Command-and-Control or Effluent Allowance Markets: Roles of Economic Analysts

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Abstract

Economists and economic analysis can play different roles in the development of water quality management programs. Economists may develop cost analysis for improving regulatory program implementation or design institutional arrangements for market-like program. We argue that cost analysis may be incompatible with effective advocacy for market-like systems.

Introduction

Regulation of effluent discharge under the Clean Water Act (CWA) is based on technology-based performance standards. According to the CWA, effluent discharge standards are identified by EPA based on the best technology available for controlling a particular effluent identified in the statute or supporting regulations. These technology-based performance standards are then used by state regulators to write permits (called NPDES permits) for point source dischargers. The permits establish conditions under which dischargers are allowed to operate, including limitations on the amount of pollutant each source may discharge. If technology-based standards are not sufficient to ensure a mandated level of water quality, the permitting authority may set more stringent limitations on individual dischargers. Once a permit is issued to a party, the CWA prohibits issuance of future permits that would allow the point source to increase its assigned discharge. The effluent standards are said to be uniform because the same EPA-identified standard is implemented within similar categories of dischargers.

Environmental economists long have been troubled by this approach and have pointed out that uniform control requirements violate the equi-marginal cost principle. Instead, if marginal waste control costs were made equal across sources the same environmental outcome (waste reduction) could be secured at lower total costs. It follows that a regulator who has full information on the costs and effectiveness of waste control at each source could vary regulatory control requirements across sources to minimize the total costs of achieving the desired environmental goal. Because such regulatory targeting would require cost information that includes all possible control approaches an important role for economic analysts would be to assist regulators in setting the effluent limits appropriate to each individual source. The analysis might proceed as follows. The marginal control cost functions are determined and total effluent control costs are then calculated assuming each discharger must meet a uniform effluent standard. An optimization model is then constructed that minimizes the costs of meeting the environmental objective by equating the marginal costs of control across sources. Sensitivity analysis might be conducted to generate a range of cost-saving estimates given different modeling assumptions and environmental constraints. If the savings from deviating from a uniform control requirement are significant then regulators could vary the control requirements at each source.

This same cost minimization logic also has been employed to justify the adoption of effluent allowance trading programs. Conceptually, an effluent allowance system defines ambient water quality goals and established an overall effluent load cap consistent with ambient goals. Discharge allowances are then defined and assigned to dischargers of the effluent. An allowance is an authorization (right) to a to discharge specified quantity (e.g. pounds, kilograms, or tons) of an effluent into a receiving water . The number of allowances issued is equal to the load cap. Dischargers are granted discretion to keep discharges at or below allowance holdings and granted permission to buy and sell allowances. Effluent allowance systems are often called cap-and-trade systems.

Standard environmental economics textbooks explain the rationale for trading in terms of the equi-marginal principle (Tietenberg 1998, 236; Field 1997; Kahn 1995, 72; Pearce and Turner 1990, 110). Economists also use the equi-marginal principle to describe the rationale of trading to other professionals (Crutchfield, Letson and Malik 1994; Letson, Crutchfield and Malik 1993; Malik, Larson, and Ribaudo 1994). Regulators often express and promote this perspective trading. The EPA’s *Draft Framework for Watershed-Based Trading* identifies the primary economic benefit of trading is minimization of costs by equating the incremental cost of control across discharge sources (EPA 1996).

Following this conceptual argument, an extensive *empirical* literature purports to quantity the costs savings from allowance trading relative to uniform standards (Hanley, Faichney, Munro, and Shortle 1998; O’Ryan 1996; Johnson and Pekelney 1996; Kling 1996; Rubin and Kling 1993; Hecq and Kestemont 1990). Much of the current interest in point-nonpoint source trading is derivative of the cost-minimization logic. For instance, it is frequently argued that nonpoint sources, many of which face no regulatory requirements, can control discharge at a much lower cost than point sources (Crutchfield 1994). Allowing point sources to sponsor effluent nonpoint source controls is a means to lower the costs to point sources of more stringent regulatory requirements. Significant efforts have been devoted to identifying these potential cost savings between point and nonpoint sources.

