Strategic Transmission of Information and the Framing of Environmental Regulation

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The paper is organized as follows. Section 1 presents a case study concerning diffuse zinc pollution in the environment. Section 2 generalizes the case study with a qualitative framework for analysis. Section 3 presents a formal game theoretical model of regulatory dispute. Section 4 concludes the paper with discussion and recommendations for the productive use of scientific research in resolving policy dispute. At stake in this paper is the role of research in clarifying and resolving public policy dispute. The case discussed suggests that research plays multiple roles in public policy. It serves an informative role, but it also serves a persuasive, signalling and strategic role in policy disputes as well.

1 Case Study: Zinc Emissions in the Environment

1.1 The Background

In the 1970s and 1980s, environmental policy aimed at reducing the pollution of Dutch waterways by focusing on large polluters (Klijn et al. 2000, van Bueren et al. 2003, Koppenjan and Klijn 2004). While this policy proved effective, water managers noticed that the maximum values of polluting substances were frequently exceeded in a variety of places. Researchers and policy makers attributed this to diffuse sources: emissions caused by use of these products spread over an area. In the 1989 National Environmental Policy Plan, the Ministry of Housing, Spatial Planning and Environment (VROM) presented a list of prioritized substances that deserved special attention since they could be found in high concentrations in the water. One of these elements was zinc. It was decided that a research report would be prepared by RIVM, a scientific institution affiliated with the ministry. This report would provide the scientific foundation for policy and define the maximum allowable values and desired values for zinc.

1.2 The Claim

The zinc report, published in 1992, provided technical information about the danger to the environment and health resulting from large concentrations of zinc. There was simply too much zinc in the water and the waterbeds: some 85 percent of the biological species were safe, but a protection rate of 95 percent was desired. Besides agriculture, the most significant source of zinc emission is the corrosion of zinc and zinc products used in construction. This source was estimated at 4,125 tons of zinc for 1989 alone. While the extent to which this source of zinc contributed to pollution was not quite clear, norms had been drafted prior to the research report. Within RIVM, an extrapolation method was developed using eco-toxicity data, and this method was applied to all important metals. Based on this method, the Ministry formulated maximum and desired values for inland waters, including those for zinc, in its 1991 Memo ”Environmental Quality Targets for Ground and Water.” In 1993 the Institute for Experimental Housing (IEH) - a private institute with public funding - distributed its ”Guidelines for Sustainable Building” to municipalities across the country. These guidelines advised architects, construction companies and municipalities to avoid the use of zinc in view of the negative environmental effects.

1.3 The Defense

The procedure for drafting research reports allows private industry and environmental interests groups to write an Addendum. Finally, the Health Council, an authoritative advisory body of the government, will provide the cabinet with a recommendation concerning the research report and the addenda. In 1994, industry requested Van Tilborg Business Consultancy, Inc. to draft an Addendum. Published in 1995, it presented an alternative model for determining norms called the Deficiency-Toxicity/Optimal Concentration Area for Essential Elements (DT/OCEE model). Unlike the RIVM model (known as the Aldenberg-Slob method), this model considered the concentration of zinc naturally present in the environment as well as the adaptive ability of flora and fauna to changing circumstances. Van Tilborg also pointed to shortcomings in the RIVM research report: the number of measurements was too limited and included species such as the American sponge that does not appear in the Netherlands. Furthermore, it was argued that contribution of corroded construction materials to the zinc concentration in inland waterways was negligible. On the basis of this Addendum, industry filed a claim against the IEH and demanded that the qualification of ”avoiding” be deleted from IEH’s guidelines. The IEH had the Addendum studied by TNO, which - on the basis of a literature review - concluded that the Addendum lacked a solid eco-toxological foundation. As a result, the court rejected the industry’s demand and suggested that Van Tilborg could not be regarded as an independent party. Next, the IEH worked to improve the factual basis of the guidelines. To do so it used Life Cycle Analysis (LCA) - a method for determining the environmental effects of materials - of rain gutters. The LCA on gutters was conducted by Tauw Inc. (an engineering company) commissioned by the RIZA, a research institute of the Ministry of Fraffic and Water Management (Tauw 1). The zinc industry claimed that the study was insufficient because it did not consider the re-use of materials. The zinc industry commissioned Tauw to conduct another investigation that would take recycling into account (Tauw 2). In 1996, as a sequel to the IEH guidelines, the first ”National Package for Sustainable Construction” - developed by organizations in the building and housing sector - was published. It provided, among other things, recommendations about which materials to use based on existing reports (such as Tauw 1) and existing government policy. The advice was, again, to avoid the use of zinc for gutters, drainpipes and roofs.

