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BRITISH BUSINESS AND RESPONSES TO
STRATOSPHERIC OZONE DEPLETION**

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**FRAGMENTING UNCERTAINTIES: BRITISH BUSINESS AND RESPONSES TO
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Every choice we make is beset with uncertainty. That is the basic condition of human knowledge (Douglas 1986).

Business and the global environment: the case of stratospheric ozone depletion

Recent decades have seen growing attention to the effects of human activity upon the physical environment. Recognition of the global scale of actual or potential environmental change has heightened concerns about the uncertain balance between the productive and destructive aspects of economic and technological development (Crone 1986; Funtowicz & Ravetz 1990; Pearce et al 1989; World Commission on Environment and Development 1987). It is increasingly apparent that problems stem not only from specific disasters and the malfunctioning of plant, but that the "pathologies of the industrial system are transferred out, so that it degrades its environment while running 'normally'" (Funtowicz & Ravetz 1990). Businesses have thus become subject to growing pressures to improve the environmental aspects of their performance: from investors, employees and other stakeholders, from consumers, pressure groups and various interested publics, and as a result of a strengthening framework of national and international legislation and regulation (Cairncross 1992; Dunlap & Scarce 1991; Greeno & Robinson 1992; Hackett 1995; Neale 1993; Vaughan & Mickle 1993; Welford & Gouldson 1993). They are urged to recognise the ethical necessity and the financial advantages of integrating environmental considerations into the planning of all other dimensions of their operations (Beaumont 1992; Cairncross 1991; Hoffman 1991; Smith 1993).

There are signs that business practices are changing and not simply as a result of external pressures (Birchard 1993; Hampson 1990; Schot 1992; Welford 1994a). Some indeed have argued that it is only business that has sufficient understanding of its own activity to be able to reduce environmental damage (Winsemius & Hahn 1992). However, evidence regarding levels of environmental awareness

and concern amongst managers is mixed and open to different interpretations (Bennett 1993; ENDS 1993c, 1995; Touche Ross 1990). There are also suggestions that many remain ill-at-ease with an environmentalism that is beyond their previous experience of business education or practice (ENDS 1993g; Newman & Breeden 1992; Winsemius & Hahn 1992). Perhaps, therefore, the clearest message from such diverse reports concerns the limitations of our knowledge of the ways in which businesses address environmental issues.

The full exploration of such themes is too ambitious a task for the present paper. However, we can begin to examine business managers' environmental attitudes and strategies through consideration of an important aspect of global environmental change, the erosion of the stratospheric ozone layer. This has attracted considerable attention from scientists, politicians, environmental campaigners and various concerned publics, especially since the discovery of the Antarctic "ozone hole" in 1985 offered strong circumstantial evidence of ozone depletion (Booth 1994; Roan 1989). Such publicity in part accounts for its prominence amongst the environmental concerns acknowledged by businesses (Touche Ross 1990; Vaughan & Mickle 1993). However, ozone depletion also became the focus of international regulatory action with the inception of the Montreal Protocol in 1987. The creation and subsequent revisions of the Protocol highlight the multiplicity of interacting forces that influence decision-making about environmental futures (Benedick 1991; Morrisette 1989). This global political initiative arose chiefly as a result of scientific evidence of environmental damage. However, its development was also influenced by politicians' perceptions of, on the one hand, the kudos to be gained from such action in an era of growing public environmental concern and, on the other, pressures to defend national economic interests. Business is thus a potential influence upon the political agenda as well as bearing major responsibilities for the successful implementation of the Protocol (Susskind 1992; Ward et al 1990). The timetable established for the phase-out of chemicals identified as ozone depleters, principally chlorofluorocarbons (CFCs) and halons, has had a direct impact on many businesses, including chemical producers, distributors and users in a range of applications from refrigeration to

fire-safety products. Such businesses have thus to carry through the phase-out of proscribed substances and to develop and implement other means of producing or delivering goods and services which we have come to regard as essential. Meanwhile debate concerning the extent, causation and effects of ozone depletion itself continues. This issue thus provides us not only with a model of international environmental diplomacy which previous commentators have praised (Benedick 1991), but also with a case study of the response, at a more immediate level, of business to environmental and political debates based on uncertain and abstract science.

Talking to business

The following discussion draws upon semi-structured interviews undertaken with managers from twelve businesses whose activities were relevant to the debate over stratospheric ozone depletion. The interviews were conducted during the winter of 1993/94 at a particularly interesting time, when revisions of the Montreal Protocol and additional action by the European Union had rendered imminent the phase-out of many of the most potent ozone depleting chemicals (cf the policy life cycle framework outlined in Winsemius & Hahn 1992). Yet both the environmental adequacy of these regulatory measures and the ability in practice to deliver the promised changes remained open to question (ENDS 1992c; McCarthy 1992). Much of the responsibility for the latter rested with businesses, amongst whom it prompted mixed reactions. Some user companies were well advanced in the reduction of their reliance upon ozone depleters, sensing economic as well as environmental advantages from the change. Others presented themselves as increasingly threatened by tightening regulatory systems that would eliminate the use of CFCs and other substances, perhaps in advance of the commercial development of proven alternatives. The position was further complicated for some users by the actions of producers in accelerating the cessation of production of chemicals with high ozone depletion potential and applying increasing effort to the development and marketing of

alternative products and technologies (Birchard 1993; ENDS 1992b).

