

Ideas and Environmental Standard-Setting: A Comparative Study of Regulation of the Pulp and Paper Industry¹

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This article examines the policy responses of Canada, Sweden, and the United States to the discovery of dioxins in pulp mill effluents and paper products, with particular attention to the impact of science and the scientific community on national environmental standards. Important areas of policy divergence were found, despite considerable scientific consensus among environmental scientists in the three jurisdictions, as the potential force of shared causal knowledge was undermined by competing domestic interests and different institutional contexts for decision-making. This analysis challenges the emphasis of the epistemic community literature on the role of scientists in promoting policy convergence, underscoring the importance of the interaction of ideas, interest group politics, and institutions in public policy-making.

INTRODUCTION

In September 1987, the U.S. Environmental Protection Agency (EPA) announced that dioxins had been detected in pulp mill effluents, fish caught downstream from pulp mills, and various paper products, including coffee filters, milk cartons, and disposable diapers. In light of dioxin's reputation as the most toxic chemical known to humankind, EPA's dioxin discovery placed the issue of pulp mill pollution solidly on both the public and governmental agendas and prompted reexamination of environmental standards for the pulp and paper industry throughout the world. The pulp and paper case thus provides a unique opportunity for comparative policy analysis, since different jurisdictions responded simultaneously to a newly discovered problem.

Soon after the EPA's announcement, there was substantial convergence throughout the industrialized world as the pulp and paper industry committed to reducing its dioxin releases. Faced with considerable consumer pressure—though arguably something less than scientific consensus concerning the health risks posed by dioxin—the industry *voluntarily* adopted process changes to reduce dioxin to nondetectable levels. In fact, it is noteworthy that industry behavior substantially converged even though national regulatory standards did not.² Soon thereafter,

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however, the policy debate expanded from dioxins to all chlorinated compounds discharged by pulp mills, with divergence of both regulatory standards and industry performance.

The focus of this article is on that second story. The policy responses of three countries—Canada, Sweden, and the United States—are examined, with particular attention paid to the impact of science and the scientific community on national standards for chlorinated discharges. Important areas of policy divergence are found among the jurisdictions studied, despite close interaction among environmental scientists in the three countries and considerable scientific consensus. The article argues that the potential force of shared causal knowledge was undermined by competing domestic interests and different institutional contexts for decision-making. The analysis thus underscores the importance of considering the impact of causal knowledge, interest group politics, and the institutional environment, and of the interactions among these factors, in studying public policy.

THEORETICAL FRAMEWORK

In focusing on the impact of science and the international scientific community on domestic policy-making, this article is situated within contemporary debates about the influence of ideas on public policy. In terms of the typology offered by Goldstein and Keohane, the emphasis here is on causal beliefs, rather than worldviews or principled beliefs. However, causal beliefs are situated here within a broader framework of ideas, interests, and institutions, with particular attention to the interplay among the three (Hall; Hecló). Following a brief discussion of case selection and methodology, this section considers each of these factors in turn.

Regulatory decisions concerning chlorinated discharges from the pulp and paper industry invariably emphasize one regulatory parameter, adsorbable organic halogens (AOX), which measures the total chlorinated organics in a mill's effluent. The emphasis on chlorinated substances limits analysis to the subset of pulp and paper mills that were the focus of policy debates, Kraft (or sulphate) mills that use chlorine bleaching. However, this is the dominant and fastest-growing sector within the industry internationally (Smith).

The three jurisdictions selected for study—the United States, Canada, and Sweden—were chosen because they are the world's largest producers of bleached Kraft pulp, accounting for roughly half of global production (Chung, Cook, and Halliburton). Moreover, the industry is at a similar stage of technological development in these three countries, and as such poses comparable environmental challenges in each one. The countries also have similar scientific capacities, both within the industry and in the public sector, setting the stage for the sharing of scientific research and comparable uptake of technological advances. Subtle differences in institutional context and balance of interests are discussed below.

For each case study, documents from government, industry, and environmental groups and scientific publications and conference papers were reviewed. In addition, unstructured interviews were conducted with government, academic, and industry researchers, environmentalists, industry officials, and regulators in each of the three countries.³

Ideas

With respect to the impact of ideas on environmental standard-setting, Peter Haas's concept of an "epistemic community" is of particular relevance. Among students of international environmental policy, Haas (1989, 1992) has arguably placed the greatest emphasis on causal beliefs in arguing that transnational scientific communities that share values, causal beliefs, and policy prescriptions can play a critical role in promoting international convergence, even when state interests substantially diverge. The discussion that follows is thus attentive to the degree of interaction among members of a transnational scientific community, the extent of consensus among scientists on both causal knowledge and policy prescriptions, and, ultimately, the impact of science and scientists on policy decisions in each of the three countries.

Interests

The pulp and paper industry and environmental movement are both well organized and represented in environmental policy debates in each of the three countries studied. One would expect the industry to resist effluent regulations that increase production costs, and environmentalists to press for more stringent environmental standards, in all three countries. However, there is reason to anticipate that the industry would have greater influence relative to environmentalists in Canada and Sweden than in the U.S.

The pulp and paper industry is one of the leading manufacturing sectors in Canada, with roughly 100,000 employees constituting over five percent of manufacturing employment nationally (Statistics Canada). At the time of the EPA's dioxin announcement in the late 1980s, there were 156 pulp and paper mills in Canada, including 40 Kraft mills. The industry is even more economically significant in Sweden, employing roughly 40,000 workers at 46 mills (Swedish Forest Industries Federation). Although only 15 of those are bleached Kraft mills, those 15 account for 80% of domestic pulp production. The U.S. pulp and paper industry is the largest producer in the world, with 550 mills accounting for roughly a third of global production (IIED). Half of those mills produce paper only using pulp purchased from other sources. Of the remaining mills, Kraft mills constitute only about a third (86), but they account for over 80% of domestic pulp production (U.S. EPA 1995). However, although the U.S. industry employs roughly 200,000 workers (U.S. EPA 1995), that represents a considerably smaller fraction of U.S. domestic employment than

in the other two countries. Thus, one might expect the industry to exert greater influence in Canada and Sweden than in the U.S.

One other difference between these three domestic industries is worth noting. The Canadian and Swedish pulp and paper industries are both highly export-oriented, with the Canadian industry exporting over 70% of the value of its production and the Swedish industry exporting over 80%. Canadian mills export primarily to the U.S., while Germany is the leading destination for Swedish exports. In contrast, the U.S. has historically been a net importer of pulp and paper products, led by newsprint and pulp imports from Canada. With only 10% of its production exported, the U.S. industry is more insulated from global market forces than its Canadian and Swedish competitors (Norberg-Bohm and Rossi).

Institutions

In recent years, many students of public policy have focused on the influence of political institutions in shaping policy choices (Hall and Taylor). Over time, the emphasis has gradually shifted from questions of the autonomy of the state to the contingent effects of institutions—that is, the ways in which the impacts of institutions are conditional on other variables, not least among them the balance of political interests (Steinmo, Thelen, and Longstreth; Weaver and Rockman). In focusing on the impact of causal beliefs, this article is particularly attentive to the interaction of political institutions with ideas. How might some institutions be more receptive to certain ideas than others?

It is noteworthy that Haas (1992) offers limited recognition of the importance of institutions, in that he anticipates that members of an epistemic community will have greater influence if they are well positioned within state decision-making structures. However, Raustiala argues for broader analysis of the role of institutions, not just in offering access points for particular scientists, but in terms of how receptive different institutional structures are to the ideas and policy prescriptions advanced by epistemic communities. In pursuing this question, a fruitful avenue of research is likely to be the distinctive policy legacies of each country, since they represent the institutionalization of the dominant ideas of the past (Pierson).