1.4 Response and Counter Response

In early 1996, RIVM and the RIZA published a report entitled ”A Further Look at Zinc,” which reviewed the most important data in view of criticism from the zinc industry. This report provided no reason to reject or alter the Aldenberg-Slob method or change the norms in the research report. RIVM believed that the industry critique had been refuted. The zinc industry responded with their own report entitled ”A Further Look at Zinc Refuted,” in which they defended the DT/OCEE model.

1.5 The Judgment

Parties eagerly awaited the advice of the Health Council, in the belief that it would provide a conclusion to the discussion. The advice was published in 1998. The Council questioned the existing methods of determining zinc concentrations. None sufficiently considered the fact that zinc is an essential element in nature and occurs in varying concentrations. The development of a new method would take a substantial amount of time. Meanwhile, the Council advised a pragmatic approach that would take high and low concentrations for ecosystems in water and ground into account, and to differentiate measures by area depending upon background concentrations. The Council also stated that cabinet policy for reducing emissions should continue.

1.6 Interpretations of the Judgment

In view of the recommendation, the cabinet concluded that measures for limiting diffuse emissions of zinc and other metals were legitimate and that it could debate this with industry. At the same time, industry concluded that the council agreed with their critique of the method used for arriving at norms and anticipated their own involvement in the further development of the new method. The consultation that followed was difficult. Government held to the water quality norms and emission estimates while industry disputed them. In the meantime, the discussion about eco-toxicity of zinc moved to the European level. The Netherlands served as rapporteur in a risk analysis for the EU. In this procedure, data are collected and tested on the basis of peer reviews. Then the results are discussed between the member states and may result in policy measures. The Ministry of Housing, Spatial Planning and Environment contracted RIVM to fulfill this rapporteur's role and RIVM thus got the lead in the analysis. The Aldenberg-Slob method was initially used to determine the eco-toxicity of xinc, and the RIZA method was used to determine the origin of zinc emissions. This generated criticisms from industry. External experts updated the data in the eco-toxicity database and evaluated these on the basis of criteria developed between the parties involved. However, industry claimed that in the final report to the EU at the end of 1999, the ”old” criteria from RIVM reports were used.

1.7 Is Uncertainty Reduced?

In early 1999, the debate seemed to be getting somewhere. First, the zinc industry indicated that they were thinking about product innovations. Developers worked on coatings for gutters, roofs and facades. Zinc companies developed a program for the use of duplex systems for controlling corrosion, the development of a compound with decreased corrosion and layer thickness optimization. The zinc industry sought a governmental guarantee that these products would be given a chance even though they were more expensive than the existing products. Furthermore, they wanted national government to ask local and provincial governments to limit their policy of discouraging the use of zinc in construction projects. Government, however, did not want to provide these guarantees. In the debate on the volume of zinc emissions from building materials, parties hoped to overcome their differences by means of ”fact sheets” that provided an overview of the points of agreements. While the fact sheets were incomplete, they did serve to bring parties closer together. Thus, the ministries because convinced that more research into the corrosion speed of zinc was necessary. The RIZA and the zinc industry together requested TNO to investigate this. A much lower emission of zinc corrosion emerged from this research than in the previous governmental reports. Also, TNO concluded that the total zinc emission could no longer be explained from the known sources and its estimated size. This was because of the reliability interval of the estimates and the presence of alternative sources of zinc (for instance, zinc emissions from plant leaves and trees). Furthermore, the parties agreed that it was not the corrosion speed, but the discharge speed that was an important parameter for estimating zinc emissions in the environment.

2 Games and Government Regulation

The case reveals an instance where industry is presumed guilty in the absence of conclusive evidence of responsibility. Complex societal issues rarely afford a certainty about responsibility, yet government actors are still expected to take regulatory action. The next section now examines the costs associated with regulation from a governmental perspective. The government's strategy for regulation or no regulation is viewed in light of societal costs. Having committed to a regulatory strategy, the value of new information requires a very high standard of proof. The government actor will not easily reverse its decision without extensive proof.

2.1 Regulation and the Value of Information

Figure 1 shows the government costs associated with the game. There is a cost to society for a failure to regulate. These costs start at zero, and the expected costs rises proportionally with a belief in industry responsibility. There is also a cost to industry for unnecessary regulation. These are highest when the belief of industry guilt is zero. These expected costs diminish as belief in industry responsibility rises: the government is more willing for the responsible industry actor to bear the costs of regulation. The two cost curves intersect at an intermediate value of belief.