The empirical literature designed to document the cost advantages of trading requires estimates of discharger control cost functions. In addition, Stavins (1995) has argued that empirical work should also consider transaction costs. He concludes that in some instances significant transaction costs from setting up allowance trading institutions and from making trades could mean that uniform standards have lower costs. He argues that a cost analysis that incorporates transaction costs will determine whether the cost saving potential outweighs the cost of allowance market creation.

> … it is possible that in some circumstances that total cost of compliance (including transaction costs) of a tradable permit system could exceed (depending upon the initial allocation of permits) the costs of a uniform performance standard (which exhibited small administrative costs). There is no simple answer, no policy panacea; case-by-case examinations are required (Stavins (1995, 144).

Empirical work (cost minimization studies) is required to identify wheter cost differentials among pollutant sources will support deviations from a uniform control requirement through allowance trading (Crutchfield, Letson and Malik 1994; Hanley, Faichney, Munro, and Shortle 1998; O'Ryan 1996; Johnson and Pekelney 1996; Kling 1996; Stavins 1995; Hecq and Kestemont 1990; Letson 1992) and preferably to determine whether measured cost savings exceeds transaction costs under allowance market systems (Stavins 1995; Atkinson and Tietenberg 1991).

However, this empirical literature to compute cost savings is incompatible with the underlying economic logic for creating market-like systems for environmental protection. In fact, two well recognized economic perspectives on the role of markets support this assertion. First, markets serve to reveal information on participants' individual economic circumstances. In the case of water pollution control if the discharge control cost information lies with the discharger rather than a regulatory agency, then market-like instruments would reveal cost information among dischargers and trading of allowances can identify the least cost combination of controls. On the other hand if the regulator has better information on the costs and effectiveness of controls then targeted command and control rules are to be favored over effluent allowance trading. Clearly, empirical optimization work cannot demonstrate the advantages of allowance markets if the information on which to build the analysis is not available to the regulator or to the analysts. The whole rationale for instituting the allowance market in the first instance is to force revelation of information on costs and effectiveness of controls. If analysts and regulators know enough to build a cost minimization model and target regulatory limits to minimize total cost then there is no need to establish a market in allowances.

A second perspective is that allowance markets encourage the discovery, development, and implementation of previously unrecognized pollution prevention opportunities. This discovery function of markets is frequently associated with a neo-Austrian school of thought (Kirzner 1997a, 1997b; Cordato 1992). The discovery and the information revealing functions of markets are consistent in one respect: regulators do not have adequate information on pollution control alternatives and so construction of empirical cost minimization models is not possible. However, unlike the information revealing argument, the discovery argument is that the dischargers themselves may not have information about possible costs and effectiveness of pollution control alternatives. Possible pollution control strategies are not known in advance, but are discovered and created through decentralized individual decision-making. For example, elements of the discovery argument are reflected in the work of Michael Porter. Based on case study analysis, Porter argues that additional management attention, decision-making flexibility, and financial incentives can often result in the discovery of previously unrealized environmental management alternatives (Porter and van der Linde 1995).

To construct empirical models of cost savings is to imply that analysts and regulators can know what needs to be known for implementing non-uniform regulatory requirements. Such empirical work would be designed for regulatory targeting. Accepting either the information revealing or discovery functions of markets means that the cost-savings from a trading program cannot be calculated and cannot be used to make the case for market trading systems. With either market perspective analysts will direct their professional attention to market design issues. In this paper, we illustrate these perspectives using a case study of efforts to manage nitrogen discharges into Long Island Sound and will suggest that there may be a fundamental incompatibility between the empirical work for cost minimization modeling and advocacy of allowance markets.

