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Introduction

Under the Porter-Cologne Water Quality Control Act, the State Water Resources Control Board has the ultimate authority over state water rights and water quality policy.[1] The Act also establishes nine Regional Water Quality Control Boards ("Regional Boards") to oversee water quality on a day-to-day basis at the local and regional level.[2] The Regional Boards engage in a number of water quality functions in their respective regions. One of the most important is preparing and periodically updating water quality control plans, also known as basin plans.[3] Each basin plan establishes beneficial uses of water designated for each water body to be protected; water quality standards, known as water quality objectives, for both surface water and groundwater; and actions necessary to maintain these standards in order to control non-point and point sources of pollution of the state's waters.[4] Permits issued to control pollution (i.e., waste discharge requirements and NPDES permits) must implement basin plan requirements (i.e. water quality standards), taking into consideration beneficial uses to be protected.[5]

The Regional Boards regulate all pollutant or nuisance discharges that may affect either surface water or groundwater. Any person proposing to discharge waste within any region must file a report of waste discharge with the appropriate regional board.[6] No discharge may take place until the Regional Board issues waste discharge requirements, or a waiver of the waste discharge require-

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1. CAL. WATER CODE, Div. 7, Water Quality.
2. CAL. WATER CODE § 13200.
3. CAL. WATER CODE § 13225.
4. CAL. WATER CODE §§ 13240-13241.
5. CAL. WATER CODE § 13263.
6. CAL. WATER CODE § 13260.

ments, and 120 days have passed since complying with reporting requirements.[7]

Under the auspices of the U.S. Environmental Protection Agency ("EPA"), the State Board and nine Regional Boards also have the responsibility of granting Clean Water Act National Pollutant Discharge Elimination System permits, commonly known as NPDES permits, for certain point source discharges.[8] In summary, California routinely issues NPDES permits to selected point source dischargers and either waste discharge requirements or conditioned water quality certification for other discharges. The nine Regional Boards differ somewhat in the extent they choose to apply waste discharge requirements and other regulatory actions.

Before a Regional Board can impose these requirements, however, the Act requires that it "shall take into consideration" the following factors: "the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the provisions of Section 13241."[9] Section 13241 in turn lists six "factors to be considered," including "economic considerations" and "water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area."[10]

While the requirement to consider economics under the Porter-Cologne Act is absolute, the legislature and the courts have done little to particularize it. This article is an attempt to fill the gap and provide the State and Regional Water Boards with some guidance as to how economics can and should be considered as required by Porter-Cologne. We begin the paper with a discussion of why economic analysis is important for sound rulemaking, and how economic insights can provide a roadmap toward more effective and efficient interventions. At the federal level, economic analysis in regulation is well established, and federal agencies are often required to at least consider economic impacts prior to taking action. It is also illuminating to review economic analysis of federal environmental regulations; after all, there is now a track record from over two decades' worth of research.

We then turn to a description of how water quality regulations can affect the economy. Some of these impacts are fairly obvious and easy to quantify. Others are subtle, or depend on interactions among firms or sectors of the economy. Economic impacts can sometimes be limited to a small number of well-defined groups. Often, however,

7. CAL. WATER CODE § 13395.

8. CAL. WATER CODE § 13370.5.

9. CAL. WATER CODE § 13241.

10. *Id.*

many groups will be implicated, especially if impacts are propagated through market interactions.

Next, we treat the economics of environmental benefits resulting from water quality regulations. While we are not advocating that a full cost-benefit analysis be performed in every case (and are certainly not suggesting that the Regional Boards adopt only regulations that pass a strict cost-benefit test), the Regional Boards are required by Porter-Cologne to consider the "beneficial uses" to be protected by their actions; those uses should include the economic impact.