EFFLUENT STANDARDS FOR THE PULP AND PAPER INDUSTRY

Canada

The impact in Canada of the U.S. EPA's 1987 dioxin announcement was compounded by several domestic factors, not least of which was a dramatic surge in public attention to the environment similar to that experienced in the U.S. in the late 1980s. Attention to pulp mills in particular was heightened by the leak, also in the fall of 1987, of a federal government study that reported that the majority of Canadian mills failed to

comply with existing federal regulations (Sinclair). A concurrent expansion of the pulp and paper sector in the province of Alberta also occasioned public debate about the risks associated with pulp mills using chlorine bleaching (Harrison 1996b, 146). Finally, attention paid to the pulp mill issue coincided with the passage in 1987 of a new federal environmental statute, the Canadian Environmental Protection Act (CEPA). Dioxins and “effluents from pulp mills using bleaching” were two of the 44 classes of substances on the CEPA Priority Substances List slated for evaluation and, if necessary, regulation (Environment Canada).

The first CEPA assessment to be completed was the assessment of polychlorinated dioxins and the related furans (Government of Canada 1990). In 1990, the federal government concluded that both substances were toxic as defined in the CEPA and proposed regulations requiring that the pulp and paper industry reduce dioxins and furans to nondetectable levels. Those regulations were consistent with a voluntary commitment already offered by members of the Canadian Pulp and Paper Association.

Although the government had indicated its intention to propose an AOX limit of 1.5 kilograms per air-dried metric ton of pulp (kg/ADt) in its discussions with provincial governments (Harrison 1996a), its department of the environment, Environment Canada, subsequently decided in 1991 not to regulate AOX at all. The second CEPA assessment report, released in December 1991, concluded that bleached pulp mill effluents were indeed toxic as defined by the CEPA (Government of Canada 1991). However, in response to emerging findings by federal government scientists that indicated that AOX discharges were not correlated with environmental impacts, the government declined to issue additional regulations concerning AOX. However, the dioxin regulations, which were finalized in 1992, were considered equivalent to an AOX standard of about 2.5 kg/ADt.

Although this article focuses on regulatory decisions by national governments, it is important to note that Canadian provinces have independent authority concerning the environment. Four of the ten provinces—Ontario, Quebec, Alberta, and British Columbia—have chosen to regulate AOX with varying degrees of stringency. The province with the strictest limits, British Columbia, has established a schedule of increasingly demanding AOX standards for the industry, culminating in a requirement of zero discharge of chlorinated compounds by 2003—the most stringent AOX regulation in the world.

Sweden

Until 1999, Swedish pulp and paper mill discharges were regulated under the Environmental Protection Act, at which time that legislation was amalgamated with other environmental laws in a new Swedish Environmental Code. Under the Environmental Protection Act system, in contrast to the North American approach, permit conditions for individual mills

were set on a case-by-case basis via a quasijudicial process. Permits were issued by the national Environmental Franchise Board, which considered proposals from the Swedish EPA, as well as submissions and testimony from industry, environmentalists, and others.

More subtle differences between the approach of the Swedish government and that of North American governments existed well before the chlorinated organics controversy. Since the 1970s, Swedish regulators had emphasized internal process changes to promote pollution prevention, rather than the end-of-pipe treatment approach common in North America. As a result, Swedish Kraft mills pioneered development and installation of oxygen delignification technology as early as the 1970s in order to reduce discharges of conventional pollutants, including color and biochemical oxygen demand (BOD). Although that technology was commonplace in Swedish mills by the late 1980s, few had secondary treatment systems, which were standard at the time in the United States (though less common in Canada). In contrast, oxygen delignification was utilized by only a handful of mills in North America at the time. Conveniently for the Swedish industry, in light of the subsequent emergence of concern about AOX, oxygen delignification also reduces generation of chlorinated compounds.

Regulatory interest in chlorinated discharges from the pulp and paper industry emerged earlier in Sweden than in Canada and the United States. The presence of polychlorinated biphenyls (PCBs) and other persistent chlorinated organics in the Baltic was a prominent issue on the Swedish environmental agenda well before the U.S. EPA's dioxin announcement. In the early 1980s, the Swedish EPA launched a major research project, Environment/Cellulose I, to examine the impact of chlorinated organics from pulp mills on the marine environment. When Environment/Cellulose I researchers reported significant environmental impacts from pulp mills as early as 1985, the Swedish government began to seek limits in mills' permits on chlorinated organic discharges. This occurred just before the U.S. EPA's dioxin announcement, though the latter also had an important impact on consumers and the general public in Scandinavia.

In 1987 the Swedish EPA issued its Action Plan for Marine Pollution, which stated that all mills using chlorine bleaching should have initiated measures to reduce discharges to roughly 2.0 kg/ADt AOX⁴ by 1992 (Lagergren). The plan adopted a long-term goal of total elimination of chlorinated discharges. The EPA's targets were subsequently reinforced by the 1988 Swedish Government Bill on Environmental Policy, which, while nonbinding, offered authoritative policy guidance to the Franchise Board. In response to technological developments, in 1990 the EPA tightened its AOX targets to 1 kg/ADt by 1995 and 0.5 kg/ADt by 2000 for mills pulping softwood, and 0.5 kg/ADt by 1995 and 0.3 kg/ADt by 2000 for mills using hardwood (Simons Consulting Group, Appendix 2, 49).⁵

In practice, permit conditions vary between mills, reflecting technological advances over the last decade as well as case-by-case consideration by

the Franchise Board of environmental impacts and economic achievability. However, the Franchise Board tended to adhere to the EPA's long-term goals in its permitting decisions (Auer 1998b). In any case, since the early 1990s the Swedish industry has significantly outperformed its regulatory limits in response to demand from German consumers for "chlorine-free" paper (Simons Consulting Group). By 1994, all Swedish Kraft mills had installed oxygen delignification, and all had either fully substituted ClO_2 for chlorine gas ("elementally chlorine free," or ECF, bleaching) or, in the case of three mills, eliminated chlorine use completely ("totally chlorine-free," or TCF, bleaching). Average AOX discharges had fallen from 3.5 kg/ADt in 1988 to 0.4 kg/ADt in 1993 (Lagergren). Industry officials interviewed claim to have further reduced AOX discharges to an average of 0.1 kg/ADt by 1995, well below government targets for the year 2000.

Interestingly, the Swedish government never bothered to set dioxin limits in mills' permits, since the industry had resolved the problem on its own. As one industry official explained, "it was just assumed" that the industry would continue to achieve nondetectable discharges of dioxins. In contrast to the Canadian position that AOX is not a meaningful regulatory parameter, the Swedish EPA continues to regulate AOX. Although the government no longer emphasizes the long-term goal of zero AOX to the same degree, it has not withdrawn or relaxed AOX limits in mills' current permits.

The United States

The Clean Water Act regulates U.S. pulp and paper mills' discharges using a two-pronged approach. First, the EPA issues uniform technology-based guidelines for comparable sources, which are then incorporated (typically by state governments) in individual facilities' permits. Standards for toxic pollutants are set to reflect performance of the "best available technology economically achievable" for each sector (Clean Water Act, section 1311). A second, water-quality-based approach allows more stringent conditions to be set for individual facilities if needed to achieve water-quality objectives. Although many state governments pursued the latter approach to control dioxin discharges from U.S. pulp mills, the courts have set many permits aside. The policy community's attention has thus been focused on the revised technology-based standards promised by the EPA.

In July 1988, the EPA agreed, in a settlement with several environmental groups who had sued the agency, that it would consider regulating dioxin discharges from pulp mills and other sources (*Environment Reporter*). In 1992, the EPA merged development of air, water, and sludge regulations for the pulp and paper industry in what thereafter became known as the "cluster rule." In December 1993, the agency proposed regulations for comment (*Federal Register* 1993). An AOX limit of 0.156 kg/ADt was proposed for Kraft mills, which was considered achievable with a "best available technology" of complete substitution of ClO_2 for chlorine gas plus oxygen

delignification and/or extended delignification. The U.S. pulp and paper industry strongly opposed the proposal, arguing that the AOX limits were not economically achievable.

