone Trends Panel's findings. They recognized that the study's findings would soon result in an acceleration of the regulatory timetable for phasing out CFCs. Moreover, they knew that DuPont's announcement was sending a clear message to customers that they would need to speed up their plans for a changeover.

DuPont acted quickly and unilaterally in announcing a phaseout (anon, 1988; DuPont, 1988). DuPont vice-president for external affairs, Malloy, sought to convince his colleagues that other producers would withdraw publicly from the CFC business if DuPont failed to act. Given DuPont's position as the dominant producer and political leader of the industry, Malloy wanted DuPont to make the first announcement and to obtain the largest share of the public credit for its phase-out. (CFCs would soon be used as the primary example of DuPont's new corporate environmentalism.) The unilateral announcement did, however, foster concerns among major users with whom DuPont had been allied politically for more than a decade about the continued availability of a supply to service their billions of dollars of existing equipment that depended on CFCs for its operation.

The phaseout announcement won accolades from those outside the industry. Governmental officials and environmentalists praised DuPont for its newfound environmental consciousness. Referring to DuPont's announcement Lee Thomas, the EPA administrator, stated that it sends an 'unmistakable signal that alternatives and substitutes can be available in the near future' (Thomas, 1988). However, DuPont's rivals viewed the announcement as a logical and incremental step in the evolution of ozone-depletion policy. Mike Harris of ICI described DuPont's 1988 announcement as anything but a major shift in position: 'It's been quite clear that ultimately there won't be any fully halogenated CFCs around' (Reisch and Zurer, 1988).

DuPont's phaseout highlighted the technical and economic feasibility of a transition to CFC-like substitutes. Along with the mounting scientific case against CFCs, the industry position was critical to the London revisions of the protocol that were signed in June 1990. Two of the primary obstacles to a total phaseout were access to technology and financial aid for developing countries. The developing countries argued that the ozone-depletion problem was not of their own making because industrialized countries consumed more than 80% of CFCs. Yet consumption was growing rapidly among the developing countries so that the Montreal treaty would be in jeopardy if these countries refused to ratify it. The industrialized countries agreed to establish a multilateral fund to provide financial assistance and promised to facilitate access to technology among developing countries. However, the agreements lacked specificity as to how this technology transfer and licensing were to be accomplished. DuPont's and other companies' interests were protected because mandatory requirements for technology licensing had been rejected by the international community. Nevertheless, the resolution of these difficulties enabled the London revisions to be signed, establishing a timetable leading to a total phase-out of CFC production by the year 2000.

Political and economic consequences of regulation

The international regulatory regime transformed the market structure for the CFC business, but it also had unanticipated consequences in the political and market arenas. DuPont had expected that the overall demand for CFC-like products would fall as major users shifted to substitutes. Those foreign manufacturers still relying on CFCs for aerosol propellants would begin using nonchlorine-based alternatives, as they had in the USA. Some foam blowing applications would also be converted to alternatives outside the chlorofluorocarbon family. Recycling would go a long way towards meeting the needs of existing refrigeration and air conditioning equipment for servicing. If all went as DuPont planned, the transition would occur in a smooth and orderly fashion with few economic disruptions.

The demand for CFCs 11 and 12 has fallen even more rapidly than DuPont had anticipated. Use of fully halogenated CFCs has declined swiftly in the aerosol and foam sectors. As expected, the high costs of the substitute compounds did not turn out to be a key transition problem. In most applications, CFCs make up a small proportion of the final costs of the products in which they are used. Therefore, where substitutes that do not require equipment or process modification are available, even if the substitute material costs several times more than the original CFC, the changeover will not have not have major impacts on the final cost of the product.

Contrary to DuPont's strategy for commercialization, the electronics industry moved swiftly from CFC 113 to aqueous solutions or to a no-clean process for manufacturing printed circuit boards. The environmental manager of one major electronics firm explained the reasons that the industry did not wait for DuPont to develop a drop-in substitute: 'The writing was on the wall. It was going to happen sooner or later. We figured we would be better off moving at our own pace.' The electronics industry's skill in introducing new technology undercut the most profitable portion of DuPont's remaining CFC business.