All the businesses contacted were located in the United Kingdom, comprising both domestically-owned companies and the British divisions of foreign-owned multi-nationals. The study included a cross-section of past and present producers, suppliers and consumers both of substances identified as ozone depleters and products and processes claimed as "environmentally friendly" alternatives. Efforts were also made to involve businesses operating at scales from the smaller single-plant companies to major multi-nationals. The composition of the group studied (Table 1) was, of course, also influenced by the willingness of companies to participate in the project. This degree of self-selection might create a bias towards those who felt that they had a positive environmental record. While this must be acknowledged, the study does reveal a wide range of environmental attitudes and concerns. This also reflects the diversity of interviewees and the way in which many discussed both company policy and personal perspectives upon environmental issues. During our initial approaches to participants, companies themselves were invited to nominate the most appropriate contact with whom to discuss environmental issues associated with stratospheric ozone depletion. All of our resultant interviewees were in managerial positions, up to and including managing director. The study thus included individuals with responsibility for the long-term development of strategic policy as well as those whose opinions and decisions impacted most directly upon the day-to-day operation of the business. The specific areas of responsibility of interviewees within their respective companies showed a bias towards technical operations, which is of itself revealing, and relatively few companies appeared to designate individuals with specific or explicit responsibility for environmental matters.

The project thus rests on detailed investigation of the attitudes of a relatively small number of managers, rather than repeating the common pattern of an extensive structured survey. The latter approach, while allowing the accumulation of a statistically significant sample may be limited in the depth of its exploration of actions and opinions, given that questions are often phrased in a way that

Table 1: Companies and interviewees included in the study.

Company	Major relevant activity	Designation of interviewee
1	Chemical producer	Environmental Director
2	Chemical producer	Technical & Regulatory Manager
3	Pharmaceuticals producer	CFC Project Manager
4	Manufacturer of domestic refrigeration equipment	Free Standing Product Manager
5	Manufacturer of commercial refrigeration equipment	Production Manager
6	Supermarket chain	Head of Refrigeration
7	Manufacturer of fire safety products	Product Manager - Portables
8	Dry cleaners	Group Technical Director
9	Solvent suppliers	Product Managers
10	Foam blowers	Managing Director & Technical Director (2 interviewees)
11	Moulders of blown foam	Quality Engineer
12	Anti-corrosion engineers	Marketing Managing Director

will generate short and standardised answers. The present project seeks to develop a more nuanced understanding of the manner in which business-people view environmental issues, their sources of information and opinion, and relationships between company policy and personal perspectives. We aim to explore why individuals expressed the views that they did concerning environmental issues per se and the links between business and the environment. Such a study raises issues of confidentiality for the individuals and companies concerned and none of our respondents are named. Where material is specifically attributed it derives from a published source and companies so quoted were not necessarily included amongst those interviewed.

Extensive use is made in the following discussion of the interviewees' own words, not simply as a means of reporting our findings but also to highlight the importance of language. Some words admit of more than one meaning; this is true of "environment" itself which, for example, was conceived of by our interviewees at a variety of spatial scales from the very local to the truly global. Any affirmation of environmental concern and its incorporation in company policy thus requires scrutiny. Moreover, there are instances where positive environmental initiatives at one scale create unwanted and unconsidered effects elsewhere. Thus for some interviewees their responsibility for safety in the immediate environment of the workplace seemed at odds with any larger concerns for global futures.

Interconnecting uncertainties

We must also acknowledge further the uncertainty which surrounds much of the debate concerning stratospheric ozone depletion itself and the nature of the human response. The Montreal Protocol has been lauded as a pioneering effort to implement the preventative principle, as action was taken before the worst of any potential environmental damage was either apparent or proven (O'Riordan & Cameron 1994; Seidel & Blank 1990). Uncertainties about the existence, extent, causes and terrestrial

consequences of stratospheric ozone depletion predate the implementation of the Protocol by over a decade and are still not all amenable to ready solutions today (Drake 1995). Debate surrounding the response to ozone depletion thus reflects the limitations of even the most advanced scientific understanding of the workings of complex atmospheric systems. Indeed we need to examine not only the creation and destruction of stratospheric ozone, but the process of global warming. Both CFCs and other chemicals, including HFCs, marketed as alternatives are directly implicated in the enhanced greenhouse effect. Moreover, the use of alternative technologies in sectors such as refrigeration may have implications for energy efficiency and thus indirectly affect the production of greenhouse gases (Hoffman 1990).

If the existence of such scientific uncertainty has had an impact on business decision-making we might expect this to be reflected in the thinking of companies in our sample. Thus, we consider the extent to which the scientific basis for concern was acknowledged by our interviewees and the manner in which it was represented. In some cases an apparent contrast was struck between the uncertainties of science and an assertion of a company's own certainties concerning the safety, utility and profitability of its products or services. However, uncertainties born directly of abstract science were expressed only by a minority of our interviewees. We therefore examine the extent to which such scientific concerns and indeed the wider theme of environmental protection per se are revealed as issues for business. For many companies it would appear that environmental issues do not constitute a separately defined source of uncertainty shaping the context of their decision-making. Rather, they add new dimensions to traditional elements of the "business environment", influencing the actions and attitudes of consumers, stockholders, competitors, suppliers, governments and regulatory agencies which it has always been part of a successful company's task to monitor and anticipate (Dill 1958; Duncan 1972; Thompson 1967).