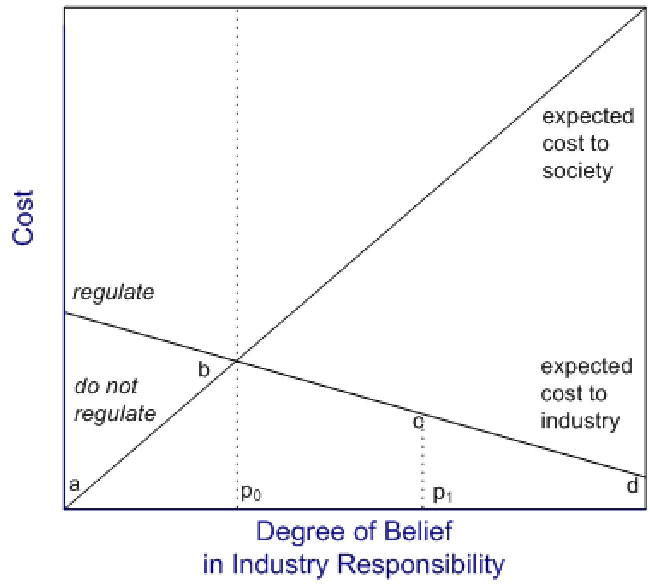

Figure 1: The Costs of Regulation

Prior knowledge (even if incomplete) enables government to choose a least cost regulatory strategy. A convex hull of strategies shows how the government may switch strategies from regulation to no regulation as evidence of responsibility shifts. When belief in responsibility is low, the optimum strategy is not to regulate (line segment a-b). When the belief in responsibility rises beyond a certain value p_0, industry regulation is the best choice. This is represented by the line segment from b to d. Any given level of belief (for instance p_1) corresponds to a given minimum cost strategy (for instance c). A government which places a higher value on societal costs rather than industry costs will have a comparatively larger range of beliefs under which industry regulation is the preferred strategy.

This regulatory cost framework has implications for the willingness of the government to entertain new evidence regarding the responsibility of industry for pollution (figure 3).

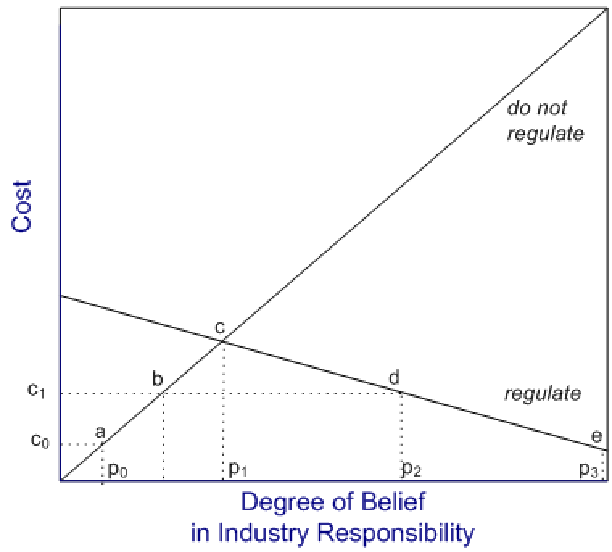

Figure 2: The Value of Information

Prior knowledge (belief at value p_3)places the shadow of responsibility on industry; therefore the government promulgates legislation (intersection with the regulation cost curve at point d). However, having made the decision to regulate, there is no additional value placed on information that does not change the government decision. Therefore research results that shift prior probabilities from c to e have no value for the government and this additional research will not be conducted. In fact, even evidence up to point b will not be entertained since it will only increase the expected cost of regulation. The weight of new evidence must change the decision, result in a positive value of information, and be worth the additional cost of research needed to gain the information. Thus, new evidence must shift government opinion to point a before it will be entertained. The value of information at point a is $c_0 - c_1$.

2.2 Precaution and Precommitment

Industry protest shifts the burden of evidence in two ways. First, protest may cause the government to update its belief in the responsibility of industry for pollution. Second, the additional information provided by new research may, at this point, carry the government over the threshold of new evidence causing it to revise its decision. Thus industry protest may be an instrumental component of a strategy for government information; a strategy which may enable additional investigation in a cost effective manner. Under such circumstances, conflict and protest are natural outcomes of the regulatory strategy.

In the diffuse zinc case, the government committed to specific environmental regulations, necessitating further response from industrial parties to resolve the dispute. Faced with additional protest, the government expanded its research into the area, and eventually softened its stance with regard to the responsibility of the construction industry.

2.3 Protest and the Pursuit of the Truth

Levels of conflict are likely to be more severe under several circumstances: high societal values, high levels of uncertainty, high research costs, and inconclusive research results. When the government places a high value on societal costs, precautionary regulation is more likely. When levels of uncertainty are high there is a greater likelihood of regulation pursued in error. When research is expensive, then a higher burden of proof is expected before the research can be conducted. When research itself is inconclusive, signals such as industry protest become a greater part of the government's information seeking strategy.