Long Island Sound

Long Island Sound is an estuary on the northeastern coast of the United States. It is 110 miles long and bounded by the state of Connecticut and Westchester County, New York to the north and Long Island to the south. The Sound is an unusual estuary in that it is open at both ends, at the East River to the west and the Race at the eastern end. Long Island Sound drains one of the most highly urbanized areas in North America. Certain areas of Long Island Sound Long also frequently suffer from hypoxia. Hypoxic conditions occur in the late summer, when high water temperatures limit the amount of oxygen that can be dissolved in the water. Hypoxic conditions generally last between 40 to 80 days and can affect anywhere from 25 to 40 percent of the bottom area of the sound. The areas at the far western end of the sound are most impaired by hypoxic conditions. Dissolved oxygen levels in the late summer in this area regularly approach 1.5 mg/L and have been known to go much lower (LISS 1994, 1997). Figure 1 shows dissolved oxygen levels in the Sound. The basin wide management goal of a minimum DO level of 3.5 mg/L at all times and in all portions of the sound has been established.

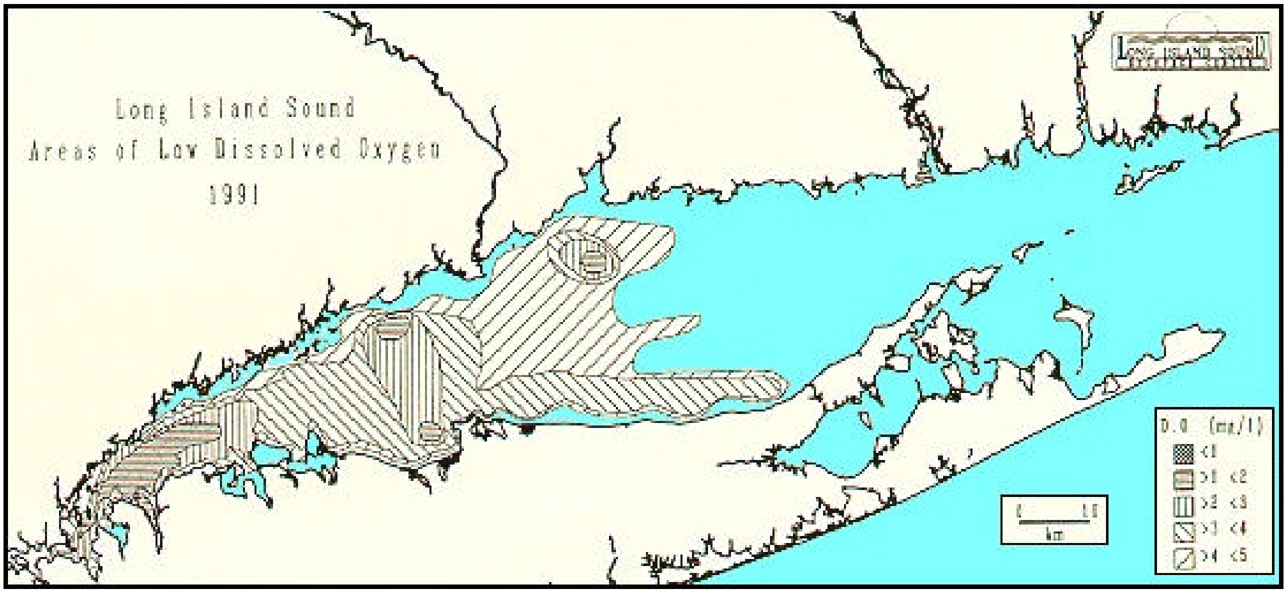

Figure 1. Areas of low dissolved oxygen in Long Island Sound (source EPA/LISS)

The cause of low DO levels is excessive amounts of nitrogen deposited in Long Island Sound. Large amounts of nitrogen stimulate large algae blooms. When the blooms die off, bacteria decompose the plant matter in a process that requires oxygen. Such oxygen depletion results in hypoxia. Discharge from wastewater treatment plants is the most significant source of anthropogenic nitrogen. Some runoff from nonpoint sources, especially urban stormwater, may also be a significant factor.