Following our detailed treatment of economic costs and benefits, we turn to the practical question of how the Regional Boards can and should put it all together, namely what steps should be followed to gather and use information on economic impacts. While adoption of these procedural steps would be an advance, they do not answer the question of *how* economic impacts are to be measured. Despite the frequent complexity of actual impacts, one of our main goals in this paper is to articulate and defend a baseline set of measurements that need to be performed to achieve the minimally adequate "consideration" of economic impacts under Porter-Cologne. We propose a series of economic impact tests that are relatively easy to interpret and are at least rough measure of the economic impacts caused by water quality regulations.

Of course, in some situations, it will be apparent that water quality regulations have large economic impacts, and more detailed analysis will be required. In these cases, our general discussion of the economic effects of water quality regulation will provide guidance to analysts at the Regional Boards and in the regulated community. It is worth reinforcing that traditional economic analysis may not always be adequate to capture the effects of regulation. In particular, water quality regulation may alter competition in an industry; result in firms relocating to other areas; cause delay, loss of flexibility, and insolvency; result in unintended risks; have dynamic consequences (especially when regulations result in capital replacement); and affect the operation of public sector facilities. These effects are all somewhat outside the bounds of traditional economic analysis of regulation, but are examples of factors that should be considered in the case of Porter-Cologne.

1. Why Consider Economics?

Over the last two hundred years, economists have developed a rigorous methodology to assess the impacts of government actions. The approach derives from the basic principles of public finance and welfare economics, and it adopts a holistic perspective by considering the well-being of many groups in society. Fundamental to most economic impact analyses is an articulation of the tradeoffs involved with policy alternatives. The economist's approach to assessing government actions also combines considerations of efficiency and equity, and it has been widely applied to problems of environmental regulation.

At its heart, economic analysis of regulation is an accounting of the consequences of a governmental action. This accounting is often quantitative, but a number of economic analyses also treat impacts qualitatively, especially for non-standard commodities.[11] Ideally, the economic analysis will also give information on the distributional impacts of the intervention, or a description of the level of impacts on certain groups in society that are affected by the action.

A requirement to "consider economics" is not the same as a directive to adopt only those regulations that pass a cost-benefit test. Agencies can use the results of economic analysis, but not be bound by "bottom-line" numbers. Most economists would hesitate to argue that quantified costs and benefits tell the whole story, or that precise measurements of either are possible. But when economic analysis reveals low or non-existent benefits and high costs, something is likely amiss. It would seem that the California legislature sought to avoid such a socially undesirable outcome by mandating a consideration of economics when making water quality regulation.

While the notion that economics should have a seat at the table when forming water quality regulations in California is controversial, it should be noted that we are largely past this point with respect to many federal regulations. The federal government has maintained a decades-long commitment to economic analysis of regulation. This policy began in the Nixon Administration, which initiated Quality of Life Reviews of federal regulations in 1971.[12] The two main events in the history of economic analysis at the federal level, however, occurred in the Reagan and Clinton Administrations. President Reagan issued Executive Order 12,291, perhaps the most decisive step in the cost-benefit record.[13] This Executive Order established a set of principles for agencies to follow "to the extent permitted by law," including a commitment to cost-benefit analysis. The order required Regulatory Impact Analysis of major rules, and also established a formal mechanism for Office of Management and Budget ("OMB") oversight of interventions.

11. *See generally* WILLIAM J. BAUMOL & WALLACE E. OATES, THE THEORY OF ENVIRONMENTAL POLICY (Cambridge University Press 2d ed. 1988).

12. Memorandum from George Schulz, Dir., Office of Mgmt. and the Budget, October 5, 1971.

13. Exec. Order No. 12,291, 46 Fed. Reg. 13,193 (Feb. 17, 1981).

In 1993, President Clinton issued Executive Order 12,866, which reaffirmed the basic commitments to economic analysis and conferred bipartisan legitimacy.[14] This order also introduced some reforms to the economic analysis process that were designed primarily to assuage fears of industry capture. These reforms included procedures for conflict resolution and inclusion of equity considerations.