Furthermore, the government's commitment to rapid resolution of conflict may itself increase the likelihood of future protest by industry. Such a government response effectively reduces the costs of protest, thereby making protest a viable strategy even if industry is responsible for the environmental damage. Faced with regulation, industry must face an expensive and also possibly ineffective protest strategy. Polluting or non-polluting, both types of industry actors have an interest in causing the government to revise its regulatory strategy.

3 Signaling, Strategy and Information Transfer

The previous discussion demonstrates that research serves multiple purposes in environmental dispute resolution. Research does serve an informative role. Research, in the form of an industry "report war" in response to preemptive regulation, also serves a strategic and signaling role. Actor incentives, both government and industry, intersect in evaluating the sincerity of protest, and the validity of externally funded research. The section to follow presents a model of strategic information transfer. The goal of the model is to examine where and when protest is likely, and the quality of the resultant information which emerges as a result of the conflict.

The following section discusses a model of strategic information transfer as applied to the diffuse zinc case as discussed previously. In this model the industry decision to protest is a signal, to be both knowingly manipulated and knowingly interpreted by both players. Likewise, the government decision to pursue additional research is a strategic variable pursued both for additional information and for the ability to shape industry actions. The principal technique for modeling learning in the model is by updating belief in light of new information through the use of Bayes' theorem. Opportunities for learning occur twice in the game: if and when protest happens, and if and when research is pursued. Our goal in pursuing the model is to examine how the system of incentives created by the game impact the ability of government and industry actors to learn from one another.

The original model of signaling was developed by Crawford and Sobel (1982). These authors examined the credibility of communication given the incentives for falsification. This model of signalling, or as it is sometimes called "strategic information transmission," has been widely applied. Perhaps the most notable example is the work of Spence (1973) which considers the role of educational degrees as a device for signaling employee capability to employers.

Signaling and information transfer theories have been less often applied to public policy and public administration. This is despite a tradition of qualitative game theory in public administration which links strategic interaction between parties to mutual dependencies in policy outcomes (Koppenjan and Klijn 2004). Nonetheless an interesting and fruitful investigation of the role of signaling in policy is emerging. Letterie and Swank (1997) for instance considers a parliamentary structure where the choice of policy advisor serves both informative and persuasive roles in bridging the preferences of different political parties. Tonon (2008) furthers the analysis by consideration of a "presidential" model of governance. Tonon's mdoel examines the role of a professional, independent executive bureaucracy in easing communication costs between branches of government.

3.1 Parts of the Game

Figure 3 shows the timing of the report war game. There are four stages: the issuing of new regulation, the industry decision to protest, the government decision to research, and the resultant action by government to potentially revise its original regulation.

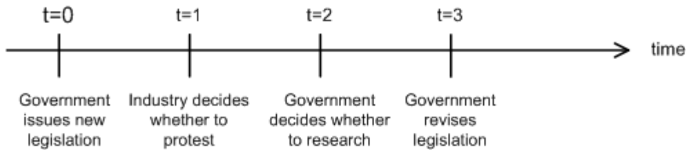

Figure 3: Timing of the Report War Game

The game is further explored in extensive form (figure 4). In the report war game, the industry strategies are protest, no protest. Government strategies are research, no research and promulgate, no promulgate. The states of nature are confirm, deny for research, and responsible, not responsible for pollution.

The government presumes that there are two types of industry players occurring with probability π_i (polluting) and 1-π_i (non-polluting) respectively. Should the government choose to research, the following probabilities are associated with the research outcomes. If industry is responsible, then research will deny industry responsibility with probability p_1 where the probability p_1 is greater than 0.50. If industry is not responsible, then research will confirm industry responsibility with probability p_2 where the probability p_2 is greater than 0.50. Probabilities p_1 and p_2 are related to type I and type II statistical errors. Furthermore, the model assumes that industry knows its own responsibility for environmental damage.

The costs for industry are c_1 (the costs for protesting), and c_2 (the compliance costs for the new legislation). The costs for government are d_1 (the cost of being protested), d_2 (the costs of research), d_3 (the costs of promulgating legislation if industry is not guilty) and d_4 (the costs of not promulgating legislation, if industry is in fact guilty). In discussion to follow d_3 is named the "regulatory burden" and d_4 is named the "social cost."