The existence and development of regulatory regimes seems to have been particularly important for

many interviewees. In setting standards for compliance regulation may be seen as establishing new certainties for businesses and was identified by several interviewees as a significant and, indeed, necessary spur to change. However, in practice, regulation may itself become a focus of new uncertainties. Our discussions revealed different perceptions of the balance between problems and opportunities created by regulation. For some the financial costs of change were not readily calculable and their difficulties were compounded, not by the absence of alternatives to ozone depleting products and processes, but by the multiplicity of potential alternatives promoted by commercial suppliers and the scarcity of impartial advice as to the most effective means of meeting particular needs. Several interviewees also commented on the uncertainties created by changes to the regulatory framework. The tightening of the phase-out schedule for ozone depleting chemicals is justified by increasing knowledge of the extent of stratospheric ozone depletion. However, recent changes have highlighted what is perhaps the greatest uncertainty of all, the ability of business to construct a response which is both economically and environmentally acceptable. One of our interviewees, at least, presented the prospect of failure as real and threatening to the survival of his operation.

Uncertain science: uncertain business

An examination of the perceptions of selected business managers and decision-makers concerning ozone depletion will take us into a number of different but related territories. Concerns are not raised only, or directly, by abstract science and the vagaries of our understanding of atmospheric systems. Uncertainties born of the workings of commercial and regulatory systems were often of more immediate concern to our interviewees. However, it is from an initial scientific focus that these interacting and fragmenting uncertainties derive. It seems appropriate therefore that we begin by exploring the impact of science upon business in this particular context.

Ozone depletion differs from many other triggers to environmental action; it creates no immediate and

dramatic disaster event or visible concentration of pollution. Concern thus derives from the specialised realm of theoretical science (Drake 1995). It was fuelled in particular by Molina and Rowland (1974) who drew the first link between ozone depletion and CFCs, man-made compounds then in use for some forty years and hitherto regarded as safe and effective in a growing range of applications (Stern et al 1992). Initially, however, such findings were widely regarded as speculative. Despite moves to reduce the use of CFCs in applications - primarily aerosol propellants - where alternatives were readily available, the following decade was characterised chiefly by continuing debate over the existence and magnitude of ozone depletion (cf the characterisation of the recognition of risk in Ravetz 1990). In 1985 the measurement of significant seasonal thinning of the ozone layer over Antarctica, since found also in the northern hemisphere and at mid-latitudes, provided evidence of the reality of ozone depletion. Subsequent research, perhaps most famously the 1988 NASA report often credited with convincing Du Pont to withdraw completely from CFC production, strengthened the connection between ozone depletion and man-made chemicals (Barrett 1992; Birchard 1993). Yet such links, while strong, are still not conclusive. As one interviewee noted "Nobody's ever precisely tagged CFCs as being responsible for ozone depletion but the total level of chlorine in the atmosphere has been growing and circumstantial evidence suggests that at least part of it comes from CFCs" (Interview 2).

The scientific argument on which concern about the substances identified as ozone depleters rests thus remains uncertain. This uncertainty can be seen as characteristic of all science, yet it contrasts with lay images of scientists as providers of truth and certainty (Funtowicz & Ravetz 1990; Ravetz 1990; Highfield 1994; Jones 1994). Such perceptions create a feeling that the science which underpins debate over ozone depletion is somehow unusual and this has coloured the response of businesses involved as producers, distributors and consumers of the implicated chemicals. The attitudes of many companies have changed over time (Barrett 1991; Marcil 1992; Tombs 1993). Several major chemical corporations have abandoned their initial position in which scientific uncertainty was presented as a reason for temporising. It was argued that the certainty of the utility (and profitability) of existing

production systems should not be precipitately overthrown by uncertain science, the most pressing need being, rather, for research to resolve that uncertainty (Barrett 1992; cf Funtowicz & Ravetz 1990). In the light of such research companies now present themselves as convinced of the potential for damage to the ozone layer. While uncertainty as to the extent of environmental change remains there is now credit, economic and environmental, to be obtained from being seen to take the initiative in advance of ultimate (and in truth illusory) certainty. The representative of a major chemical producer thus distinguished between scientific or technical considerations and the broader basis for managerial decision-making: "I think our technical people ... are always seeking the purity of scientific and technical proof and find it hard to accept sometimes that decisions are not made purely on scientific grounds and that you can win the technical argument but lose the case" (Interview 1).

Such a stand may be presented as exercising responsible care and precautionary principles in defence of the environment. It is also intended to maintain business advantage in changing circumstances of regulation and the development of alternative products and technologies (Barrett 1991, Birchard 1993; cf Arrington & Sawaya 1984; Vallance 1993). Indeed, in the face of environmental and economic uncertainties businesses again proclaim their own certainties; particularly of the utility and even necessity of their new products, for as ICI's publicity material asserts "'Doing without' would not only mean changing a lifestyle it would affect health, safety and economies, and not only in the western world; third world countries would be affected as well" (ICI undated; cf Baden 1992). But there are also claims of the environmental virtues of the solutions offered by the chemical corporations, which sometimes seem to imply an unwarranted degree of certainty in an ability to predict and even control the state of the global environment. ICI has been reprimanded by the Advertising Standards Authority for implying that the future contribution of HFC refrigerants to global warming was both predictable and small (ENDS 1993e; Greenpeace 1993). Elf Atochem also seems open to criticism for its promotion of HCFCs, which themselves contribute to ozone depletion, albeit less than CFCs. Their claim that "The effects on the environment are positive: the chemical modification of the ozone layer

is under control and the chlorine content of the atmosphere will decrease significantly in the next several years." (Elf Atochem 1992) seems disingenuous. The assertion that key aspects of atmospheric chemistry are "under control" seemingly acknowledges no significant limitations to human understanding of a complex natural system. This is dangerous, not least because we might wish for it to be true and so assure us of the safe human management of the global environment.