In July 1996, the EPA published what was effectively a new proposal (*Federal Register* 1996). It solicited comments on two options. A new option A predicated on complete substitution of ClO_2 but no oxygen delignification roughly corresponded to a counterproposal that had been offered by the American Forest and Paper Association. The original proposal was relegated to option B.

In November 1997, EPA announced its widely anticipated decision in favor of option A, although the *Federal Register* notice promulgating the new standards was not published until April 1998 (*Federal Register* 1998a). The final rule was considerably less stringent, and thus about \$1 billion less expensive for the industry by the EPA's estimate, than the original proposal. The EPA justified its selection of option A over option B on the basis of a prediction that the costs of installing oxygen delignification technology would result in the failure of one firm. It is noteworthy that the EPA determined that option B was not economically achievable even though one-third of U.S. Kraft mills had already installed oxygen delignification and all Swedish Kraft mills had equivalent technology in place (and 11 of 15 had more advanced technology) as early as 1994 (Radian Corporation).

U.S. mills now face discharge standards for 2,3,7,8 tetrachlorinated dibenzodioxin (the most toxic of the family of related dioxins) and the comparable chlorinated furan, 12 chlorinated phenolics, chloroform, and AOX. Existing Kraft mills discharging directly to the environment face a monthly average AOX limit of 0.623 kg/ADt, while new mills must install oxygen delignification to achieve 0.272 kg/ADt.⁶ A coalition of U.S. environmental and native groups have challenged EPA's decision in the Ninth Circuit Court on the grounds that the standard for best available technology is too lenient.

COMPARISON OF REGULATORY STANDARDS

There has clearly been considerable convergence in both regulatory standards and industry performance. All three jurisdictions have issued new regulations demanding reductions of discharges of chlorinated compounds from pulp mills, and the pulp and paper industry in all three jurisdictions has invested a great deal of money to do just that. However, there remain differences in regulatory approach and standards that have significant economic implications for the industry. Sweden regulated the industry first, in 1990 setting AOX targets of 0.3 to 0.5 kg/ADt to be met by existing mills by the year 2000. The Canadian federal government chose not to regulate AOX at all, though compliance with the dioxin standard requires that mills partially substitute ClO_2 bleaching for chlorine gas, with the effect of reducing AOX discharges to about 2.5 kg/ADt. The

U.S. government acted last, choosing a position between the other two jurisdictions. Although the U.S. standard for existing Kraft mills of 0.6 kg/ADt AOX appears on the surface to be very similar to the Swedish standards, it is significant that the slightly higher AOX standard was deliberately chosen by the U.S. EPA so that it could be met by mills employing only full substitution of ClO_2 for chlorine gas. U.S. mills thus will not have to incur the expense of installing oxygen delignification and extended delignification like their Swedish competitors, a concession worth \$1 billion to the U.S. industry.

In practice, actual industry performance in the three jurisdictions is somewhat closer than suggested by formal regulatory requirements. In response to a combination of European consumer demand and tighter provincial requirements, many Canadian Kraft mills have moved to complete chlorine dioxide substitution and thus achieve lower AOX levels than those required by the national standard. Similarly, a third of U.S. bleached Kraft mills have already installed oxygen delignification, even though it is not required under the cluster rule.⁷ As noted above, Swedish mills' performance has also significantly exceeded regulators' expectations. However, while some mills in each country have gone beyond regulatory requirements, the performance of laggards, who comply with minimum standards if that, continues to diverge significantly. Moreover, the leaders in Sweden have gone much further in reducing chlorinated discharges than have their North American counterparts.

The following sections seek to explain these differences by considering the influence, in turn, of evolving causal knowledge, conflicting interests, and institutional context.

EVOLVING CAUSAL KNOWLEDGE

The 1980s and early 1990s were a period of active and fruitful academic, governmental, and industry research on environmental aspects of the pulp and paper industry, particularly in Canada and Sweden. As Smith has noted, to a large degree the mature and complacent U.S. industry effectively conceded the research lead to these countries. However, U.S. researchers remained active members of the transnational research community that emerged, attending international conferences and keeping abreast of the latest research through personal contacts.

Researchers at the Canadian industry-funded Paprican laboratories determined relatively quickly—by the end of 1988—that production of dioxins and furans could be dramatically reduced through substitution of ClO_2 for chlorine gas (Cl_2) in the bleaching process. Nondetectable levels of dioxins could be achieved with as low as 40% ClO_2 substitution (Thompson and Graham). The North American and Scandinavian industries quickly responded to the combination of threatened regulation and public pressure with a voluntary commitment to reduce dioxin discharges to nondetectable levels. However, by that time environmentalists

had extended the debate to include the several hundred other chlorinated organic compounds released by pulp mills. Dioxins, they argued, were merely the tip of the iceberg.

Competing Environmental Effects Research

In 1982, the Swedish EPA launched Environment/Cellulose I to investigate the ecological impacts of effluents of pulp mills using chlorine bleaching. Government and university researchers collaborated in an innovative effort to examine the ecological impacts of pulp mill effluents in actual receiving environments, in contrast to past studies that tended to emphasize impacts on single species in controlled laboratory environments. The Swedish scientists, who focused on one particular bleached Kraft mill in the Gulf of Bothnia, documented disturbing impacts on fish, including gross deformities and effects on sex characteristics and reproduction, as far as 50 km from the mill. Effects were correlated with concentrations of chlorinated compounds in the effluent as both declined with distance from the mill. Moreover, similar effects were not observed in the vicinity of another mill that did not use chlorine bleaching. The Swedish research team thus tentatively concluded that the observed effects were a result of chlorinated compounds, though they offered caveats that the causal relationship had not been conclusively established (Södergren 1989, 81, 91). Their findings were presented in a series of public meetings, where graphic images of deformed fish had a profound impact.

In 1990, Canadian government researchers at the National Water Research Institute (NWRI) launched their own research program on the environmental impacts of bleached pulp mill effluents in response to domestic controversy surrounding a proposal for a large new Kraft mill in Alberta. They quickly found effects downstream from existing mills analogous to those observed by the Swedes. However, in a significant departure from the Swedish findings, they found that the observed effects were not correlated with AOX levels in either the effluent or receiving environment. The CEPA assessment of effluents from pulp mills using bleaching (Government of Canada 1991), which was published in December 1991, concluded that pulp mill effluents were toxic to the aquatic ecosystem. However, the report (Government of Canada 1991, 38) made a subtle but critical point that "AOX values . . . give no indication of effluent composition nor of its potential toxicity, persistence, or fate." The federal government thus announced that it would not regulate AOX beyond the measures already proposed to require reduction of dioxin and furan discharges to nondetectable levels.

The absence of a correlation between AOX and environmental impacts clearly demonstrated that AOX is a flawed regulatory parameter. That finding alone need not have deflected attention away from chlorinated organic compounds, since the problem could simply have been that the

aggregate test, AOX, fails to distinguish between more and less toxic chlorinated substances. However, between the time the CEPA report was written and the time it was actually released in late 1991, NWRI scientists observed the same sublethal effects in fish downstream from mills that did not use chlorine (Carey, Hodson, Munkittrick, and Servos). The Canadian researchers thus concluded that something other than chlorinated compounds was the problem, and redirected their research program in search of the unknown "compound X." As one government scientist put it, "the basic message is good news; that is, it's not chlorine. The bad news is, it's the wood" (VanNijnatten, Leiss, and Hodson, 18).

The Canadian research findings and the Canadian regulatory decision were a direct challenge to the Environment/Cellulose I studies and to Swedish scientists' and regulators' continued emphasis on chlorinated substances. Canadian researchers argued that the correlation between the concentration of chlorinated substances in the receiving environment and environmental effects observed by their Swedish colleagues was a spurious one (i.e., since other toxic substances in the effluent were also being diluted with distance), which had deflected attention from nonchlorinated compounds in the effluent. In response, an International Conference on the Fate and Effects of Bleached Pulp Mill Effluents was convened in Stockholm, Sweden in late 1991. At the conference, Swedish scientists reported results from their follow-up studies in the Environment/Cellulose II project. They had observed reduced environmental impacts as mills reduced their discharges of chlorinated substances, but significant impacts remained (Förlin, Andresson, Balk, and Larsson). Canadian government scientists presented their findings that comparisons across mills were correlated with neither AOX nor dioxin concentrations (Munkittrick; Williams, Servos, Carey, and Dixon 1992). Questions concerning the toxicity of chlorinated organics and the suitability of AOX as a regulatory parameter were "intensively debated" (Södergren 1992, preface). According to one account, in a straw poll held at the conclusion of the conference, 100 of 110 scientists present at the conference rejected AOX as a basis for regulation (Executive Director).