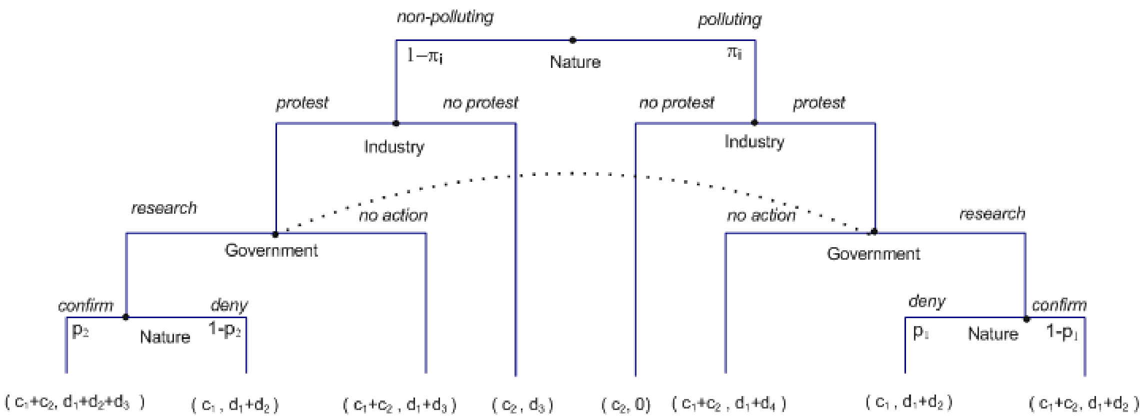

Figure 4: The Extensive Form of the Game

The game is solved by seeking a perfect Bayesian equilibrium (Fudenberg and Tirole 1991, Harsanyi 1967). These games entail the updating of belief about the intentions of other actors in the game. For instance, the choice of protest by industry may cause the government to have less conviction about industry responsibility for pollution. Or, having protested, industry may believe that government is now more likely to engage in research to support their regulatory goals. The goal of seeking the Bayesian equilibrium is finding a self-consistent set of beliefs for both players given known incentives and observed actions. Calvert (1985) similarly explores the consequence of learning and decision-making in the presence of incomplete and biased information. The resultant model is therefore distinct from other models of legal action, such as that of Png (1983). Png's model admits no learning or updating of belief even as it examines the likelihood of strategic or even frivolous law suits.

Assume the probability of industry protest if responsible for the pollution is ψ_1. Also assume the probability of industry protest if not responsible for pollution is ψ_2. Our goal is to find a sustainable level of protest for industry given the known incentive structure of the game, and thus to identify the values of ψ_1 and ψ_2. The probability for the government to research if protested against by industry is ϕ. The probability for the government to do nothing if protested against is $1-\phi$. As previously noted seek values for (ψ_1, ψ_2, ϕ) which are consistent with Nash equilibrium, i.e. values such that there is no incentive for either player to defect from their chosen moves given the choices of the other player.

3.2 Solution of the Game

First we create a model of learning in the presence of research. This is needed by industry to determine the relative value of protest versus compliance. Consider the result of research which confirms industry responsibility. The government knows this may be the result of accurate research in the presence of industry responsibility, or a type II error in the presence of an industry which is not responsible. The consistent way of updating belief in the presence of error is Bayes' theorem; thus the new probability of industry responsibility is given in equation 1. Likewise, consider the result of research which denies industry responsibility. The government knows this may have happened because industry is in fact not guilty, or because the research produced a type I error (see equation 2). In the equations which follow the probability of industry guilt given confirmation of guilt by further research is π_{1c}. The probability of industry guilty given denial of guilt by further research is π_{1d}.

$$\pi_{1c} = \frac{\pi_0(1-p_1)}{\pi_0(1-p_1) + (1-\pi_0)p_2} \tag{1}$$

$$\pi_{1d} = \frac{\pi_0 p_1}{\pi_0 p_1 + (1-\pi_0)(1-p_2)} \tag{2}$$

Industry, unlike government, knows its own responsibility. Given the consistent updating of belief by government as described by Bayes' theorem, industry need only be concerned with the conditional probabilities of research confirming or denying their responsibility for the pollution. Industry faces additional costs for protesting, which are only offset by the possibility of persuading the government to reverse its decision to regulate. The principal difference in cost for the two industry types polluting, non-polluting arises from the type I and type II errors associated with additional research; thus the costs for industry differ by industry type.

$$\psi_1(c_1 + c_2\phi p_1 + c_2(1-\phi)) = (1-\psi_1)c_2 \tag{3}$$

$$\psi_2(c_1 + c_2\phi(1-p_2) + c_2(1-\phi)) = (1-\psi_2)c_2 \tag{4}$$

Equating these two formulas and solving for the equilibrium behaviors for protest gives equations 5 and 6.

$$\psi_1 = \frac{c_2}{c_1 + 2c_2 + c_2\phi(1-p_1)} \tag{5}$$

$$\psi_2 = \frac{c_2}{c_1 + 2c_2 + c_2\phi p_2} \tag{6}$$

This level increases as the compliance cost increases, and decreases as the protest cost increases. As government increases its probability of responding by research, the two types of industry players begin to distinguish themselves. The non-polluting industry type ramps up protest much faster than the polluting type, as it is the type most likely to be vindicated by additional research.