The case presented by chemical corporations in developing and marketing alternatives to CFCs has not only been subject to criticism from outside the business world (Moore 1990; Doyle 1992). Interviewees from user industries felt that chemical producers had been opportunistic in their approach. One considered that "perhaps some of the largest chemical companies learnt very early how to maximise the marketing of some of their less than friendly environmental products and we as consumers allowed them to do so" (Interview 10); another voiced "a suspicion that we've been conned ... by the advertising people" (Interview 11). Chemical producers had allegedly "manipulated" debate over ozone depletion, because they "coined the phrase 'CFC free' and also coined the argument that HCFCs are not CFCs, therefore if you use HCFCs you can say you're CFC free. That's a very spurious argument in my view" (Interview 10). The force of this complaint is strengthened by evidence of confusion between the term 'CFC free' and zero ozone depletion potential.

It is also possible to trace a trajectory of response amongst some users of ozone depleting chemicals to concerns about their products and processes of manufacture. In fields such as electronics both apprehensions that uncertain science might undermine profitable businesses and inertia have been overcome (ENDS 1989a). Indeed there has been a recent proliferation of alternative technologies claimed as environmentally and economically sound (ENDS 1993a). It is unsurprising, however, that particular businesses react in different ways reflecting the perceived scale of dislocation to their individual interests. Amongst our interviewees, the two extremes of response were represented by pharmaceuticals and producers of fire-safety products. The use of CFCs in medical aerosols and

metered dose inhalers to treat respiratory conditions was still claimed as essential in the absence of alternatives proven to be safe and viable (International Pharmaceutical Aerosol Consortium 1993a & b). It does not seem coincidental, therefore, that it was the interviewee from a pharmaceutical producer who placed the greatest stress on the uncertainty of connections between CFCs and ozone depletion

CFCs are nasty and that's fine if they are. If they prove not to be, then my God what a waste of time, energy and everything else.... [T]he work [on the effects of CFCs] was done in the early 80s which indicated there may be a problem and that maybe was a theoretical issue and even today there are people who question [it].... [T]here are some eminent groups who question the causal connection between the release of so-called ozone depleting substances and ozone depletion. It's at what stage do you say this is something I have to act on and that's a judgement between ... how you understand and concur with the science and what the cost is going to be. Now I don't mean the cost in just money, I mean in terms of risk and disruption of everything else (Interview 3).

The uncertainty of the science is set against the certainty of the medical utility of existing products and also the risk to the economic future of the company: "the pressure is so intense that if we can't meet the deadlines [to develop alternatives] in a market sense then we don't have a future ... and the six and a half thousand people that work ... [here] ... will no longer [do so]..." (Interview 3). By contrast considerations of scientific uncertainty were not raised by the interviewee from the fire-safety products manufacturer (Interview 7). Having sharply reduced their reliance on halons there was little sense of threat to core business. Halons were presented both by our interviewee and the company's publicity material as a proven threat to the ozone layer, to be withdrawn from all but a handful of specialised applications. This seems a markedly more positive position than the doubts expressed by both chemical producers and the fire-safety industry in the late 1980s about the availability of a safe and effective alternative in the short- to medium-term (ENDS 1989b). Indeed, the new argument extended almost to undermine the case for halons ever having been applied in this area; stress was also placed on their toxicity when directly inhaled and on their limitations in combatting many types of

fire. Alternatives, including such established technologies as water and carbon dioxide, were thus both environmentally superior and more effective fire-safety products.

Science, environment and the "business environment"

While the views discussed above differed in the degree of certainty accorded to links between ozone depletion and their own past or present activities, all did refer to scientific understanding of stratospheric ozone depletion. The scientific background to concern and action did not, however, figure largely in discussion with other users of chemicals implicated as ozone depleters. The uncertainties which many managers see, whether as threatening existing practices or as business opportunities, often relate only indirectly to core atmospheric science. This initial scientific uncertainty interacts with other aspects of the context of business operations and thus fragments producing new uncertainties perceived as more immediate. The preoccupations of most interviewees were those of the "business environment" traditionally defined - the volatility of markets and supply chains, legislation and regulation, the attitudes of competitors, the costs of developing, adopting and using alternative products and processes - rather than those relating directly to the science of the natural environment (cf Bourgeois 1980; Dill 1958; Mascarenhas 1981; Thompson 1967).

Environmental scientific knowledge or concern per se seems to play little part in either the daily decision-making or the longer term strategic planning of several of the companies in the study. Some interviewees without a scientific or technical background acknowledged their difficulties, especially initially, in assessing environmental arguments "particularly ... in terms of the environment with CFCs and ... refrigeration etc.... [T]hat is actually quite a difficult subject to come to grips with because in a way you have to be perhaps a chemist or a physicist to purely weigh up all the pros and cons" (Interview 4). Our interviewees sometimes also revealed confusions in their environmental

understanding, even when accompanied by expressions of personal commitment to green causes. Thus concern voiced regarding the mistaken equation of the label CFC free with a zero ozone depletion potential seems justified in the light of the response that "I wouldn't really know, I thought one ... virtually ... meant the other" (Interview 11). Individuals thus displayed their own uncertainties about uncertain science, but noted that the requisite expertise was available from the company's scientific and technical staff. The implication that the existence of such staff absolves others from an informed understanding of the environmental impact of the business which they manage is not, however, reassuring. Nor is it compatible with calls for environmental education and awareness throughout a company as a tenet of sound management (ENDS 1993b; Smith 1993; Touche Ross 1990).