Discharged nitrogen has a different effect on the impaired areas of the Sound depending on where in the watershed it is released. Not all nitrogen discharge or runoff reaches the impaired portions of the sound. Nitrogen discharged farther north and east in the watershed has less of an effect on the impaired areas for two reasons. First, some nitrogen is assimilated through natural processes during river transport before it reaches the Sound. Second, once in the Sound, some nitrogen will drift out of the Sound through the Race or the East River without affecting the impaired areas. The unassimilated nitrogen that reaches the impaired areas of the Sound is referred to as the delivered load. Nitrogen attenuation ratios expressing the relative impact of nitrogen discharge have been developed for both processes described above and used to translate end-of-pipe discharge in various areas of the watershed into delivered load.

Management efforts currently call for anthropocentric nitrogen loads to be reduced by 58.5 percent from 1990 levels by the year 2015. Connecticut Department of Environmental

Protection (CTDEP) plans to meet these overall goals by requiring Connecticut's seventy-four publicly owned wastewater treatment plants (POTWs) to reduce delivered nitrogen loads by approximately 70 percent from 1990 levels. Steps to achieve a 10 percent reduction in delivered nitrogen from nonpoint sources through voluntary measures will also be taken. Taken together, the mandatory point source reductions and the voluntary nonpoint source reductions would meet the overall 58.5 percent delivered load reduction goal. CTDEP calculated the delivered load from Connecticut POTWs in 1990 to be 10,407,393 pounds. A 70 percent reduction is 7,951,185 pounds, which translates into a delivered point source load cap of 2,456,210 by 2015.

Economic Perspectives Applied to Long Island Sound

Different economic analysts perspectives were applied to Connecticut's approach to achieving water quality goals in Long Island Sound. The following sections illustrate both types of research activities and suggest roles economists might play in water quality management program design.

Cost Analysis and Recommended Actions

The economist working under a cost minimization approach perspective would attempt to calculate the cost-saving potential of moving from a uniform standard approach to non-uniform control requirements as a way to meet Connecticut's nitrogen load cap. Data would be gathered under the assumption that these data provide the best available information on costs and control effectiveness at each source. The data intensive nature of this work is illustrated by the brief discussion in this section.

The analyst constructs a math programming model to minimize the costs of achieving the 70 percent reduction in point source nitrogen discharges. The primary constraint is that goals for the amount of nitrogen delivered to impaired waters of Long Island Sound be met. The model solves the following problem:

Minimize: $?_{i=1}^{74} (C_i * N_i)$

where:

C = cost to control one normalized pound of nitrogen

N = total N controlled, in normalized pounds

i = POTW

subject to:

Total reduction ? total required reduction

The model allows each of seventy-four POTWs to select from a number of analyst-prescribed different nitrogen control options. For each control option the nitrogen removal effectiveness and the cost to achieve that reduction is specified in the model. There are six choice variables for each plant, each corresponding to a specific nitrogen reduction strategy. Three choice variables are for capital improvements (high-grade, low-grade or no capital investment). Three choice variables are the number of delivered pounds of nitrogen to be controlled with each strategy. Constraints are set up so that the model may choose one capital upgrade and then must select the number of pounds reduced subject to the technological control limit for the chosen upgrade. Each pound reduced has an associated annual operating costs.