There is a hyperbolic relationship between the probability of protest of the polluting type ad the probability of protest of the non-polluting type. This is demonstrated by substituting equation 3 into equation 4. The resulting equation is shown in equation 7.

$$a\psi_1\psi_2 + \psi_1 - \psi_2 = 0 \tag{7}$$

$$a = \phi(1 - p_1 + p_2) \tag{8}$$

For simplicity the factor a, which determines the shape of the curve, has been abstracted out of the equation and given in 8. The value of a is dependent upon the magnitude of type I to type II errors, as well as the choice of the government to research when faced with industry protest. The value of a ranges from 0.5 to 1.5.

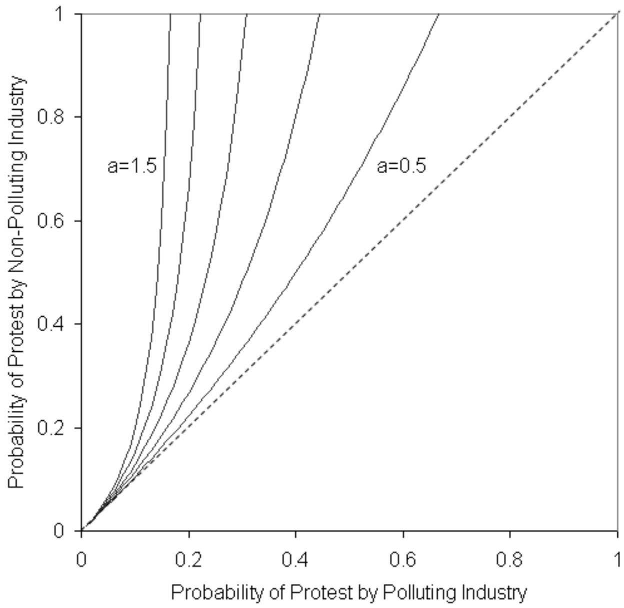

Figure 5: Protest Propensity

A representative function showing the propensity to protest is plotted in figure 5. Any given game is associated with specific values of (ψ_1, ψ_2) according to the relative costs of protest versus compliance. For instance, when compliance costs are low, it is unlikely that the industry actor will protest. As compliance costs increase, or as protest costs decrease, the relative propensity for protest increases. As the figure demonstrates, high protest situations are actually highly informative government, and might be preferable when determining responsibility.

The dotted line in figure 5 shows a situation where protest is not a meaningful indicator of industry responsibility. In the game specified, protest always serves to clarify industry responsibility. Furthermore, a government committed to rapid response by research will only move the curves leftward, resulting in a clearer signal of industry responsibility. However a research commitment is only as good as the quality of the research itself. Research with a relatively high level of type I error promotes strategic protest by industry actors.

Industry protest (or even the lack of protest) contributes valuable information to the government. Using this information the government can then update its beliefs regarding industry responsibility. As previously discussed Bayes' theorem enforces a consistent procedure for updating belief given new information. Let π_1 be the updated belief of industry responsibility given the protest signal, absent any additional research.

The game as described constitutes a perfect Bayesian equilibrium, since the government updates its belief in light of protest, and most importantly, industry knows the beliefs are updated and uses this information strategically in guiding its decision to protest the regulation.

These beliefs about responsibility enter into the government decision to pursue research. Equation (7) shows the trade-off between the social costs of not regulating, and the regulatory burden imposed on an industry which is not responsible for polluting. The resulting mixed strategy (if it exists) is shown in equation (8).

$$\phi(\pi_1 p_1 d_4 + (1 - \pi_1)p_2 d_3 + d_2) = (1 - \phi)((1 - \pi_1)d_3 + \pi_1 d_4) \tag{9}$$

$$\phi = \frac{d_3 + \pi_1(d_4 - d_3)}{d_2 + d_3(1 + p_2) + \pi_1(d_4(1 + p_1) - d_3(1 + p_2))} \tag{10}$$

The expression for the equilibrium probability of research is based upon the mixed strategy equilibrium implied by 9 and given in 10. The respective ratio of costs changes with the presumption of responsibility. If industry is deemed not responsible, then the ratio of research cost to regulatory burden is the factor guiding decision-making. If industry is deemed responsible, then it is the ration of research cost to social costs that becomes the principle factor guiding decision-making. The relative ratio of social costs to regulatory burden shifts as the belief in responsibility changes. High research costs lower the probability of research. Inaccurate research (higher values of p_1 and p_2) also reduces the probability of the government doing additional research.