Some interviewees, often those closer to the management of day-to-day operation of the company, appeared to have a somewhat restricted view of any connections between the immediacies of their business and larger scientific or environmental issues (cf Winsemius & Hahn 1992). Global concerns were on occasions dismissed as distant and abstract. One interviewee, responsible for the provision of refrigeration equipment for a supermarket chain, discounted any connection between his decision-making and "the [global] environment which everyone gets excited about and no-one can prove. Which is all hypothesis and extended figures and theorising" (Interview 6). More concrete and thus more important was the specific environment of the store or workplace. Thus, displaying a perspective on environmental concerns which others have attributed to an association in many managerial structures with established remits concerning health and safety (Shrivastava 1993), accident prevention within the workplace was given priority, for concern about the global environment "has little to do with my mother or grandmother going to buy a tin of beans...". Thus despite initiatives by other supermarket chains in Britain and abroad (eg ENDS 1993d), experimentation with alternatives to CFC refrigerants was regarded by our interviewee as highly problematic. The use of ammonia, in particular, was dismissed as incurring unnecessary risks to customer safety within the immediate environs of the store.

Others amongst the interviewees accorded the immediate health and safety aspects of various technologies and chemicals more weight than any wider environmental implication. Even the representatives of the foam blowers, who showed one of the clearest appreciations of global environmental concern used the vocabulary of health and safety in stressing that their "main objective is to use chemicals which are safe for internal use, safe for public use and to be constantly aware of the processes we are using to make sure that we use the safest alternative materials available" (Interview 10). A concentration on practicalities rather than the largely unfathomable scale and uncertainty of global environmental change is hardly unexpected. It is most conspicuous in promotional material intended for consumption within industries, here the uncertainties of environmental science are replaced by bluntly stated imperatives. In particular it is the certainty of change enforced by legislation and international regulation, specifically the Montreal Protocol, which is stressed. Little attention is spared for the environmental concerns which prompted regulation, nor indeed for the logic or detail of regulatory provisions. It is the simple existence and inevitability of change that is the message (cf Touche Ross 1990). Thus material issued by the solvent distributor is headlined "Time is running out.... [Y]ou will soon be forced to find an effective environmentally sound replacement...". While electronics corporations and other large-scale users of solvents have pioneered alternative cleaning systems there is evidence that smaller companies have been much slower to recognise the need for change (Department of Trade & Industry 1990). Such a view was echoed by the interviewee from the solvent distributor; the emphasis of their advertising reflected the belief that "Without legislation there is no incentive ... without legislation people won't move" (Interview 9).

Regulation: ending old uncertainties or creating new ones

Viewed in such a light legislation or regulation creates a new, albeit artificial, certainty for business decision-makers (cf Funtowicz & Ravetz 1990) through the political imposition of common rules for

the phase-out of the production and consumption of a designated group of chemicals. However, the difficulties - technical, financial, organisational and environmental - of responding effectively to increasing controls on the use of ozone depleting substances and, indeed, the wider changes in the distribution of economic power that may follow from regulation may create new uncertainties, especially for small and medium-sized enterprises (cf ENDS 1995; Touche Ross 1990).

The public face, at least, of the environmental policies of many major corporations has changed in recent years; their hostility towards regulation, particularly at the international level, has softened (cf Susskind 1992). Ostensibly this reflects increased scientific evidence of the implication of CFCs and other chemicals in ozone depletion, but important also is the recognition of potential strategic advantage in the pursuit of their own business interests (Barrett 1991, 1992; Doyle 1992). Initial perceptions that major chemical manufacturers might yield significant windfall profits as regulation increased the prices of CFCs have receded in the face of commitments to end their production totally (Barrett 1991). However, regulation is argued to have become an integral part of the defence of investment made by major chemical companies in the production of "in kind" substitutes, particularly HCFCs and HFCs (Barrett 1991, Doyle 1992). An enforced and foreshortened phase out in the use of CFCs is likely to increase dependence on the most direct substitutes, not least because it restricts the time available to develop and win popular acceptance for more radically different alternatives. Moreover, regulation of HCFCs and HFCs is a two-edged weapon. On the one hand it does set an end point, albeit so far rather ill-defined, for the use of chemicals which are themselves environmentally damaging. Yet it at the same time it may help to underwrite investments made in new productive capacity by giving some official recognition to their use as CFC substitutes within any stated period (Moore 1990).

The major chemical producers are not, however, alone in perceiving potential advantage from environmental regulation. Indeed, it has been suggested more generally that larger concerns are better

able to initiate environmental innovations, perhaps in advance of changes enforced by regulation, and thus reap competitive advantage as public and legislative expectations of environmental performance are progressively raised (Cairncross 1992; Kaufman & Ferguson 1992; Welford 1994b). Moreover, those smaller businesses which are environmentally progressive in their own productive technologies and/or in the goods and services they market may become increasingly attractive take-over targets. Thus one effect of the greening of business may be its increasing concentration in the hands of major corporations.

In so far as our interviewees from larger multi-national companies touched upon such issues they presented their case chiefly in terms of the temporising of other and, by implication at least, smaller concerns and the consequent necessity of their own environmental and business leadership. Thus the representative of a major white goods manufacturer suggested that "a lot of people are ... saying 'Oh well, it's [the phase out of CFCs] not until 1995 so we'll wait' ... that's what certain companies are doing (Interview 4). While an interviewee from a chemical producer implied inertia at "the grass roots level, ... the one man and his dog type of business whose attitude is, well there may be something out there but everyone else will have to look after it and tell me when it's time to change" (Interview 2). It might be questioned, however, whether the response of smaller businesses is simply characterised by indifference or whether it reflects the practical difficulties of communicating environmental and commercial messages to smaller companies (Interview 2) and the potentially punitive costs that they may face in complying with increasingly stringent environmental regulation. While the threat of closure might be over-stressed by some small businesses as a means of avoiding what is perceived as unwelcome regulatory interference, some of our interviewees from medium-sized and larger companies did express at least a degree of sympathy with their case: "you're never going to rule out the small companies ... chucking stuff down drains, ... those employing half a dozen people get away with [it] ... but there again would they be put out of business ... if there was legislation? I would say they would do" (Interview 11).