Subtle differences between the Canadian and Swedish research agendas persisted in the early 1990s in the wake of the Stockholm conference. The summary report of the Environment/Cellulose II project made a point of justifying a continued emphasis on chlorinated organics on the grounds that they are persistent in the environment (Södergren 1993, 94). The report acknowledged the Canadian researchers' observation of the same metabolic effects in the absence of chlorine bleaching, but nonetheless argued that less pronounced effects were observed as mills discharged less chlorinated material (Södergren 1993, 101.) In contrast, Canadian researchers stressed the degree of effluent toxicity remaining even after reductions in AOX discharges, which they believed to be associated with hormone-like substances released from the wood itself.

The Canadian position had gained significant support by the time of the Second International Conference on the Fate and Effects of Pulp Mill Effluents, held in Vancouver in 1994. In acknowledging the significant effects observed even in the absence of chlorinated discharges, the leader of the Swedish Environment/Cellulose I project concluded, "It is likely that environmental concerns will continue to be a decisive factor for the pulp industry but the focus will shift from chlorine to other issues."

Two common themes could be discerned in the overview and research papers. First, there was a high degree of consensus that environmental effects from pulp mills are not correlated with AOX, particularly since comparable effects are observed at mills in the absence of chlorine bleaching (Hodson; Williams, Carey, Burnison, Dixon, and Lee 1996). By then, Swedish researchers had confirmed that conclusion (Axegård, Dahlman, Haglind, Jacobson, Mörck, and Strömberg 1993; Sandström, 454). Second, there was agreement that considerable toxicity is associated with natural constituents of wood. Even the toxicity of bleach plant effluent may result largely from carryover of lignin released during the pulping stage and additional release of lignin during pulping (Lehtinen; Servos). This conclusion has two policy implications. First, there is no guarantee that bleaching processes that use alternatives to chlorine, such as ozone and peroxide, will be better for the environment, since more or less lignin may be released and transformed by alternative bleaching agents (Williams et al. 1996, 387). Second, policy-makers should not focus exclusively on the bleach plant, but should instead pursue measures to encourage the industry to eliminate mill effluents altogether by "closing the loop." The concluding chapter of the proceedings declared with bravado that "[t]he conference made it clear that no more research is needed in the fields of organochlorines such as AOX" (Folke). As another researcher subsequently put it, "the research community has basically lost interest in AOX. They've moved on" to closing the loop (confidential interview).

Engineering Developments

As fisheries biologists were studying the impact of pulp mill effluents, engineers were working in parallel to develop new technologies to reduce mills' reliance on chlorine. The two communities were in close contact, presenting papers at each other's international conferences. However, it is noteworthy that process development was driven not only by emerging research on environmental effects, but also by consumer demand for "chlorine-free" paper products. As noted above, the dioxin issue was resolved relatively quickly through partial substitution of ClO_2 for chlorine gas. In 1989, for the first time, a Swedish mill achieved market quality pulp using 100% ClO_2 substitution. This represented not only a technological advance but also a marketing coup, since pulp bleached without chlorine gas could be marketed as "chlorine-free."

In 1990, another Swedish mill was the first to produce bleached pulp without the use of any chlorinated compounds at all. This led to a distinction between elementally chlorine free (ECF) pulp, which is produced with ClO_2 , and totally chlorine-free (TCF) pulp. Although some industry analysts had predicted in the early 1990s that TCF would win the marketing war, consumers' willingness to pay a premium for TCF pulp subsequently declined in parallel with declining public attention to the environment more generally. While production of ECF pulp increased dramatically, from 4% of global bleached pulp production in 1990 to 62% at the end of the decade, TCF production leveled off at about 6–7% of world production (AET).

It remained to be seen whether scientists and regulators would confirm consumers' apparent satisfaction with ECF pulp. At the Vancouver conference in 1994, conflicting comparisons of the impacts of TCF and ECF effluents were reported, but there was general agreement that any differences were relatively minor (Servos). Although the world's leading producer of TCF pulp, the Swedish firm Södra Cell, insists that TCF is environmentally preferred to ECF, even they acknowledge that the differences are "small" and "difficult to see" (confidential interview).

Pulp and paper engineers' attention has now turned to achieving an "effluent-free" or "minimum impact" mill. Until recently, it was believed that it would be easier to close the loop with TCF bleach processes, which would not have to contend with corrosive chlorinated compounds. However, progress in developing "kidney" technology to remove chlorinated compounds has led some industry researchers to conclude that both TCF and ECF are compatible with a high degree of system closure (Axegård, Carey, Folke, Gleadow, Gullichsen, Pryke, Reeve, Swan, and Uloth 1997).

Consensus and Uncertainty

The foregoing discussion indicates that evolving causal knowledge with respect to pulp mill effluents has been facilitated by the existence of a close-knit transnational research community. But did scientists achieve broader consensus with respect to causal beliefs? The concept of consensus is especially difficult to operationalize for the scientific community, where unanimity is rare and debates are not typically resolved with votes.

As discussed above, the proceedings of the 1994 Vancouver conference and subsequent publications suggest a substantial degree of consensus among government, industry, and academic scientists with respect to the flaws of the AOX parameter and the relative impacts of chlorinated vs. nonchlorinated substances. (While less definitive, the results of the straw poll at the end of the first international conference suggests a high degree of consensus as early as 1991.) It is noteworthy that, in contrast to many other environmental policy debates, the public did not witness the common spectacle of dueling scientists (Jasanoff) in the pulp and paper case.

Although there were certainly important areas of disagreement between the Canadian and Swedish government and academic researchers in the early 1990s, those interviewed tended to refer to each other as “close colleagues” and even “friends.” The degree of consensus achieved is reinforced by the fact that, by the time of the Third International Conference on the Environmental Impacts of Bleached Pulp Mill Effluents in Rotorua, New Zealand in 1997, Swedish and Canadian government and academic researchers were frequent coauthors of research papers.

Another indication of the extent of scientific consensus with respect to the environmental impacts of bleached pulp mill effluents can be found in statements by independent bodies and critics. As discussed below, even though the U.S. EPA chose to regulate AOX, it openly acknowledged that AOX is not correlated with environmental impacts. A major international study of the paper industry by the International Institute for Environment and Development also concluded that “AOX does not reliably predict toxicity” and that “the relevant bioactive agents are most probably nonchlorinated compounds present in natural wood extracts” (Grieg-Gran, Bass, Bishop, Roberts, Robins, Sandbrook, Bazett, Gadhvi, and Suba, xx, 117). Similarly, a task force of U.S. university, environmentalist, and industry partners stated that AOX concentrations “do not provide information on the potential toxicity of the effluent, and therefore are not appropriate to evaluate the potential impacts on the environment” (Paper Task Force). Finally, by 1996, even the Greenpeace scientists who initially were highly critical of the Canadian research were citing those studies without criticism in arguing for the need to eliminate pulp mill effluents altogether (Johnston, Stringer, Santillo, Stephenson, Labounskaia, and McCartney).