3.3 Extensions to the Game

Several assumptions in this game are worth further discussion. First, we have assumed that government does not learns from the content of the protest, which as we have seen from the case involved a series of elaborate and costly research reports from independent consultants. This abstraction serves to better model a situation (such as described in the case) where there is very little trust in industry sponsored research. An extension to the current model, which does not involve learning by content, would involve a continuous decision variable ”cost of protest” which could allow industry to demonstrate the depth of its displeasure in government regulation. If, as is the case in this model, it is in the balance of interest of a non-polluting industry to protest, then a costly signal could prove to be a higher quality signal to government than a non-costly signal.

Second, we have assumed that industry knows its type before protest. This is a rather restrictive assumption, but it allows us to focus on the basic challenges of signalling and learning in a situation of high mistrust. It is instructive to examine the simple case where industry does not know its type whatsoever. Both polluting and non-polluting types have the same incentives to protest. Government can infer nothing about the protest, and chooses to research if and only if the value of information (as discussed in section II) is sufficiently high. More complex is the situation where industry begins with a prior belief in its own responsibility, which may be less informed than that of the government. Government research will be convincing to industry to the extent that the government is more concerned with regulatory burden over social costs. An increasing conviction of innocence on the part of industry results in more vocal protest, but without further tactics available to industry does not otherwise substantially change the model as described.

The model as presented explicate some of the mechanisms within policy networks, including learning and strategic information transfer. Real world policy networks, unlike the model presented here, entail repeated interactions across multiple arenas. Such interactions present greater opportunities for learning on the part of both industry and government. In the following section we complete discussion of the case, focusing on the resolution of the dispute. Further, we discuss the prospects for creating research mechanisms, within policy networks, which are capable of enhancing learning. The model and case are descriptive; however prescriptive lessons for future policy analysis activities are possible based on these findings.

4 Concurrent Conduct of Research

In traditional policy analysis, research activities are linked to the various phases in the process of problem solving as distinguished in the rational policy model. (Hogwood and Gunn 1984) distinguish: issue search, issue filtration, issue definition, forecasting, setting objectives, option analysis, policy implementation, monitoring and control, and evaluation. For each of these steps there is the adage think first (do research), then act.

When we accept that, in reality, the problem solving process does not develop linearly but rather in a zigzag and jerky fashion, this should have consequents for the place and nature of research activities. Organizing research separately in the chronological steps that, according to the rational decision making model, make up the problem solving process, does not conform with this non-linear model. If research for solutions precedes decision making and solutions, it is likely that the demarcations, assumptions and conditions used in research are already obsolete by the time decisions are made and solutions are elaborated. When research is conducted ex post, then the findings come too late. The solution has already been elaborated and decided upon and research will have a legitimating function at best, and will be destructive at worst: the designed solution cannot be supported and the problem solving process must be repeated (de Bruijn et al. 2004).

If we want research to constructively contribute to the problem solving process, it should not be organized as a separate phase in the process but as a parallel stream: a second arena, a research arena alongside the original arena where the game is played and in constant contact with that arena. Knowledge questions and conflicts emerging in the first arena are brought into the research arena as research questions. The findings are then fed back to the main arena (van Eeten and ten Heuvelhof 1998). They may provide an impulse for joint image building and the development of cooperating strategies in that arena, but they may also lead to new knowledge questions. Thus, the activities in the research arena do not follow the chronological steps of the rational phase model. The knowledge questions that emerge at various points in the game can be very different by nature and may not fit into a chronological order (first issue research, then issue filtration, etc.).

4.1 Research that Facilitates Policy Agreement

Research will not resolve knowledge conflicts between parties in the policy game. Research does not have that kind of authoritativeness. What is more, research will often not be conclusive either. So when research is, nonetheless, given the role of arbiter, it will become a target of the strategies of actors, that try to influence the formulation of the problem and the solutions considered. Their conflict will trickle into the research arena. In fact, both arenas will merge and the potential contribution of (scientific) knowledge research to cross-frame learning and the development of negotiated knowledge will be lost (Salter 1988, Jasanoff 1994). So, instead of settling disputes authoritatively, the role of science and research is to facilitate the interaction between stakeholders.