Such considerations are, however, compounded by a series of uncertainties which contribute significantly to the slow pace of change amongst some companies. Perceptions of an increasingly predatory big business may contribute to this uncertainty. Some interviewees also voiced concerns about unfair foreign competition reflecting a perception that national environmental legislation could be used, and was perhaps even designed, as a means of trade protectionism (Interviews 5, 7, 10). Yet the most basic or widely expressed concerns reflected uncertainty as to how to respond to regulation of the consumption of ozone depleting substances. As previously noted there remain difficulties in finding safe and effective substitutes for CFCs in some specialised applications. However, in a growing number of cases the dilemma is not so much the availability of alternatives but the need to choose between what may seem a bewildering variety of solutions; each invariably marketed as the answer in the search for the simultaneous maximisation of both economic and environmental advantage.

Changing business policy and practice: choices, confusions and costs

Ozone depleting chemicals, in particular the various CFCs, have been applied to a wide variety of tasks and no single multi-purpose replacement can be envisaged. Thus the markets formerly satisfied by CFCs are in the process of fragmentation with a range of different products and technologies being developed as alternatives. Markets are also being squeezed as an increasing emphasis is placed on the minimisation of emissions of regulated chemicals - including the HCFCs and HFCs newly marketed as alternatives to CFCs - and the recovery and recycling of materials already in use. Such circumstances are problematic for chemical companies with a major stake in the production of CFCs and their direct alternatives. Greater efficiency in the use of existing chemicals and the increasing potential of "not in kind" alternative technologies represents a double threat to their power over what were previously established and growing markets. Both the chemical producers interviewed estimated that their sales of replacements would be around one-third of the size of peak demand for CFCs

(Interviews 1 & 2). Hence, the chemical producers' attempts to reassert control through an insistence on the necessity of their own new products as the only solution that was immediately available, effective, safe and minimally disruptive of both existing technologies and business profitability (Doyle 1992). Such claims are in part an attempt to influence the position of national governments in future negotiations over the tightening of international regulatory regimes. They are also central, however, to the marketing of new products and technologies to potential customers, seeking, or being forced to seek, alternatives to CFCs.

Indeed, it is not only the established chemical companies who are engaged in this competition for business, the suppliers of a range of other products and processes are equally active. Thus, for example, users considering alternatives to CFCs as a solvent face the choice between chemical companies' advocacy of HCFCs and HFCs, and also cleaning systems using water, terpenes or derivatives from citrus peel as well as the potential for developing "no clean" systems in some applications. The resolution of the uncertainties inherent in such a range of alternatives may become a difficult task. The representative of a chemicals manufacturer indicated that even from his partial perspective

We are still in a time of quite substantial change and a time in which the industry still has got to work towards the final make-up of its bag of alternatives. There are probably too many alternatives available at the moment and this is the common cry from the user industry at the moment: 'hey, come on, simplify it, let's cut down the number of alternatives' (Interview 2).

The interviewee from the manufacturer of commercial refrigeration equipment claimed that the diversity of alternatives to CFCs had lost them business as their choice of replacement refrigerants had not always coincided with the options for which their existing distributors had developed service facilities (Interview 5). The manufacturer of domestic white goods also looked for a greater degree of standardization. Having investigated several alternative refrigerants and technologies they aimed to "get something that applies to as much of the range [of equipment for different contexts and on

different scales] as possible ... because ultimately we'd like to have just one option" (Interview 4). Clearly there are likely to be operational and financial gains for large producers of chemicals and products previously reliant on CFCs in the standardization of alternatives, but such moves may also offer reassurance to smaller companies currently faced by a confusion of alternatives.

The interviews also expressed a need to clarify the perceived uncertainties regarding the cost of adopting new processes or products. A major chemical producer felt that this was still an area in which the understanding of many small firms was inadequate: "they don't realise it costs a lot of money to switch out of CFCs" (Interview 1). Some interviewees emphasised not so much the scale of their own investment in alternative technologies but the initial uncertainty of the financial commitment. The representatives of the foam blowers perhaps exaggerate the scale of the uncertainty, but their argument is sound. Recalling an initiative taken in the mid 1980s, relatively early in the evolution of business responses to debate over ozone depletion, they claim

We had no idea when we started the project what it was going to cost. The only cost we were prepared to quantify at that time was a building. We put in a building and a purpose made production line down to developing CFC replacements. We ... had no idea what it was going to cost us, £500,000 or £50 million (Interview 10).

For some firms at least the financial uncertainties of compliance with environmental regulation have been little changed by the experience gained within the business world as a whole during the intervening decade.

In some instances suppliers, such as the solvent distributor, saw themselves as sources of advice for their smaller customers (Interview 9) and several users did acknowledge suppliers, rather than an external and perhaps more disinterested authority, as their major source of advice on both the regulation of CFCs and the availability of alternatives (suggesting that change since the survey reported in Department of Trade and Industry 1990 has been limited). The need to increase the

circulation of information about the options available to reduce dependence on CFCs in particular applications, particularly to smaller and medium-sized companies, has been previously noted. Concerns about the adequacy and disinterestedness of the information that is available were voiced by several interviewees. Thus in the dry cleaning trade it was suggested that

one of the big concerns is the confusing information for an independent cleaner. Unfortunately many independent cleaners are not members of industry, trade or research associations which give good valuable advice. So they don't get advice from independent authorities. They get advice from machinery suppliers who have vested interests so there is some apprehension about what they should do (Interview 8).