For uses requiring a CFC-like substitute, DuPont planned to replace CFCs 11 and 12 with a number of different chemicals tailored to specific uses. Each of the chemicals would be produced at smaller volumes but sold at higher prices. Because of the technical complexity, production would be, at least initially, confined to the major chemical companies based in industrial countries. This was a source of contention with the developing countries in London in 1990 and after. The large producers are joint winners under the international regulatory regime, whereas small producers (especially those in developing countries) which are unable to compete in the new markets are the primary losers. Each of the major chemical companies planned to specialize in the production of certain chemical compounds, thereby limiting competition and enhancing potential financial returns.

Despite the lower quantities of CFCs substitutes being demanded, the total revenues for the business would increase through higher prices. DuPont saw refrigeration and air conditioning as the sectors that would drive the future growth of the business. With its announcement and the subsequent London agreements that mandated a global phase-out by the year 2000, DuPont accelerated its commercialization of substitutes.

Once committed to a phase-out, DuPont's scientific analysis complemented its commercial strategy. Rather than underscoring the scientific uncertainties of ozone depletion as it had in the past, DuPont highlighted the risks involved in delaying regulatory action. In 1991 DuPont executives, armed with the most recent scientific findings from the US Airborne Arctic Stratospheric Expedition, had actually encouraged the EPA administrator to speed up the regulatory timetable. President George Bush subsequently announced that the USA would unilaterally phase out production of CFC by the end of 1995 rather than by the year 2000 (anon, 1992).

DuPont's new corporate environmentalism improved its relationships with Congress and government agencies. Yet problems remained. Responding to the urging of environmental groups, Congress adopted a windfall profits tax as part of the 1990 Clean Air Act Amendments which captured some of the revenues that might have otherwise accrued to DuPont from the restricted supply of regulated chemicals.

Even more importantly, environmental groups proposed a ban on many of the HCFCs. DuPont officials argued that many of the HCFCs were absolutely necessary as part of a transition strategy because other substitutes would not be available in sufficient volumes to meet the requirements of the refrigeration and air conditioning industries. A DuPont spokesman testified before Congress: 'We caution you to be sceptical about claims that technologies other than HCFCs are viable in the near term for all current applications' (Bedsole, 1990). Even the possibility of regulation, they asserted, would discourage adequate amounts of investment in research and development for the substitutes. Without these compounds, many user industries might delay their shift from fully halogenated compounds, causing increases in the total volume of chlorine being released into the atmosphere. If permitted by public authorities, DuPont planned on meeting as much as 40% of future CFC demand through the production of HCFCs. Despite DuPont's arguments and plans, Congress adopted limits on the use of HCFCs in the 1990 Clean Air Act Amendments. These included an eventual ban on HCFC 22, the most widely used of the substitutes then in production.

By 1991, DuPont retreated further from its stand on HCFCs, accepting the need for regulation of the most ozone depleting of the substitutes. DuPont officials still insisted that chemicals such as HCFC 123, which had less than 2% of the ozone-depletion potential as CFC 12, were necessary transition chemicals. Even the HFC substitutes that DuPont was developing for refrigeration markets had an environmental cloud hanging over them as they contributed to global warming. HFC 134a was a more potent greenhouse gas per unit than carbon dioxide even though emitted at drastically lower volumes. The global automobile industry has been moving rapidly to the use of HFC 134a as the chemical of choice for automobile air conditioning. Yet some auto industry executives remain concerned about its long-term environmental acceptability.

Faced with mounting environmental pressures in the mid-1980s, DuPont had sought government intervention that mandated a shift to substitutes, transforming a mature and marginal business into a more profitable one. But DuPont's new course of action also encountered some complications as the science and politics of ozone depleting substances continued to evolve. The US government had established a windfall profits tax on fully halogenated CFCs, instituted its own more rapid timetable for a phase-out, and banned some of the potential substitutes – all actions that hindered DuPont's interests. The market size for substitutes also continued to contract as the user industries shifted to chemical-free technologies and improved the efficiency of their products.