However, a high degree of scientific consensus does not mean that there are no remaining areas of uncertainty. In particular, although scientists agree that chlorinated organics, particularly dioxins and furans, are problematic at uncontrolled AOX levels, and that any differences remaining between ECF and TCF mills at low AOX levels are minor, there appears to be no consensus on the precise AOX level at which chlorinated organic compounds cease to be problematic. Canadian researchers (Carey, Halliburton, Munkittrick, and Cook 1997) assert that there is “no justification for AOX reductions beyond reductions resulting from dioxins controls,” which can be achieved at an AOX level of 1.5 kg/ADt or higher. In contrast, Swedish scientists, regulators, and even industry officials interviewed in 1996 continued to defend their original policies to target chlorinated substances, and tended to draw the cutoff below 0.5 kg/ADt AOX. It is in this region of continuing scientific uncertainty that one sees divergence in the policy recommendations of scientists in different jurisdictions. As discussed below, these differences tended to coincide with both personal interests, in defending professional reputations, and national interests, in defending the competitiveness of economically significant industries.

COMPETING INTERESTS

Causal knowledge does not arrive in tablets from on high. It is developed by real people with pride and ambition. In turn, their scientific findings are represented by other actors in policy debates, who strategically select and interpret science in support of their own objectives. This section considers the personal interests of scientists, representation of scientific research by environmentalists and industry, and finally interest group perspectives on the pulp and paper issue unrelated to science.

Personal Interests of Scientists

Social studies of science have long debunked the myth of the independent, objective scientist (e.g., Latour and Woolgar). Interviews with Canadian and Swedish scientists involved in research on the environmental effects of pulp and paper mills reveal that—not surprisingly—they, too, are real human beings who want to be perceived as being right. Thus, the leader of the Swedish research team, Anders Södergren (1996), emphasizes that the opening paragraph in a Canadian paper presented at the 1991 Stockholm conference affirmed the earlier Swedish findings. In turn, Canadian researchers point with pride to the place in the proceedings of the subsequent Vancouver conference where Södergren (1996) conceded that there were still significant effects even after substantial reductions of chlorinated discharges.

The degree to which scientists are personally invested in their scientific findings is undoubtedly reinforced when policy decisions costing the industry hundreds of millions of dollars are predicated on them. Thus, Swedish scientists interviewed defended their conclusions in the Environment/Cellulose I project in light of subsequent research by stressing that they had offered appropriate caveats that the causal link to chlorinated substances had yet to be proven, and that the Swedish EPA had made appropriately precautionary regulatory decisions. A Canadian researcher argued that his Swedish colleagues were more “reluctant to back off” and accept the implications of the NWRI research because billion-dollar investment decisions had been based on their earlier findings. However, as discussed below, Canadian researchers themselves became actively engaged in defending their government’s decisions and the Canadian industry’s reputation.

The personal element of the scientific debates in the early 1990s was also exacerbated by what one NWRI staff member considered “vicious personal attacks” on the integrity of NWRI science and scientists by Greenpeace (confidential interview). Personal pride and ambition thus may lead scientists who are in substantial agreement on the state of the science nonetheless to offer divergent policy advice, especially by emphasizing alternative interpretations within remaining areas of scientific uncertainty.

Environmentalists' Interpretations of the Evolving Science

Environmental groups' objective of protecting the environment is strengthened by scientific studies documenting the nature and scope of environmental impacts. Environmentalists around the world shared news of the Environment/Cellulose I findings and played a key role in disseminating them to governments and the public. Greenpeace's role was critical in all three jurisdictions studied. In response to the emerging Environment/Cellulose I studies in Sweden, Greenpeace decided to launch an international pulp and paper campaign in 1986. The international campaign was subsequently energized by EPA's 1987 dioxin announcement. Greenpeace staff throughout the world maintained close contacts via email and travel. As one Canadian Greenpeace campaigner interviewed put it "working for Greenpeace, I can know 24 hours after something happens in Sweden. The Ministry of Environment doesn't have anyone in Sweden" (confidential interview).

Greenpeace Sweden's staff attended the early public meetings at which Environment/Cellulose I researchers presented their findings. They then used individual mills' licensing hearings as a key forum to present their position. Simultaneously, the leading Swedish environmental group, the Swedish Society for Nature Conservation (Svenska Naturskyddsföreningen SNF), greatly enhanced the impact of the Environment/Cellulose I and EPA dioxin findings on consumers through ecolabeling of products without chlorine bleaching.

Greenpeace staff also played a crucial role in disseminating the Swedish research findings to North America. Greenpeace's American-born pulp and paper campaigner, based in Sweden, summarized the emerging Swedish studies in English in a widely distributed paper coauthored with the international director of the pulp and paper campaign, a German national based in Canada (Rainey and Kroesa). In addition, Greenpeace played a critical role in placing the issue of pulp mill pollution on the North American agenda (Harrison and Hoberg). It is noteworthy that the EPA released its dioxin findings in 1987, several years after the agency first discovered that dioxins were discharged by pulp mills, only after Greenpeace had issued a report on the subject based on leaked EPA documents (Van Strum and Merrell). Similarly, the EPA's announcement had relatively little immediate impact in Canada until Greenpeace held a press conference to announce that dioxins had been detected (by laboratory analyses arranged by Greenpeace Germany) in a sediment sample it had collected near a BC pulp mill.

As noted above, Greenpeace campaigners actively disseminated the results of the Swedish Environment/Cellulose I studies to North America. In contrast, the Canadian NWRI research, while still documenting troubling environmental impacts, was incompatible with environmentalists' emphasis on chlorinated compounds. Greenpeace Canada initially sought to discredit the research in a scathing press release written by a Greenpeace

scientist in the UK (Greenpeace 1993). Greenpeace U.S.'s submission on the proposed cluster rule continued to cite the Environment/Cellulose I and II studies, and simply dismissed the debate over the impacts of chlorinated vs. nonchlorinated compounds as a campaign driven by companies "tied to chlorine-dependent technology," without citing any of the relevant research (Greenpeace 1994, 9–10). However, it is noteworthy that the same UK Greenpeace scientist who was initially critical of NWRI now cites the Canadian research uncritically (Johnston et al.). Greenpeace's interpretation of the significance of the Canadian studies documenting toxicity from nonchlorinated substances from the wood itself still differs from that of the Canadian researchers, however. While both agree that mill closure is the long-term solution, Canadian researchers emphasize the need for primary emphasis on pulping liquors, leaving open the possibility that TCF and ECF bleaching may be equally compatible with mill closure (Williams et al. 1996). In contrast, Greenpeace asserts that TCF is a necessary step en route to mill closure, in effect assimilating causal knowledge to offer a new rationale for its longstanding goal of eliminating chlorine.

Other U.S. environmentalists simply placed less emphasis on environmental impacts research from either Canada or Sweden than had their counterparts in those countries. The "big 10" U.S. environmental groups' formal submission in response to EPA's cluster rule proposals tended to emphasize the availability and affordability of control technology, rather than environmental impacts (Environmental Defense Fund, National Wildlife Federation, Natural Resources Defense Council, and Natural Resources Council of Maine; Natural Resources Defense Council, Environmental Defense Fund, Canadian Institute for Environmental Law and Policy, and National Wildlife Federation).

Interpretation of Science by Industry

The national industry associations in all three countries—the Canadian Pulp and Paper Association, the American Forest Products Association, and the Swedish Forest Industries Federation—were also well versed in the evolving research and used science to craft arguments in support of their positions. It is noteworthy that the industry in all three countries had its own research laboratories: Paprican in Canada, the National Council for Air and Stream Improvement in the U.S., and the Swedish Pulp and Paper Research Institute. Industry researchers were active in the same networks as the government and academic researchers, presenting their research at the same conferences and, in some cases, engaging in joint research projects.⁸

However, there were important differences between the positions of the Swedish and North American industries. Although the Swedish pulp and paper industry initially sought to discredit the Environment/Cellulose I studies and opposed introduction of AOX limits in their permits, by the late 1980s the industry had established a competitive advantage in European

markets based on its ability to produce “chlorine-free” paper. Swedish companies thus did not embrace the Canadian research findings as an opportunity to argue that chlorinated compounds were unproblematic, as their North American counterparts did. An industry association official interviewed for this article commented, “In 1990 we wrote a paper with Paprican saying 1.5 AOX was OK. But now we think it’s justified to go further, to about 0.2 or 0.3.” When pressed for a rationale, the official offered only that “we keep it because it’s EPA’s idea.”