Data for the model application include 1990 baseline dischargers, costs of low and high capital upgrades, nitrogen attenutation ratios, and annual operation and maintenance costs and the projected future flow for each plant. These data were developed by from the Connecticut Department of Environmental Protection (CTDEP). The 1990 calculated discharge is found by multiplying the 1990 wastewater flow by a nitrogen concentration of 18 mg/L (note, however, that discharge is given in pounds). Costs for capital upgrades are estimated by CTDEP and annualized over 20 years at an interest rate of 6 percent, which reflects the cost to POTWs of borrowing to finance capital upgrades. Projected future flows from each plant were assumed to increase by 20 percent at the end of 15 years. Effluent concentrations after capital upgrades were also estimated by CTDEP. High-grade upgrades should reduce nitrogen concentration to 3.5 mg/L, low-grade upgrades reduce concentration to 7 mg/L and no upgrade results in 18 mg/L. The control option selected and the corresponding discharge levels simulate what each individual POTW would discharge at the end of a 15-year phase-in period under a trading system.

The least cost solution as calculated by the model can be compared against a uniform reduction requirement to derive an estimate of the cost-savings from a trading system. One type of uniform standard would require each POTW to reduce delivered loads to LIS by 70 percent. Calculated 1990 discharge levels are multiplied by 30 percent to obtain the discharge limit for each plant. The appropriate control strategy (high-grade capital improvements, low-grade capital improvements and non-capital process changes) for each plant is chosen based on whether the technology is able to reduce discharge to the required level.

The cost minimization model also could be used to examine the cost implications of shifting nitrogen control responsibility from POTWs to nonpoint sources. This is accomplished by recalculating the costs of achieving a less stringent point source cap. The total cost of achieving a uniform and nonuniform nitrogen load allocation is recalculated as described above using a 60 percent reduction goal. Changing the reduction requirements increases to size of the POTW cap from 2.456 million pounds to 3.275 million pounds per year (a difference of 819,000 pounds). The difference in costs to POTWs between a 70 percent and 60 percent required reduction should be equal to what towns are willing to pay to get nitrogen reductions from some alternative source besides their treatment plants. Nonpoint sources, particularly nitrogen in urban stormwater runoff, are obvious alternatives.

An empirical model for this Long island Sound problem was constructed. The model estimated total cost of a uniform 70 percent nitrogen discharge reduction at every POTW is $63,095,100 per year. However, even at this total cost a 70 percent reduction is not achievable for all plants because at 32 plants, construction of high-grade capital projects cannot achieve a 70 percent reduction in delivered nitrogen loads. Reducing discharge by as much as possible (using the high-grade capital option) at those 32 plants and by 70 percent at the 42 other plants results in a total delivered load of 2,495,906 pounds per year. This exceeds the cap of 2,456,210 pounds by almost 40,000 pounds.

Using the cost minimization model, the estimated cost of control under an nonuniform total nitrogen waste load is $48,120,600 per year. A nonuniform allocation of nitrogen discharge results in savings of approximately 24 percent over the uniform standard, or almost $15 million annually. Furthermore, the overall nitrogen cap is met. Those plants that are able to do so are required to reduce nitrogen discharge beyond 70 percent of 1990 levels.

Relaxing the nitrogen cap from 2.456 million pounds to 3.275 million pounds would lower costs substantially. The model calculates that the least cost combination of controls that would meet the 60 percent reduction goal would cost $29 million annually -- 40 percent lower under a 70 percent reduction requirement. The $19 million reduction in total costs suggests that the average cost to control the last 819,000 pounds of nitrogen is slightly more than $23 per pound.

From these results an analyst would conclude that substantial cost reductions)15 million dollars annually) are gained by implementing non-uniform control requirements. . The analyst also would report that significant cost savings would be achieved by incorporating nonpoint source controls into a regulatory program. For instance, the $23 per pound cost of controlling the last 819,000 is significantly greater than current cost estimates associated with many nonpoint source BMPs (Virginia Department of Environmental Quality 1995). The cost analyst might propose more refined analysis of the costs of incorporating nonpoint sources (transaction costs for measurement, monitoring and enforcement costs) before bringing non-point sources into the program in place of point source controls. However, none of the empirical results are , for the reasons described above, a basis for recommending an allowance trading program. Nor would the cost analysis work completed provide any insight into how such a trading program should be designed.