Sunstein has articulated a notion of "default" principles for statutory interpretation that describe what agencies are permitted to do when implementing carrying out regulatory programs.[15] In brief, these principles allow federal agencies to

1) Allow *de minimis* exceptions to regulatory requirements;
2) Authorize agencies to permit "acceptable" risks, departing from a requirement of "absolute" safety;
3) Permit agencies to take account of both costs and feasibility; and
4) Allow agencies to balance costs against benefits.

Taken as a whole, Sunstein argues that the default principles are making a substantial difference in regulatory policy, both because of their effects in litigated cases and because of their systematic consequences for policy. The default principles have, in effect, emerged as a central part of the federal common law of regulatory policy.

A general point about the emergence of the default principles is that they indicate a general acceptance of the notion that cost-benefit analysis of regulation is desirable. Sunstein notes that the debate about the acceptability of cost-benefit analysis appears to be "terminating with a general victory for its proponents, in the form of a presumption in favor of their view, signaled above all, perhaps, by President Clinton's substantial endorsement of cost-benefit balancing via Executive Order."[16] The analysis in this article exemplifies a second-generation inquiry into how cost-benefit analysis should be conducted. In particular, we are concerned with the development of a consistent methodology for assessing the economic impacts of water quality regulations and identification of ways to streamline potentially burdensome procedural requirements to consider economics. Other examples of second-generation questions include how to value human life and health, how to deal with the welfare of future generations, and how to value changes in environmental quality.

What has economic analysis of regulation uncovered so far? Without prejudging what economists will find in the case of Califor-

14. Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Sept. 30, 1993).
15. Cass R. Sunstein, *Cost-Benefit Default Principles*, 99 Mich. L. Rev. 1651-1723, (2001).
16. *Id*. at 1655.

nia water quality regulations, the results have been quite revealing. The findings also indicate why Congress and a series of Presidents have required economic analysis of regulation.

The most basic finding of economic analysis is the large aggregate cost of federal regulation. Since 1981, OMB has reviewed 249 major rules with estimated costs and/or benefits to the private sector or state and local governments of over $100 million annually.[17] OMB calculates that in the past 25 years, over $123 billion of annual direct costs have been added by the major regulations issued by the executive branch agencies.[18] Total regulatory costs are on the order of $200 billion annually.[19]

Another major finding is that despite the federal government's general commitment to economic analysis, regulation is not uniformly efficient.[20] This overall pattern of noncompliance with cost-benefit principles is a cause for concern, even for those who doubt the wisdom of economic analysis but merely want more coherent regulation and better use of agency resources. Hahn and Sunstein, among others, argue that a review of the federal record finds many successes in the form of regulations and other interventions that deliver significant benefits at reasonable prices. But in many cases, regulations seem to do more harm than good. In their review, Hahn and Sunstein conclude that the most serious problem at the federal level is "exceptionally poor priority-setting, with substantial resources sometimes going to small problems, and with little attention being paid to some serious problems."[21]

A review of some regulations is illustrative of this general point. Table 1 from Hahn and Sunstein displays the net benefits of some interventions, defined as annual benefits minus costs. The results display a remarkable lack of consistency among regulations, and also reveal that, despite federal provisions requiring economic analysis, at least some regulations do not pass muster.[22]

17. Office of Mgmt. and Budget, *Draft 2006 Report to Congress on the Costs and Benefits of Federal Regulation*, at 26, *available at* http://www.whitehouse.gov/omb/inforeg/reports/ 2006_draft_cost_benefit_report.pdf

18. *Id.* at 27.

19. Robert W. Hahn, *The Economic Analysis of Regulation: A Response to the Critics*, 71 U. Chi. L. Rev. 1021, 1021-54 (2004).

20. Robert W. Hahn & Cass R. Sunstein, *A New Executive Order for Improving Federal Regulation? Deeper and Wider Cost-Benefit Analysis*, 150 U. Pa. L. Rev. 1489, 1489-1552 (2002).

21. *Id.* at 1490.