When the chlorinated organics issue emerged in 1987, North American mills, which with few exceptions had not installed oxygen delignification, had much higher AOX levels than their Swedish competitors (as high as 10 kg/ADt) and thus faced much higher costs to reduce their AOX discharges. Moreover, with the exception of the few mills selling primarily to European customers, Canadian and U.S. mills did not face the same degree of consumer pressure to reduce their chlorinated discharges. Not surprisingly, the Canadian and American industry associations opposed stringent AOX regulations. The Canadian and U.S. industry positions on research findings were thus the reverse image of those of North American environmentalists.

The industry initially cited a report by an “expert panel” hired by Proctor and Gamble, which argued that the effects observed by the Environment/Cellulose I study would not be found in North America (Mehrle, Dickson, Hartung, Huggett, McLeay, Oikari, and Sprague). Although Canadian government scientists did subsequently document comparable environmental impacts in North America, the NWRI studies nonetheless had strategic value for the industry in reinforcing its opposition to AOX regulation. The U.S. industry thus relied heavily on the NWRI findings in opposing oxygen delignification under EPA’s option B.⁹ A key player in debates about science was the Alliance for Environmental Technology (AET), a coalition of pulp producers and chemical companies producing sodium chlorate (which is used by mills to generate ClO_2). The AET made especially effective use of the Internet to disseminate supporting scientific reviews it had commissioned attesting to the environmental benefits of ECF bleaching (e.g., Axegård et al. 1997; Solomon, Bergman, Huggett, Mackay, and McKague).

The competing interpretations of the environmental effects research offered by environmental and industry groups resulted in politicization not only of the science, but also of the scientists themselves. As the political significance of the NWRI findings became apparent, the project director in particular was drawn out of the lab and into very public debates. Convinced that there was no environmental basis for AOX regulations, the federal government sought to protect the industry not only from foreign consumers but also from what it saw as misguided and unnecessarily burdensome AOX regulation by Canadian provincial governments. The government sought to buttress the credibility of its regulatory position by relying heavily on research scientists as spokespersons. It was thus the director of the NWRI research team, John Carey, rather than the federal

Environment Minister, who responded to letters written to the Minister questioning the government's position (Van Nijnatten, Leiss, and Hodson). Carey was sent across Canada to brief provincial governments on NWRI's research. To the consternation of both environmentalists and the Ontario government, Carey also presented his work at the invitation of the Ontario Forest Industry Association at a meeting at which the industry lobbied against the provincial government's proposed zero AOX standard.

The Canadian industry was threatened not only by aggressive provincial regulation but also by European consumers' demand for chlorine-free paper. Canadian trade missions overseas thus used the NWRI research to defend the Canadian industry's reputation. At the request of the Canadian Pulp and Paper Association, Carey was also sent to Europe to present NWRI's research.

Beyond Science

As the forgoing suggests, there was much more at stake than interpreting data correctly. It is thus not surprising that the U.S. and Canadian industries also offered arguments against AOX regulation that had little or nothing to do with science. That is, they offered the traditional, and politically powerful, argument that the costs of compliance with stringent environmental regulations would hinder domestic competitiveness and sacrifice jobs. In response to EPA's 1993 proposal, the American Forest Products Association commissioned a study of economic impacts which predicted that the proposed regulation would result in 33 mill closures and a loss of 21,500 jobs (Everett).

The U.S. industry was particularly effective in mobilizing its employees in opposition to the proposed rule. The United Paperworkers' International Union (UPIU) and the Association of Western Pulp and Paper Workers (AWPPW), which together represent over 300,000 members, formed the Pulp and Paperworkers' Resource Council to oppose environmental restrictions on logging and pulp mill operations. The Council organized effective letter-writing campaigns to the EPA, the White House, and members of Congress. The EPA received more than 2,700 comments from workers and residents of pulp mill communities.¹⁰ Similar letters to members of Congress generated hundreds of letters from individual members to the EPA. The industry calculated that congressional letters might carry greater weight in light of the Small Business Regulatory Enforcement Fairness Act, which authorized a congressional veto of EPA regulations within 30 days.¹¹ Although environmental groups also generated letters with their own "Action Alerts," they had greater difficulty mobilizing concern about distant rural mills among a largely urban membership.

INSTITUTIONAL CONTEXT

The forgoing discussion reveals how causal knowledge interacted with interest group politics and the self-interest of scientists to yield different

policies in each country. This section considers how the legacy of past decisions directed Canadian, American, and Swedish policy-makers to subtly different paths.

Canada

Environment Canada regulates water pollution under two main statutes, the Fisheries Act and the Canadian Environmental Protection Act (CEPA). Both focus on environmental impacts. Under the Fisheries Act, the federal government must be able to document harm to fish to justify regulations predicated on its constitutional authority concerning fisheries. CEPA's basis on the federal government's criminal law power is considerably broader, but the statute's drafters still sought to justify federal action using a definition of toxicity that emphasizes harm to the environment or human health in practice. While the CEPA definition still gives the government considerable discretion, particularly since a finding of toxicity only requires that a substance "may" have adverse impacts on the environment or human health at levels at which it is present, the language of the statute nonetheless framed discussion in a way that gave greater weight to NWRI's findings questioning the environmental relevance of AOX.

Sweden

Two institutional factors were relevant in the Swedish case: the Swedish EPA's historical approach to the pulp and paper industry and the case-by-case nature of Swedish regulation. First, as noted above, the Swedish EPA historically placed greater emphasis on pollution prevention and internal process controls than did its North American counterparts. The demand for precautionary reductions in AOX was thus an extension of Sweden's regulatory trajectory (Auer 1998b). It was easier for Swedish regulators to focus on chlorinated discharges in the 1980s, since Swedish mills had already invested in oxygen delignification (albeit for reasons unrelated to chlorinated discharges) and thus had lower AOX levels to start with. In contrast, North American mills that had invested capital resources in end-of-pipe treatment facilities were at a competitive disadvantage. The legacy of past decisions also helps to explain why the Swedish government did not relax its expectations concerning AOX in response to emerging scientific evidence. Once the Swedish mills had invested in process changes to further reduce their chlorinated discharges, the industry had little to gain from weaker AOX standards. Indeed, a relaxation of the Swedish government's position on AOX might have hurt the Swedish industry's "chlorine-free" reputation in European markets.

Sweden's case-by-case approach to permitting also arguably facilitated the Swedish government's tighter AOX standards. Rather than setting a uniform standard that would apply simultaneously to all mills (as Canadian and U.S. regulators did), the Swedish EPA could gradually raise its

expectations with each successive permitting hearing. This incremental strategy fortuitously coincided with a period of rapid technological change in the industry in the late 1980s, when ten of fifteen Kraft mills' permits came up for renewal (Auer 1998b).

United States

In contrast to the emphasis placed by Canadian environmental statutes on environmental impacts, the technology-based approach of the U.S. Clean Water Act invited the EPA to downplay environmental effects research and focus instead on the availability of various control technologies. The EPA openly conceded that "AOX concentrations . . . do not provide information on the potential toxicity of the effluent" and that the "EPA . . . is not today asserting a cause-and-effect relationship between AOX and environmental impacts" (U.S. EPA 1998a, 14). The agency justified its decision to regulate AOX by arguing that it did not have to demonstrate a connection to environmental harm in issuing technology-based regulations under the terms of the Clean Water Act. The EPA's carefully crafted justification for AOX regulation did not engage environmental effects research so much as it sidestepped it.