Market Creation

The presence or absence of cost savings from a cost optimization model provides no useful insight into whether a nitrogen allowance market should be pursued. Information and knowledge about current and future costs and control options are either unknown to the regulators or does not exist in any comprehensive or recoverable way. The professional attention of economists should turn to designing rules that facilitate development of markets to either reveal control cost information or create this knowledge.

Economic research with a market creation perspective uses economic logic, analogies, game theory, and experiential evidence. Research efforts may also include identifying and highlighting the behavioral and system change attributable to moving from command-based regulation to a more market-like context. Evidence may include comparative empirical studies that compare actual behavior and costs across different regulatory programs, but not against a calculated least cost solution (Environmental Law Institute 1999; Jaffe and Stavins 1995) or from case studies that document behavior and outcomes within an operational trading program (Burtraw 1996).

Research activities are focused on identifying the requirements for creating an unattentuated and stable sets of legal authorizations to discharge (discharge allowances) that support of environmental objectives (Tripp and Dudek 1989). The design rules for a nitrogen allowance system include creating enforceable caps on nitrogen discharge sources. Such systems also require that POTWs be granted decision-making authorities to determine the types of technologies or process changes that will be implemented to control nitrogen discharges. Economists would seek to implement nitrogen-trading rules that would reduce transactions costs. These market arrangements should also provide a stable set rules that would facilitate and encourage dischargers to make long-term investment decisions.

These straightforward market design rule principles, however, become quite complex to implement in a specific institutional contexts. Market arrangements must be designed within, or to overcome, formal statutory and regulatory rules, existing programs, and long-standing patterns of behavior and habits may present obstacles to implementation. Thus, to engage in the role as market designer the economist must invest significant professional energy and attention into understanding these rules. Within specific regulatory contexts, the policy efforts of economists are directed at identifying the barriers and obstacles to developing incentive structures and an secure investment climate (Foster and Hahn 1995; Stephenson, Shabman, and Geyer 1999; Shabman, Stephenson, and Tripp 1998) and suggesting specific reforms that can be overcome these obstacles.

Three particular market design issues illustrate the analysis and policy role of the economists in designing a nitrogen allowance system in Connecticut. The first involves the current NPDES permitting system. Assigning nitrogen discharge allowances through NPDES permits reduces the ability of dischargers to respond to new control opportunities and dampens incentives for seek new waste control strategies. Conditions in NPDES permits are typically prescriptive. Dischargers typically install technology and waste control practices based upon the regulatory agency's understanding of best available control technology. These technological requirements are then translated into permit conditions. Dischargers also have little incentive to search for ways to reduce waste below levels specified in the their NPDES permits. If a discharger develops an alternative waste control strategy that reduces discharge, the discharger faces the possibility that their discharge rights will be restricted when a new NPDES permit is issued (permits are issued every five years). If this occurs, the regulators confiscate an asset (unused allowance) that could be sold. This uncertainty about the security of discharger allowances undermines pollution prevention incentives.

There are tremendous difficulties of establishing decision-making flexibility, incentives and investment security under the existing NPDES permitting system. For market-like systems for discharge rights to be developed, economists could work to reform or devise new legal mechanisms to nitrogen discharge allowances. One option would assign discharge rights under a watershed or group permit. A watershed or group permit would specify the total aggregate allowable discharge for a group of dischargers. Reallocation would then occur under the watershed permit. Monitoring and enforcement of the cap and individual dischargers under the cap would be similar to the current NPDES permitting program. Under such an arrangement, POTWs could make choices about control strategies without regulator approval and without direct threat that regulators would impose more stringent requirements on the individual POTWs which achieve superior nitrogen control performance. The analytical and design challenge currently facing Connecticut and other states is to craft such a system that is legal under the CWA and would allow decision-making flexibility and stable expectations to form.