CONCLUSIONS

This review of corporate policymaking towards CFCs suggests that the international community successfully adopted the Montreal protocol because of the concordance of political values, scientific knowledge, and economic incentives. All were necessary to create international change. At the time of the protocol, the science of the Antarctic ozone hole was still uncertain. However, in the absence of scientific consensus, strong political forces unleashed by the presence of the 'hole in the sky' drove the Montreal process. The ozone hole had a unique capacity to elicit strong fears among the scientific community (because of their inability to predict or explain it) and the general public (because of the hole's magnitude, irreversibility and suggested impacts).

Industry's role was critical in facilitating the phase-out of CFCs. By the mid-1980s, the production of CFCs 11 and 12 was no longer as profitable a business as it once was. Renewed environmental pressures threatened to weaken an industry already characterized by overcapacity. International regulation offered major producers the possibility of new and more profitable markets in the long term. The benefits of international intervention are being reaped by a concentrated and politically powerful industry (with fewer than half a dozen major producers).

This switch to substitutes was made feasible because chemical producers had identified a number of alternative chemicals by the early 1980s. Many consumer industries showed reluctance to give up CFCs but the costs of transferring to alternatives were widely dispersed, diminishing potential resistance. Moreover, the major costs of adapting new compressors and other technologies were manageable if phased in over time.

Equally important as the technical feasibility of alternatives was the internal organization at DuPont. Shapiro's approach to possible regulatory changes was internalized at the company, most visibly in the external affairs department which worked with regulators and others on the CFC issue. Such an approach of engaging external actors has sometimes led DuPont to depart from the chemical industry by taking a contrary position, such as they did with the earlier Superfund controversy. However, close interaction with external, non-market forces had positioned DuPont to exploit the situation when CFC regulatory discussions were stepped up.

DuPont and other major producers obtained substantial benefits through the establishment of an international regulatory regime. This case illustrates the opportunity for early-moving companies to gain advantage by changing course concurrently with the changing external environment, rather than retrenching and opposing the changes going on around it. It is useful to consider, however, that even after taking these early actions, the uncertainties in future regulation and market demand for substitutes have posed serious challenges for Du Pont.

The Montreal protocol has been widely considered as establishing a precedent for the institutional changes that will be necessary for averting global climate change. Nevertheless, the political economy of the ozone-depletion issue differs from that for global climate change. In the ozone case, the political dynamics were shaped by the producer industry's pursuit of its long-term economic interests and the diffusion of costs among user industries. Policymaking towards global warming will not face such favourable economic and political conditions. Indeed, the costs of averting global climate change will be concentrated and the benefits will be widely dispersed.

DuPont's experience offers other lessons for environmental policymaking. During the time in which the Montreal protocol was being considered, some producers stood to gain more from the envisaged regulations than did others. Such industry heterogeneity provides frequent opportunities for coalitions of the green and the greedy, such as that between DuPont and environmental interests.

The analysis suggests that government regulators and environmentalists should be aware of this industry heterogeneity because it may provide a basis for important alliances to further environmental progress. Similar opportunities may exist for the control of other chemical classes presently, such as certain toxic and persistent pesticides which could be replaced by new substances and processes. Methods to encourage potential industry winners into supporting environmental initiatives deserve further attention.

ACKNOWLEDGEMENTS

This work would not have been possible without the intellectual contributions of Sanford Weiner of the MIT Center for International Studies. The authors would like to thank the officials of DuPont for volunteering their time and knowledge for this study. Support for the study was provided in part through the MIT Chlorine Project, the MIT Technology, Business & Environment Program, and the MIT Center for International Studies.