22. As discussed earlier, the federal commitment to economic analysis of regulations is longstanding and bipartisan. Too often, however, this commitment is superficial and, in some ways, symbolic. The solution, Hahn and Sunstein argue, is institutional reform, embedded in a new executive order and some statutory changes, that would increase the role of economic analysis in regulatory policy.

The point about a lack of consistency has been made even more forcefully in the work of Tengs et al., who gathered information on the cost-effectiveness of over 500 life-saving interventions.[23] These interventions were defined as "any behavioral and/or technological strategy that reduces the probability of premature death among a specified target population." Interventions were classified by type and included both regulatory and non-regulatory life-saving measures.

Table 1: Economic Impacts of Some Recent Federal Regulations[24]
(Net benefits, in millions, adjusted to 1996 dollars)

Regulation	*2000*	*2005*	*2010*	*2015*
Exposure to methylene chloride	-60	-60	-60	-60
Roadway worker protection	0	0	0	0
Financial assistance for municipal solid waste landfills	-100	-100	-100	-100
Pulp and paper effluent guidelines	-150 to 0	-150 to 0	-150 to 0	-150 to 0
Ozone standards	0	-235 to 240	-840 to 1,190	-9,200 to – 1,000
Child restraint system	-40 to 40	-40 to 40	-40 to 40	-40 to 40
Vessel response plans	-220	-220	-220	-220
NOx emission from new fossil fuel fired steam generating units	-57 to 29	-57 to 29	-57 to 29	-57 to 29

23. Tammy O. Tengs et al., *Five Hundred Life-Saving Interventions and Their Cost-Effectiveness*. 15 Risk Analysis 369, 369-82 (1995).

24. Hahn and Sunstein, supra note 20, at 1491.

Tengs and her co-authors defined cost-effectiveness as the net resource cost of the intervention per life-year saved. Several findings of their analysis are important. First, the authors uncovered an enormous disparity in terms of the efficiency of alternative life-saving interventions.[25] Some measures prevented premature death at a trivial cost per life-year saved — less than $10,000. Other measures, however, cost in excess of $1 billion per life-year saved. This finding suggests that interventions, including regulatory ones, are poorly prioritized.

Another main finding of the Tengs paper is that, as a category, toxin control regulations are a relatively expensive way of preventing premature death. Tables 2 and 3 present some findings relative to this general point. Table 2 shows the median cost per life-year saved of the three basic categories of interventions: medical, injury reduction, and toxin control. The results indicate that toxin control regulations are several orders of magnitude less efficient than medical interventions or injury reduction measures (leading some to ask why society is rationing access to medical care while at the same time promulgating an increasing number of environmental regulations). Table 3 shows the cost-effectiveness of regulations by agency. A similar conclusion follows from this analysis, namely that despite the federal commitment to cost-benefit analysis, there appears to be a serious discrepancy among types of interventions in terms of cost-effectiveness. This suggests that a change in priorities could save more lives at less cost than current policies.[26]

Table 2: Median Cost per Life Saved for Different Types of Interventions

(Cost per life-year saved in 1995 dollars)

Medical Interventions	$19,000
Injury Reduction	$48,000
Toxin Control	$2,800,000

Source: Tengs & Graham at 369.

25. See also John F. Morrall, III, *Saving Lives: A Review of the Record*, 27 J. Risk & Uncertainty 221 (2003); Cass R. Sunstein, *Risk and Reason: Safety, Law and the Environment*, (Cambridge University Press 2002); Stephen Breyer, *Breaking the Vicious Circle: Towards Effective Risk Regulation* (Harvard University Press 1997).

26. This point was made forcefully by Tengs and John Graham. *See* Tammy O. Tengs & John Graham, *The Opportunity Costs of Haphazard Social Investments in Life-Saving*, Risks, Costs and Lives Saved: Getting Better Results from Regulation (Robert W. Hahn ed., Oxford University Press and AEI Press 1996). Tengs and Graham argue that the present pattern of investments in 185 life-saving interventions considered results in the loss of $31.1 billion, 630,000 life-years, or 61,200 lives every year.