Research will not generate ready-made solutions but will indicate which standpoints can be maintained given the state of scientific insights, which issues can not be conclusively determined, and what, given available knowledge, is the maneuver room within which solutions can be found. This, too, is a type of cognitive learning and a contribution to the reduction of substantive uncertainties in the main arena of the policy game in which stakeholders are trying to develop strategies by which the problem can be solved or at least managed.

By investigating the effects of solutions proposed by parties and demonstrating the degree to which the various preferences of actors may lead to different or comparable outcomes, research can help to understand conflicts and knowledge disputes in the negotiation arena and thus make them easier to overcome.

Research can generate new insights and knowledge that contribute to the quality of the policy discussion and the problem formulations and solutions that are advanced. It can improve cognitive learning and help enhance the quality, innovativeness and integrative character of solutions.

In linking up with the negotiation arena, researchers are forced to explain their assumptions, methods and outcomes to the stakeholders. This contributes to both the quality and focus of research activities as well as to communication about them with stakeholders.

The wish to collaborate in research activities contributes to the convergence of ideas and insights between stakeholders. If stakeholders want to influence joint research activities, they will be forced to consider the research questions that must be addressed and will have to reach agreement about the assumptions and criteria which will serve as the basis for judging the research findings. This negotiation and argumentation process encourages joint image building.

Research may contribute to a de-politicization of conflicts between parties in the main arena if these conflicts are translated into research questions. Sometimes research will not lead to answers, but it may bring out aspects of a problem that have received little attention, or lead to refining earlier opinions. Research an thus contribute to a situation where parties no longer confront each other but, instead, acquire new insights, experience cognitive learning and see opportunities for new solutions. It is exactly through the loose coupling of research findings and subsequent actions that conflicts over research and research results can be represented. And, as a result, research can develop substantive answers to the knowledge questions and arguments of both parties so that substantive quality is improved and the divergence of perceptions decreases.

5 Conclusions and Recommendations

One of the few points where cognitive learning occurred in the zinc case was due to the joint commissioning of research. The zinc industry initially fought the scientific foundation of zinc policy. This proved to be ineffective. The research that they initiated as an interested party was viewed as partisan by government actors and not taken seriously. For a number of years, the zinc industry and the RIZA (the research institute of the Department of Transport, Public Works and Water Management concerned with research in the field of water management) disagreed with each other's research findings on the diffusion speed of zinc and zinc building materials into the waterways as a consequence of corrosion. Since the research design, demarcations and assumptions were different, the outcomes were different too

- even when the research was done by the same institute. In the end, everyone arrived at a point where a decision was made to have research done on the basis of a jointly formulated research assignment. The outcome of the research that was done on the basis of this assignment, succeeded in convincing both parties. With the RIZA, this led to the acknowledgement that the corrosion speed of zinc was much lower than earlier government figures indicated.

The zinc case also demonstrates that attempts by parties to involve others in their research projects often fail because the way this is done is inappropriate. Thus, government invited the zinc industry to participate in a working group that would think about the design and implementation of research for new norms for zinc. At crucial moments, however, government took unilateral decisions to influence the research, reasoning that, after all, the success of the research was its responsibility. Participating parties allowed this to happen following the same logic: they considered the research to be, first and foremost, an activity of government. This meant that, although they were involved in the research process, they did not really feel responsible for the research. Hence, they also did not feel committed to the outcomes of it (Klijn et al. 2000).

An important objective organizing research in the process of problem solving is to prevent research from becoming advocatory. This can be done by encouraging stakeholders to jointly commission research activities (van Bueren et al. 2003). Since research is always conducted within a specific problem frame which will influence the choices made with regard to demarcation, assumptions, methods and interpretation of data, each of these issues can become a target of criticism if the parties do not agree with the research results. This is exactly the mechanism that lies behind report wars: commissioned by different interested parties, scholars criticize the choices made on each of these issues. This is not very helpful when the objective is to develop a common understanding in order to arrive at joint action. To achieve convergence, parties ought to negotiate ex ante - before they have been confronted with undesirable research results - about what research questions need to be answered, which choices should be made with regard to demarcations, assumptions and methods, and by which criteria findings will be assessed. Parties might not achieve consensus about all these points but, for instance, they may agree to a parallel investigation of assumptions or research questions. It is conceivable that they will have research demarcations that can help to overcome differences: through a sensitivity analysis, parties may explore the degree to which different assumptions lead to different outcomes. These findings can then be used in the negotiation arena to establish trade-offs. The aim of research is not to arrive at ready-made solutions nor achieve consensus between parties, but to coordinate and share generated knowledge, acquire insight into the nature of the differences, and to support and enrich the negotiation process.

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