REFERENCES

anon (1975a) Fluorocarbon Ads, Proposal Under Attack, *Advertising Age*, 14 July.
anon (1975b) The Sky is Falling: Chicken Little is Alive and Well and Worrying About the Ozone, *Barons*, March.
anon (1975c) S.C. Johnson Drops all Fluorocarbons in its Aerosol Products, *Advertising Age*, 23 June.
anon (1987) Winds, Pollutants Drive Ozone Hole, *Science*, 38, 29 October, 156–158.
anon (1988) *DuPont Again Breaks Ranks on CFCs, Announces Phaseout Goal*, Ends Report 158, March, p. 6.
anon (1992) CFCs: Hole-Stoppers, *The Economist*, 7 March.
Bedsole, D. (1990) Testimony at the Hearings on Stratospheric Ozone Depletion, Subcommittee on Health and Environment of the Committee on Energy and Commerce, 25 January.
Benedick, R.A. (1991) *Ozone Diplomacy*, Harvard University Press, Cambridge, MA.
Chemical Manufacturers' Association (1990) Report of the CMA Fluorocarbon Program Panel, December.
Doos, B.R. (1994) Why is Environmental Protection So Slow?, *Global Environmental Change* **4**(3), 179–184.
Dotto, I and Schiff, H. (1978) *The Ozone War*, Doubleday, Garden City, NY.
DuPont (1988) *DuPont Policy Statement: CFCs*, 24 March.
DuPont (1989) *Company Policy in the Face of Global Commons: The Ozone Issue as a Model*, Freon Products Division, DuPont, September.
Environmental Data Services (1986) Report: *DuPont Leads Industry Shift on CFCs*, October, p. 6.
European Fluorocarbon Technical Committee (1987) *Chlorofluorocarbons and the Ozone Issue: The View of the European Fluorochemical Technical Committee*, European

Council of Chemical Manufacturers Associations, January.
Glantz, M. (1995) Creeping Environmental Problems in the Aral Sea Basin, presented at the United Nations University Public Forum, 27 March, Tokyo, Japan.
IMOS (1975) *Fluorocarbons and the Environment*, Report of the Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS), p. 15.
Lubkin, G.B. (1975) Fluorocarbons and the Stratosphere, *Physics Today*, October.
Maxwell, J.H. and Weiner, S.L. (1993) Green Consciousness or Dollar Diplomacy? The British Response to the Threat of Ozone Depletion. *International Environmental Affairs* **5**(1), 19–39.
Molina, M. and Rowland, F.S. (1974) Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom Catalyzed Destruction of Ozone. *Nature*, 49(5460), 10-12.
National Academy of Sciences (1982 and 1983) *Causes and Effects of Stratospheric Ozone Reduction: An Update*, National Academy Press, Washington, DC.
Oye, K. and Maxwell, J. (1995) In R. Keohane and E. Ostrom (eds), *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains*, Sage, London.
Reinhardt, F. (1989) Harvard Business School Case Prepared for the National Wildlife Federation, Washington, DC.
Reisch, M. and Zurer, P. (1988) CFC Production: DuPont Seeks Total Phase-out, *Chemical and Engineering News*, 4 April.
Rothenberg, S. and Maxwell, J. (1997, in press) Industry Response to the Banning of CFCs: Mapping the Paths of Technological Change, *Journal of Technology Strategy.*
Shapiro, I. (1986) Unpublished Manuscript DuPont Corporation.
Thomas, L. (1986) Cited in Paul Brodeur, Annals of Chemistry – In the Face of Doubt, *New Yorker*, 9 June, 86.
Thomas, L. (1988) Cited in How Long a Farewell to CFC Production? *Chemical Week*, 6 April, 7.
Tolba, M.K. (1987) The Ozone Agreement and Beyond *Environmental Conservation*, 4(4), 290.
Watson, R.T., Prather, M. and Kurylo, M.J. (1988) *Present State of Knowledge of the Upper Atmosphere 1988: An Assessment Report*, 15 March.
US International Trade Commission *Synthetic Organic Chemicals*

BIOGRAPHIES

James Maxwell, JSI Research and Training Institute, Inc., 44 Farnsworth Street, Boston, MA 02210 1211, USA, Tel: +1 617 482 9485. Fax: +1 617 482 0617.
Email: maxwell@jsi.com@jsi.com
Sanford Weiner, Massachusetts Institute of Technology, MA, USA
Forrest Briscoe, JSI Research and Training Institute, Inc., 44 Farnsworth Street, Boston, MA 02210 1211, USA, Tel: +1 617 482 9485. Fax: +1 617 482 0617.
Email: fbriscoecjsi.com@jsi.com

Bus. Strat. Env, Vol. **6**, 276–286 (1997)