Table 3: Median Cost of Regulation per Life Saved for Different Agencies
(Cost per life-year saved in 1995 dollars)

Agency	Cost
FAA	$23,000
Consumer Product Safety Commission	$68,000
National Highway Traffic Safety Commission	$78,000
OSHA	$88,000
EPA	$7,600,000

Source: Tengs & Graham at 371.

There is nothing intrinsically anti-regulatory about economic analysis. For example, implicit in the finding cited earlier that regulations vary widely in terms of their cost-effectiveness is the notion that some regulations are highly efficient and achieve their objectives at low cost. Perhaps a better measure of desirability is net social benefits, or benefits minus resource costs. In an influential survey of federal environmental policies, Freeman concluded that some policies are cost-benefit "winners" while others are "losers."[27] Winners include removing lead from gasoline, controlling particulate matter in air pollution, reducing lead in drinking water, cleaning up hazardous waste sites with the lowest cost per cancer case avoided, and controlling CFC emissions. Freeman's losers include mobile source air pollution control, most waterway discharge control, many regulations under the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA"), the Toxic Substances Control Act, the Safe Drinking Water Act, Superfund, and policies aimed at controlling ground level ozone.

Hahn has argued that economic analysis can help to lower the cost of achieving given social objectives such as environmental quality.[28] He points to the famous example of market-based approaches for achieving environmental goals.[29] The savings of market-based

27. A. Myrick Freeman, III, *Environmental Policy Since Earth Day I: What Have We Gained?* 16 J. ECON. PERSP. 125 (2002).

28. Hahn, *supra* note 19.

29. Thomas H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy*, (Resources for the Future Press, 1985).

versus command-and-control policies result from differences in the cost of compliance with regulations.

Another insight from economic analysis of regulation is that risk-reducing policies may themselves impose risks that are frequently not considered by regulators. In Sunstein's terminology, "Risks never exist in isolation. They are part of systems. For that reason, any effort to reduce a single risk will have a range of consequences, some of them likely unintended."[30] Hahn cites examples including fuel economy standards for automobiles that are designed to reduce environmental risks but make automobiles less safe, banning the manufacture and use of asbestos that led companies to use more dangerous substitutes, and efforts to remove asbestos from public buildings that may cause risks to workers.[31] When such risk-risk tradeoffs are dealt with explicitly through economic analysis, they often result in regulators taking a closer look at proposed interventions.

Economic analysis makes the regulatory process more transparent. In his early work on regulatory impact analysis, Hahn concluded that there were numerous problems with the presentation of information.[32] Documents frequently did not summarize findings or include an assessment of the costs and benefits of the regulation. To counter this deficiency, he helped develop a "scorecard" for regulation. This scorecard summarizes key aspects of a regulation such as agency estimates of both qualitative and quantitative costs and benefits.[33] The use of the scorecard helps promote agency accountability at the federal level by allowing OMB and the public to evaluate how well agencies are performing. OMB is now required to produce scorecards that operate in a similar way.[34]

Hahn also argues that the use of scorecards can promote the establishment of institutions that hold regulators accountable.[35] One such idea is a "regulatory budget" that would limit the costs an agency can impose on the public through regulation .[36] A variant would also consider benefits and give agencies a defined budget in terms of net benefits. As long as they implement regulations with positive net benefits, the budget is not depleted. However, a policy

30. Sunstein, *supra* note 15, at 1653.

31. Hahn, *supra* note 19.

32. *Id*.

33. Hahn & Sunstein, *supra* note 20.

34. The Budget and Fiscal, Budget, and Program Information, 31 U.S.C. § 1105 (2006).

35. Hahn, *supra* note 19, at 1045-46.

36. Eric A. Posner, *When Reforming Accounting, Don't Forget Regulation*, AEI-Brookings Joint Center Policy Matters 02-35 (2002), http://www.aei-brookings.org/policy/page.php?id=104.

that has an apparent negative net benefit would be costly to the agency.