While the forgoing argument justifies the EPA's authority to regulate AOX, it begs the question of why it would do so. There the agency offered several arguments (U.S. EPA 1998a). First, it argued that the AOX parameter provides an indication not of environmental impacts, but of whether a mill had installed the desired control technology. That rationale still begs the question of why that technology is desirable in the first place. Second, it argued that AOX offers an inexpensive test that can be used as a surrogate for testing of specific regulated compounds, including dioxin, thus offering annual savings of up to \$1 million for a single mill. However, again, if there is a correlation between AOX and concentration of substances believed to be toxic, one would have expected to see a correlation between AOX and environmental impacts. Third, the EPA justified AOX regulation as a precautionary measure, on the grounds that the more chlorine present, the greater the likelihood that dioxins are present at nondetectable levels. Again, however, it did not attempt to square this argument with the absence of a correlation with environmental effects. Ultimately, the agency simply offered faith in arguing that "although a statistically significant relationship between AOX and adverse environmental effects has not been established, EPA believes that reduction of AOX (a valid measure of the total chlorinated organic matter) will result in water quality benefits" (*Federal Register* 1998b).

Whether scientifically defensible or not, these arguments help to explain the grudging acceptance of AOX regulation by the U.S. industry. The political battle in the U.S. was about technology rather than environmental impacts, and in particular, whether the industry would be required to install oxygen delignification technology. Victory or defeat on the

technology question would be reflected in the AOX limit chosen. (As noted above, U.S. environmental groups also took their lead from the statute in focusing their comments primarily on the availability and affordability of technology to reduce chlorinated discharges.) Thus, the industry responded to the EPA's 1993 proposal with an AOX counterproposal. This concession of the inevitability of AOX regulation tended to further displace arguments about the environmental validity of the AOX test.

CONCLUSIONS

This article has documented important differences between the policies of Sweden, Canada, and the U.S. regarding chlorinated organic discharges from the pulp and paper industry. The Swedish government regulated first, demanding AOX discharges of less than 0.5 kg/ADt from existing Kraft mills by the year 2000. Thereafter, the Canadian federal government decided not to regulate AOX beyond the level necessary to reduce dioxins to nondetectable levels, approximately 2.5 kg/ADt. The U.S. EPA finally issued its long-awaited "cluster rule" in 1998, setting an intermediate AOX standard of 0.6 kg/ADt for existing Kraft mills. As discussed above, the seemingly small differences between these AOX standards had significant financial implications for the industry in the three countries.

The case studies presented here reveal significant impacts of science and scientists on public policy-making. However, ideas in the form of causal beliefs provide only one piece of a complex puzzle. As Hecló (375) has stated, "understanding is best advanced, not by giving priority to one or another type of variable, but by concentration on the interrelationships of ideas, interests, and institutions. The 'action,' so to speak, is at the intersection."

Ideas

Evolving causal beliefs played a pivotal role at several points in the forgoing history. Most obviously, the combination of EPA's detection of dioxins downstream from pulp mills and Swedish researchers' documentation of ecosystem impacts from pulp mills led to policy change and significant investments by the industry in all three countries. It is inconceivable that these changes would have occurred in the absence of those scientific findings. The Swedish case offers another example of the impact of causal knowledge, when the government demanded strict measures to control AOX in response to the Environment/Cellulose I research, despite opposition from the economically powerful Swedish pulp and paper industry. And the Canadian federal government abruptly withdrew its proposal to set an AOX standard of 1.5 kg/ADt in response to research findings by its own scientists.

It is noteworthy, however, that in each of these cases the impact of science on policy reinforced prevailing interests and the domestic policy

trajectory. The “road map” offered by science (Goldstein and Keohane) apparently was most compelling when it offered policy-makers a route to achieve predetermined political goals through familiar institutional terrain. With respect to dioxin, public alarm in response to EPA’s dioxin announcement was sufficiently strong that the industry did not even wait for regulations to voluntarily change its processes. In the Swedish case, the decision to pursue significant AOX reductions was consistent with the trajectory of past policy decisions. Moreover, although the government’s decision to regulate AOX was initially opposed by the pulp and paper industry, it received strong public support during a period of unprecedented public concern for the environment in the late 1980s. (Although a similar wave of public concern emerged at the same time in Canada and the U.S., it had subsided by the time those countries finalized their standards in the 1990s.) Finally, the Canadian government’s embrace of its own scientists’ AOX research was consistent with the interests of the politically powerful Canadian pulp and paper industry.

In contrast, the Swedish case also provides an example of the lack of impact of causal knowledge when it was not consistent with dominant interests. It is noteworthy that the Swedish EPA did not subsequently change its regulatory course in response to the consensus view that chlorinated compounds were not the primary cause of environmental impacts at low AOX levels. By that time, prevailing causal beliefs were no longer consistent with the interests of Swedish scientists, environmentalists, or even industry. While conceding that the new findings represented “good science,” Swedish scientists had rationalized the policy decisions predicated on their earlier work and thus did not advocate policy change. Environmentalists remained preoccupied with chlorinated organics. And, by the early 1990s, the Swedish industry had surpassed regulators’ expectations in response to demand from chlorine-conscious European consumers, and was keen to buttress its reputation with strong national environmental standards.

Interests

It was anticipated at the outset that the pulp and paper industry would exert greater influence in Canada and Sweden than in the U.S. by virtue of its greater economic significance in those countries. Although that hypothesis did in fact prevail—the U.S. industry was forced to compromise, while both the Canadian and Swedish industries ultimately got what they wanted—that occurred with an unexpected twist. In response to pressures from different markets, the export-oriented industries in Canada and Sweden sought very different policies from the state. With limited demand for chlorine-free products from North American markets, the Canadian industry maintained its historical opposition to stringent regulation. In contrast, in response to European (especially German)

consumer demand, the Swedish industry eventually supported and even surpassed regulators' demands.

However, the timing of the outcome in both cases reflected the interaction of interests with ideas. The Canadian government had initially proposed AOX regulations in opposition to the industry's position, and changed course only when emerging research offered a credible justification for reversal of its position. In Sweden, the industry's capitulation occurred only after environmentalists publicized the Swedish and U.S. research and thus mobilized consumer demand at home and abroad.

Institutions

Various authors have examined the interactive effects of institutions and political interests (e.g., Weaver and Rockman). Here, the focus is on the interaction of institutions with ideas. In each of the three cases, past policy choices, reflected both in legislation and regulatory history, framed the policy question in subtly different ways, and in so doing opened the door for differential impacts of scientific research. Thus, the emphasis of the Canadian environmental statutes on demonstrating environmental impacts magnified the impact of the Canadian AOX research. In Sweden, the historical emphasis on pollution prevention technologies made the shift to lower AOX levels in response to the Environment/Cellulose I findings cheaper for the industry and thus politically easier for regulators. Finally, the precautionary, technology-based approach of the U.S. Clean Water Act effectively rendered the emerging environmental effects research irrelevant. Rather, the U.S. statute framed the debate in terms of the availability and affordability of different control technologies, thus inviting a political compromise between the interests of industry and environmentalists. The U.S. case thus offers a cautionary reminder that causal beliefs are by no means central to all policy choices, which can be shaped by political institutions and the clash of organized interests quite independently of particular ideas.

Epistemic Communities Revisited

The forgoing analysis, which finds policy divergence despite substantial agreement within a transnational scientific community, conflicts with the emphasis of the epistemic community literature on the role of scientists in promoting policy convergence. The evidence presented here is complemented by Matthew Auer's (1998a) analysis of negotiations between Sweden and Finland concerning pulp mill effluents, in which he argues that shared expertise did not overcome differences in historical approach and national interests. Can the epistemic community framework account for this lack of convergence?

Haas (1992) defines an epistemic community as a knowledge-based community with shared worldviews, values, causal knowledge, and policy prescriptions. Scientists conducting research on environmental effects

of pulp mill effluents were personally engaged as members of an active transnational community, presenting their work at the same international conferences, regularly communicating between conferences, and eventually collaborating on joint research projects. Although this article does not examine their values and worldviews in detail, it is arguable that these scientists were as committed to environmental protection and to the scientific method as was the community of scientists in Haas's (1989) Med Plan case. Moreover, they achieved substantial consensus on the relative significance of chlorinated versus nonchlorinated substances in mill effluents, as reflected in the fact that even former critics within the environmental community have embraced once-controversial findings. More significant, however, are remaining areas of scientific uncertainty, particularly with respect to the precise point at which AOX ceases to have environmental relevance, and a resulting lack of consensus with respect to policy prescriptions. In light of the absence of consensus on policy among scientists, one can conclude that the research community examined here simply does not constitute an epistemic community as defined by Haas.