The state cost-share program is a second example of a program that could either hinder or facilitate the development of a nitrogen allowance trading program. The state of Connecticut offers generous subsidies to POTWs when plants need retrofitting or when plants face additional regulatory requirements. The subsidies include state construction grants that cover 20 percent of all construction costs and low interest loans for the remaining portion of the capital construction costs. The cost-share funds are administered and distributed to the POTWs based on a CTDEP determination of need and an internal priority weighting system. Furthermore, CTDEP is also primarily responsible for identifying and designing the capital facilities that would be installed. The current cost-share program is in essence a defacto technology standard.

Economists could argue that changes in the cost-share program are necessary to allow discharger discretion in how to manage nitrogen. Economists could help devise alternative cost-share arrangements that distribute funds based on performance (for example the total restriction on nitrogen allocations) rather than on CTDEP approved capital projects. One alternative would have the state calculate a per pound payment based on the total cost-share funds available and provide a subsidy equal to the per pound payment times the total reduction in nitrogen discharge rights. Once the cost-share funds are received, the POTW would be allowed to either undertake on-site nitrogen control strategies (by means determined by the POTW) or purchase additional discharge rights from another POTW.

Finally, the current nitrogen control program only strives for a partial cap on nitrogen discharges. Typical of water quality control programs across the country, nonpoint sources are not included part of CTDEPs plan to regulate discharges. Economists may be concerned about incorporating nonpoint sources to protect water quality, Leaving nonpoint sources outside the cap and regulatory control compromises achievement of water quality goals because growth in nonpoint source loads. Furthermore, a partial cap can create incentives that would facilitate this growth in nonpoint source loads. For instance, in Connecticut local government control over POTWs and urban and rural land use controls rests with towns. Thus stringent and expensive POTW controls could incentives for changes in zoning laws that permit more large lot developments with on-site septic systems.

At this point, some observers argue that extending a cap to nonpoint sources maybe infeasible due to high costs of measuring, monitoring, and enforcing nonpoint source caps (Boyd 2000; Bartfeld 1993). Economists would argue that decision-making flexibility and market incentives create a cost reducing dynamic that lowers costs and advances control effectiveness in creative and unanticipated ways. The same logic could also apply to transaction costs (Smith 1995). One focus of research and policy advocacy would be to design rules that grant dischargers and potential market participants' flexibility and market incentives to incorporate nonpoint sources into a trading program and lower measurement and monitoring costs. In Connecticut, towns represent a management unit that could be granted the option to extend nitrogen caps to nonpoint sources. Towns then could determine the combination of point and nonpoint source controls to meet the town's overall nitrogen allowance. Two of the authors have suggested elsewhere how rules could be designed to encourage private sector participation in quantifying and verifying nonpoint source discharge (Stephenson and Shabman 1998, 1999).

The Roles of Economic Analysts

If economists believe that both current and future costs and control effectiveness can be known, then a cost analysis could be used to encourage regulators to reallocate effluent controls among dischargers. To the extent that the current statutory and regulatory framework prevents such a reallocation, reforms could be suggested that would increase the ability of regulators to undertake such reallocations. However, the justification for markets cannot be demonstrated through a cost model. The cost analysis presumes the existence of knowledge and information that markets are designed to overcome. The research agenda is not directed at attempts to prejudge whether a market is cost effective form of regulation, but instead is to designing rules that facilitate allowance markets for the pollutant of interest.

Some economist may argue that these two perspectives on information (what is known) do not lead to mutually exclusive policy analyses. For example, some may argue that estimates of total cost savings derived from cost minimization analysis builds public support for trading among the skeptics and uninitiated. Once sufficient support is built for the general concept, economists can turn their attention to helping design rules that facilitate the development of market-like systems for discharge rights.