Consistent with these observations regarding economic analysis of regulation, the California legislature required consideration of economics and environmental benefits when establishing water quality standards, and again when issuing discharge permits.[37] A Regional Board must take a second look at water quality standards before issuing a permit.[38] It must look at the standards themselves and at the factors that were initially considered when the standards were established, including the costs of the requirements it is imposing, as well as environmental benefits that are ultimately to be gained from control of all discharges.[39]

The desirability of considering economics at the permitting stage is worth considering. Regional Boards develop water quality standards at the basin level, which may cover up to thousands of square miles.[40] For example, there is only a single basin plan for the area regulated by the Los Angeles Regional Board; within this area there are numerous rivers and streams.[41] Further, local conditions, both economic and environmental, can vary widely throughout the basin. What makes sense basin-wide may not make sense in a particular location, or for a portion of a particular stream.

2. Costs of Water Quality Regulations

Economic analysis of regulation typically quantifies both how an intervention affects the overall well-being of society, as well as how these impacts are distributed among various groups. Often, the costs of regulation are simple to calculate, for example, in cases where the regulation entails a small increase in an industry's cost of production without affecting its operations or competitive conditions in a fundamental way. But when regulation results in basic changes in production techniques, reduced competitiveness, spillover effects to other industries, or other effects, more sophisticated analysis may be required. Affordability and the threat of bankruptcy raise other important concerns that may not be fully addressed in textbook analysis, but are treated here.

The challenge facing economists considering water quality regulations is how to develop procedures based on these general approaches and determine in advance what impacts need to be empha-

37. CAL. WATER CODE § 13241 (2006).
38. *Id.* § 1258.
39. *Id.* §§ 1253, 1257.
40. *Id.* § 13200.
41. *Id.* § 13200(d).

sized. The starting point of the design of an economic impact methodology is to identify the various categories of costs and benefits that may result from regulation. While we introduce a large number of potential impacts of regulation, it is worth emphasizing that not all of these will occur in every situation.

One of the key features of economic analysis is its capacity to assess the impacts of policy on various groups. The theory of welfare economics provides the intellectual foundation to the applied analysis of regulation.[42] This approach entails a partitioning of society into individual units of analysis. These units include consumers, producers, suppliers of inputs to production, and people who consume environmental amenities. The theory suggests that the aggregate impact of a policy is the sum of its impacts on these various groups.

While environmental quality regulations are imposed on producers and firms for the most part, impacts do not end there. Rather, economic consequences are transmitted via market interactions to other groups, most importantly consumers. The propagation of the impacts of a regulation through the economy is well documented and can be quantified by economic analysis.

Economists typically distinguish between regulations that are directed at the private sector and those that are directed at the public or not-for-profit sectors. For example, regulations limiting chemical use in farming are targeted mainly at private businesses. Regulation of flood control or navigation infrastructure targets mostly public sector activities. Regulations targeting the public sector may affect agents in the private sector (e.g., elimination of roads to protect wetlands affects the economic activity and the well-being of consumers and firms). Similarly, regulations of industry may affect the cost of operation of entities in the public sector. With this in mind, we deconstruct the incidence of water quality regulations into several categories.

Producer Surplus

Producer surplus is a measure of the economic welfare of producers, and it is most simply defined as the difference between revenue and variable cost over the relevant range of output. Producer surplus is best interpreted as a measure of the rent accruing to the unique assets of firms in an industry or of their economic profit. Water quality regulation that increases the cost of production has a direct negative effect on producers through the resulting increase in variable costs, and a positive effect if it increases output prices.

42. ANDREU MAS-COLLEL, MICHAEL D. WHINSTON, & JERRY R. GREEN, MICROECONOMIC ANALYSIS 817-56 (Oxford University Press 1995).

In Figure 1, the increase in price due to the regulation increases producer surplus by the area ABDH, the increase in costs is the area FEGB, and lost profit is represented by the area P_0HBP_1. Producers may actually gain from water quality regulations if they face a demand that is not price sensitive.