While salvaging the epistemic community framework in this case, that semantic distinction simultaneously points to its limitations. The restrictive definition of an epistemic community begs two critical questions: Under what conditions do transnational scientific communities achieve consensus on policy recommendations? And under what conditions do scientists' policy recommendations prevail?

With respect to the first question, consensus with respect to both science and policy plays a critical role in the epistemic community framework, but the concept of consensus is poorly conceptualized. Haas (1992, 18) merely asserts that epistemic communities have a "consensual knowledge base," even while acknowledging (1989, 386) that in the Med Plan case, general language facilitated policy consensus by "blurring the distinctions between otherwise incompatible views" among scientists. The latter is hardly surprising, since unanimity among scientists is the exception to the rule. After all, it is the desire to explore outstanding questions that motivates scientific research. Yet the critical question of under what conditions scientists can reconcile their outstanding disagreements with agreement on policy prescriptions remains.

The case studies presented here suggest that the emergence of *policy* consensus depends on the scope and implications of scientific uncertainty. Clearly, the greater the uncertainty, the more opportunity there is for divergent policy advice. However, the economic and political implications of unresolved scientific issues are also critical. While environmental scientists in the pulp and paper case do not all agree on a precise cutoff at which AOX becomes irrelevant, the outcome could have been very different had the scientific debate focused in the range of 4 to 5 kg/ADt, rather than 0.5 to 1.5 kg/ADt, since the differential control costs for the industry are negligible in the former case but run to billions of dollars in the latter. The greater the range of unresolved scientific issues, the greater the

potential influence of competing interests and institutional factors on scientists' policy positions (Harrison 1991; Hoberg). Conversely, the more competing interests have at stake, the greater are their incentives to exploit even a narrow range of scientific uncertainty. Thus, just as policy-makers' uncertainty is the source of scientists' influence on policy decisions (Haas 1992), so too is scientific uncertainty the source of political and institutional influence on experts' policy advice.

The forgoing is consistent with Jasanoff's argument that the epistemic community literature understates the socially embedded nature of scientific knowledge. Haas (1992, 10, 19) offers an idealized image of objective scientists driven only by causal beliefs and principled values. Yet, as Jasanoff (247) argues and the case studies presented here demonstrate, "[s]cientific knowledge needs a sustaining and supporting social order—in short, a living, vibrant community—in order to reassure skeptical publics and serve as a compelling basis for policy decisions."

With respect to the question of the conditions under which scientific communities wield influence, there is a need to unpack the epistemic community framework's concepts of consensus and influence. Haas asserts that consensus on policy prescriptions is a necessary precondition for epistemic community influence via international cooperation.¹² However, in the context of comparative analysis, where domestic policies rather than international agreements are the dependent variables, it is evident that scientists and their causal beliefs can have a significant influence on public policy even in the absence of consensus on policy prescriptions. Indeed, such influence, in combination with different constellations of societal interests and political institutions, may well yield policy divergence. In this study, environmental researchers in both Sweden and Canada had a significant influence on their countries' regulatory standards for the pulp and paper industry, yet that contributed to the greatest divergence among the three countries studied.

As Hall (362) has argued, "if we want to accord ideas an explanatory role in analyses of policy-making, we need to know much more about the conditions that lend force to one set of ideas rather than another in a particular historical setting." In the case studies presented here, the influence of science was mediated by personal pride, policy legacies, and interest group competition. The "roadmap" of ideas was most likely to be followed when it led through familiar institutional terrain to a destination consistent with traditional political objectives. If we are to understand the impact of causal knowledge, we will thus require a richer understanding of the scientific community and its relationship both to policy-makers and to the larger society.

NOTES

1. Research for this paper was supported by the Social Sciences and Humanities Research Council of Canada, the Fulbright Foundation, and Resources

for the Future. The author also gratefully acknowledges the contribution of the individuals who volunteered their time for confidential interviews, the research assistance of Paola Baca and William Amos, and helpful feedback from William Leiss, Neil Gunningham, George Hoberg, Matthew Auer, and the anonymous reviewers for this journal.

2. In the three countries studied in this paper, Canada and the U.S. set standards for dioxin discharges at roughly the limit of detection in 1992 and 1998, respectively; Sweden never did regulate dioxin releases.
3. 35 interviews were conducted in Canada, 11 in the U.S., and 11 in Sweden.
4. The policy actually required reductions to 1.5 kg/t TOCl, which is an alternative measure of chlorinated compounds that has since been superseded by the AOX test. The ratio between the AOX and TOCl tests varies from mill to mill, but AOX levels are typically 30% higher.
5. It is noteworthy that Swedish AOX limits are based on annual average performance, in contrast to the monthly average requirements typically imposed in North America. The implication is that the stringency of Swedish AOX regulation is sometimes overstated, since the same numerical limits are easier to meet based on an annual average than on a monthly average. The relevant conversion factor varies from mill to mill, depending on the variability of operations, but Simons Consulting Group (57) notes that at one mill examined, an annual average AOX of 1.25 kg/ADt corresponded to a monthly average of 1.5 kg/ADt, a figure 20% higher.
6. EPA offers no explanation for the unusual practice of regulating to three significant figures. Standards for mills discharging to municipal sewers are set higher, at 1.4 kg/ADt for existing mills and 0.814 kg/ADt for new mills, since EPA assumes that publicly owned treatment works will reduce their AOX discharges to levels comparable to those set for mills discharging directly to the environment. Bleached sulphite mills, which can more readily rely on alternative bleaching agents, are required to eliminate all use of chlorine. The regulation also includes a voluntary program to promote development and adoption of more advanced technologies in exchange for regulatory incentives, including additional time to achieve compliance and reduced monitoring requirements.
7. U.S. EPA (1995) reported that 27 of 86 bleached Kraft mills in the U.S. had installed oxygen or ozone bleaching by 1993. There are several possible explanations for this. Mills may have been responding to consumer demand, state regulatory requirements concerning dioxin releases, or citizen lawsuits (on the impact of citizen litigation in prompting the one conversion of a U.S. mill to TCF bleaching, see Smith [130]), or they may have taken a chance at the time of capital expansions in the early 1990s based on the assumption (incorrect as it turned out) that EPA would require oxygen delignification.
8. Note also that the Canadian Pulp and Paper Association joins two universities and the Canadian federal government in jointly sponsoring the Paprican laboratories.
9. In commenting on the proposed cluster rule, the Chlorine Institute, for instance, simply submitted a summary by Canadian government researchers of NWRI research (U.S. EPA n.d.). See also U.S. EPA (1998b) for a summary of comments received.
10. Letter from Boyd Young, UPIU, and Lenard Roberts, AWPPW, to U.S. President Bill Clinton, February 12, 1997. Copy on file with author. A similar strategy was used with considerable success in Northern Ontario, where the mayors of pulp mill towns and the unions formed the Alliance for Responsible AOX Regulation to oppose Ontario's proposal to require zero AOX.

11. Environmentalists and industry officials offer disparate estimates of the number of letters EPA received from members of Congress. However, the EPA cluster rule docket contains at least three boxes of congressional letters. There were 120 letters in the one box I opened. While industry officials claim that they had enough votes for a veto, they did not believe they could have mustered the two-thirds of members necessary to override an anticipated presidential veto.
12. It is noteworthy that the standard of international cooperation typically adopted in the epistemic community literature, based in the subfield of international relations, is weaker than the standard of policy convergence typically adopted by students of comparative public policy. For instance, Haas's (1989, 388) influential study of the Med Plan seeks to explain international agreement with respect to a broad policy direction, even though "[d]ifferent countries specif[ied] different emission standards, ban[ned] different substances, and point[ed] to different indicators for cleanliness."

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