However, use of cost minimization models to justify the establishment of an allowance market can lead into a policy advocacy trap. The use of cost optimization logic and cost models supports current regulatory thinking and can *undermine* rather than build support for and creation of markets by misleading the policy participants about the role and function of markets. If creation of markets institutions for environmental policy is a goal of the professional economist, engaging in cost optimization calculations relays the message to other policy participants that markets primary function is one of optimization. If the main function of markets is explained in terms of eliminating known differences in marginal costs among dischargers, then the regulator through centrally-directed reallocation can achieve the same outcomes as a market. The cost model has not demonstrated any unique characteristics of markets, and the cost minimization logic may be more readily used against the establishment of markets than for them.

There are several reasons why regulators would be predisposed to favor a centralized reallocation scheme versus a decentralized allowance trading system. First, the existing cost-share and permitting programs are familiar and established. Existing systems already rely on centralized knowledge and decision-making authority to achieve water quality goals. Changing them only introduces additional costs into the system. For example, CTDEP was reluctant to seek statutory changes that would make cost-share program reform possible.

Second, the language of cost minimization calculations speaks to a regulatory process that is dominated by engineers. Engineers envision their job as designing and implementing a means to achieve a particular ends. For example, regulator trained in waste water control engineering will believe that their professional training and regulatory responsibilities better inform them of pollution opportunities than the POTW operators. In addition the mathematical language of cost-minimization gives regulators a way of thinking and a means they can understand to lower costs and improve policy. It lends credibility to the claim that costs and control options are known *a priori*. If economic models demonstrate cost minimization, it becomes harder for economists to convince engineers that market processes offer any significant advantages over regulator directed implementation plan. Indeed, during the authors' involvement in discussion of water quality management for Long Island Sound we developed and presented the mathematical programming model results reported earlier in this paper. (Shabman, Stephenson, and Tripp 1998). The regulators used the results to justify a non-uniform regulatory program that was implemented through use of targeted cost sharing funds.

Finally, a trading system requires a decentralization of control and decision-making authority. Trading requires that dischargers are granted more discretion to determine how discharges will be controlled. The current regulatory culture is focused on identifying and implementing technological controls on dischargers. Decentralized systems require that primary responsibility for pollution technology and prevention rests with the discharger. In a trading system the role of the regulator shifts from someone who prescribes control techniques for dischargers to the role of a police officer who monitors and enforces pollution control performance. An administrative reallocation system does not require regulators to relinquish this control.

In fact, there is evidence that the cost-minimization logic often has been co-opted to extend the current command-and-control regulatory approach. What is currently labeled as trading in water quality management is in fact centrally directed permit modifications. In most situations, regulators retain discretionary control over pollution control planning and are centrally reallocating pollution control obligations based on relative costs (Stephenson, Shabman, and Geyer 1999). Trades are occurring when *regulators* deem additional controls on regulated (point source) dischargers have become too expensive. Regulators allow dischargers to sponsor off-site reductions from unregulated dischargers (nonpoint sources) according to terms and controls specified by the regulators. Reallocation is occurring in the absence of markets. This may be viewed either favorably or unfavorably depending on ones perspective, but the profession should not be misled to believe this is the work of a market system.

Current water quality efforts in Connecticut are also illustrative of this point. Under proposed Connecticut legislation, CTDEP would be granted greater discretion in assigning nitrogen discharge control responsibility than is currently allowed by EPA (REF). These reforms in essence grant the CTDEP more latitude in assigning non-uniform standards to POTWs. This increased decision-making authority, however, will largely be retained by CTDEP. Thus, the current changes in the water quality management program being sought in Connecticut would transfer decision-making authority between regulators (federal to state) but not between regulators and dischargers.

A market dynamic perspective emphasizes the limits of knowledge and the powerful role incentives plays in revealing cost information and in creating new knowledge. A market perspective focuses attention on *ignorance* – the limited ability of a centralized agency to know. Arguing from a market perspective, means convincing regulators (policy makers) that they do not know costs and all control options and they need harness private sector resources and creativity to create new approaches to pollution prevention.

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