Although not referred to by our interviewees the increased emphasis placed by several of the major producers of CFCs and their direct substitutes on programmes of customer education and after-sales service (eg ENDS 1990, 1991) has been questioned by some commentators who see in them chiefly a desire to retain and control customers in an increasingly competitive market (Doyle 1992). A role has thus been suggested for trade associations and the government in providing more disinterested advice. While comments about the former source were generally favourable, reaction to government initiatives was much more mixed. Several of our interviewees expressed doubts about the adequacy of government initiatives which include measures, such as the DTI sponsored "Solvents Road Show", specifically designed to establish contacts with smaller companies. The representative of the dry cleaners while noting regular meetings, particularly through the agency of trade associations, with officials from the DoE, DTI and the European Commission suggested that these were of less significance with respect to CFCs than for other environmental issues (Interview 8). The interviewee from the producer of commercial refrigeration equipment was blunt in his assessment of the DTI: "we don't feel that they're in true contact with the industry" (Interview 5). There were also concerns that the government was ineffective in stimulating both research per se and its communication through inter-firm contacts. Thus the representative of the foam blower considered that

Certainly the government could be more active in helping to develop research and to [provide]

funding in the various matters, getting together with the best available techniques, best practice, who's doing what, where; getting the companies that are, like ourselves, ahead of the game talking round to other people and being helpful to each other. And it isn't happening (Interview 10).

Regulation: flexibility and efficacy

Rather than resolving the uncertainties faced by some businesses, regulation leads to its transformation. For the majority of companies whose environmental policies are dictated by compliance with legislation or regulation, the question is no longer whether or when to act, but how to meet the performance and emission targets set. The difficulties and uncertainties of this task may be compounded when those targets are themselves shifting (cf the argument of Chichilnisky 1992 that regulation needs to be predictable and with a long lead time if it is to promote business innovation). The acknowledged limitations of scientific understanding of stratospheric ozone depletion and its links with human activity demand flexibility in any regulatory response. The Montreal Protocol thus provides for the regular review of its terms, a structure vindicated as increasing evidence of the extent of ozone depletion has led to an acceleration of phase-out schedules for chemicals subject to initial controls and extension of the range of regulated substances. The regulatory system also aims to encourage development of alternatives to the worst ozone depleters. This is the case with regard to the definition of essential uses where the continued consumption of proscribed chemicals will be permitted after the general phase out deadline. The confirmation of essential uses is relatively late in the regulatory process since any premature decisions would discourage further investment in the development of alternatives and the promotion of recycling (ENDS 1992a). In practice the system may have had the opposite effect, "because as long as they didn't announce ... [the list of essential uses] everybody felt that their particular use, whatever it was, was going to be allowed to continue"

(Interview 1). The stringency with which the definition of essential use has been recently applied has, however, confounded these expectations (ENDS 1993f), leaving some companies concerned about the limited time available to design and implement changes in their operations.

The flexibility of the regulatory system appears justified as a response to an evolving scientific understanding of atmospheric change. For some interviewees it was also an effective way of implementing profound change within the business world. The representative of a major chemical producer suggested that an initial attempt to enforce complete and rapid phase out of CFCs would have been counter-productive: "everyone would have risen up and said it's impossible, there would be huge arguments, probably nothing very much would have got done because everyone would put their energies into proving why that wasn't feasible" (Interview 1). Much more has been achieved "by setting a realistic goal far enough ahead for everyone to see what was coming and then tightening that goal as people got used to the idea..." (Interview 1). Several of our other interviewees also expressed their desire for "realistic" legislation and there was little sense of the counter-argument that the phased implementation of stringent regulation has compromised the precautionary principle and perpetuated environmental damage. Doubts have been expressed, rather, as to whether in practice incremental regulation has enabled or required "everyone to see what was coming" and react accordingly. Indeed, the positive message here seems at odds with doubts expressed elsewhere in the same interview about levels of awareness of the need for change, especially amongst smaller businesses (Interview 1). Other interviewees themselves noted the changes in the regulatory systems as a source of uncertainty and, in some cases, apparent anxiety.

The challenge to businesses represented by regulation is perhaps increased by the variety of its origins. In addition to the international agreement of the Montreal Protocol some individual states and the European Union have established their own stricter regulatory frameworks (eg ENDS 1992d, 1994b). The timetables for any revision of these various systems do not necessarily coincide and the outcome

of that process is not always foreseeable, reflecting as it often does not only considerations of global environmental security but also the attempted advancement of their own particular economic and political interests by individual national governments. In such circumstances regulation clearly does not imply once and for all change, rather it is a progressive process whose chief certainty is that curbs on ozone depleting substances will increase, but not at a pace or with a stringency that can be confidently predicted. Several interviewees noted this as a source of uncertainty, but differed in their analysis of the consequences. The representative of the dry cleaning chain noted that in his business "there has been some confusion, particularly over the acceleration of phase-out schedules, but in some ways the uncertainty has probably speeded up its [CFC 113] actual reduction in use..." (Interview 8). However, difficulties caused by the revision of regulation were stressed by the pharmaceuticals industry:

we've consistently said that it doesn't matter how hard you squeeze us, there's only so much we can do and that's beyond our control The phase-[out] has been accelerated so that whilst we thought we would be just in time ... for a '97 phase out, as soon as it moved to '95 in Europe we knew that we couldn't meet that deadline.

In this specialised case, the use of CFCs as a propellant in metered dose inhalers for drug delivery, the producer's perceived problems are compounded by further regulatory complexities and uncertainties concerning the development of alternative means of delivering treatment

even today the European Health Authorities have not agreed what studies we need to do in order to satisfy them that the new products are safe and effective ... in developing a new product we have to demonstrate to each health authority in every country that each product is safe and effective.

Moreover "we're starting on these [clinical] studies without an understanding that that's precisely what the health authorities want.... [W]e are working on the basis of draft [proposals]" (Interview 3).

Such a response reinforces perceptions of the potential contradictions between concern for the global

environment and other influences upon the quality of life for many people. This issue also raises questions concerning the ability of some businesses to comply with regulatory framework developed by politicians. More generally, the extent to which continued use of CFCs will be permitted either through official designation of essential uses or through a failure to enforce regulation remains unclear. Thus the effectiveness of the regulatory process as a whole cannot yet be taken for granted. Indeed one of our interviewees emphasised a potentially important limitation upon the Protocol's curbs on CFCs:

you haven't got to change equipment by a specified date. You've only got to change the equipment by a time when you reckon you won't any longer be able to get gas to service it. But there's nothing that says all equipment operating on CFC 12 must be converted to something else by 31st December 1995 or any other date you care to choose (Interview 2).

The claimed "reluctance on the part of the end user to make the change before they absolutely have to" (Interview 2) might be exacerbated by developments such as the reported claim by an independent association of dry cleaners to have arranged for unlimited future supplies of CFC 113 solvent (Interview 8). Such promises whether fulfilled or unfulfilled can only delay any change to more environmentally sound products or processes and while apparently offering short term relief to businesses concerned by the costs of change such temporising may also increase to a penal extent the eventual cost of compliance with rising environmental standards. Perhaps most worrying of all are the suggestions of an emergent black-market in CFCs (cf ENDS 1994a), indeed one of our interviewees was adamant that there already "are areas where certain contractors keep their own stock of CFCs and use it unofficially. Everyone knows it goes on" (Interview 8). All such developments might not only reduce the effectiveness of the Montreal Protocol but also call into question its appropriateness as a model for future environmental initiatives.

Conclusion

It is not the intent of the present paper to proffer solutions to environmental problems, nor indeed to

develop some neat categorization of business responses to environmental concerns. Rather we aim to show the complexity of reaction to a single issue, that of stratospheric ozone depletion. It is clear that our interviewees differed in their interpretation of the interplay between scientific, environmental and economic considerations, and the degree of certainty which they accorded particular arguments. In part this variation reflected the circumstances of the individual companies with which our interviewees were connected and their own position and responsibilities within that company. It is unsurprising that those who might be considered to have felt their activities to be most threatened should seek to reduce that threat by emphasising the theoretical and uncertain basis of the science on which concern about ozone depletion rested. In some instances this was complemented by an assertion of alternative certainties: the primacy of the immediate locality over the global environment, the contribution of particular products and processes to quality of life and the maintenance of essential human systems, and the ability of businesses themselves to restore the balance between economic and environmental sustainability.

Indeed interviewees often placed stress on the responsible nature of their own company. For some this was manifest in the promptness of their response to concerns about ozone depletion and a willingness to embrace the precautionary principle in making policy and investment decisions in advance of either scientific proof or legislative compulsion. However, such virtues were not always seen to extend to business as a whole, with complaint about inertia on the one hand and opportunism on the other. Criticism of business attitudes towards the environmental impact of their activities is clearly not confined to external commentators. We might, however, consider the grounds of such criticism. In part it does reflect genuine environmental concern but there are also elements of self-interest in the exception taken to the activities of companies who derive competitive advantage by being less green or less scrupulous in the environmental claims made for their products. In this and other ways the environmental performance of business represents not so much a new issue as a facet of the traditional concerns and uncertainties of the "business environment"; not least because many companies' positions

are dictated principally by compliance with legislation.

In such circumstances environmental issues per se may become submerged. Some of our interviewees seemed not so much unknowledgeable as uncurious regarding the root causes of concern about ozone depletion; the legislative imperative being presented of itself as justification for change. Yet the need to respond to regulation and legislation could in turn create new uncertainties for business, concerning the means for compliance and the speed and extent to which it was possible. Some external commentators have shown an increasing tendency to regard stratospheric ozone depletion as a solved issue, with the implementation of a global political agreement for the phase-out of ozone depleting substances indeed providing a model for the resolution of other environmental problems. But amidst the self-congratulation by politicians and diplomats many uncertainties remain for businesses in balancing the delivery of the task of elimination of ozone depleters devolved to them, with the maintenance of their economic viability. This is especially the case for those outside the ranks of the major multi-national corporations whose well-funded R & D initiatives capture much of the attention in reviews of the greening of business. Several of our interviewees considered that insufficient effort was being put into the resolution of the uncertainties faced by businesses. Greater effort was required to disseminate good practice and make available relevant and disinterested advice to guide companies through the many competing claims made for products and processes advanced as alternatives to the use of ozone depleting substances. This is thus an area to which greater attention should be devoted in the immediate future. Responsibility lies not only with government - whose previous actions received little praise - or business itself, but also with academics and environmentalists. If we are to progress from the pursuit of academic understanding of business attitudes and actions to offer something of practical utility to decision-makers then co-operation with business to extend awareness of the means to, need for and potential advantages of environmentally inspired changes to products and processes must receive increasing attention.

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