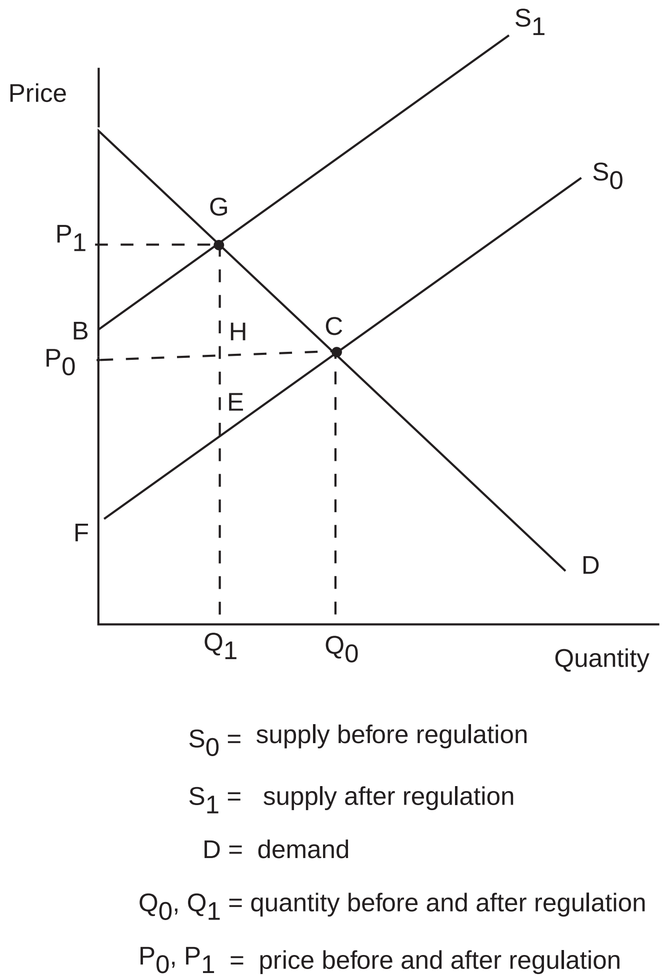

Figure 1

The reduction in output resulting from the higher costs of production because of the regulation will lead to a substantial increase in output price, and the increased revenue may more than compensate for the higher costs of operation. Situations where demand is inelastic in the long run are not very likely. A firm or region may temporarily have a monopoly in production of a product due to specific human capital or technological advantages, but as these erode, other producers or regions of production will enter the market.

Regulation can also result in out-of-pocket expenses for negotiating and obtaining needed permits.[43] These so-called transaction costs of regulation act in the same way as other cost increases resulting from regulation and add to other effects such as the need to alter production technologies or substitute inputs.

Because industries often consist of many players and the chain of production can have several layers, the analysis of producer surplus may need to be multidimensional. In particular, it should address the following considerations.

Interstate and International Competition

Given the major industries where California's firms are competing within international and national markets, producer surplus analysis of water quality regulations affecting industries such as computers, some sectors of agriculture, and biotechnology, may need to consider supply and demand in a global context. As Figure 2 suggests, the demand for major products is met by the sum of California's supply (SC) and the supply of the rest of the world (SR), forming the global supply (SG). The initial equilibrium had a price of P_0 and a quantity of Q_{G0} with California production of Q_{C0}. The initial producer surplus of California is ABC.

Strict regulation of water quality in California may reduce the supply of its producers, and that result is the shift of California's supply to SC_1. That will lead to reduction of the global supply which will shift to SG_1. The reduced supply will lead to higher P_1 and a lower global production of Q_{G1}. The higher prices will increase the output produced outside California, while production in the state will decline to Q_{c1}. The lower output of California producers and the higher costs are likely to result in a significant reduction in producer surplus, which becomes BFC in Figure 2, while the producer surplus of the rest of the world is enhanced.

43. David Sunding & David Zilberman, *The Economics of Environmental Regulation by Licensing: An Assessment of Recent Changes to the Wetland Permitting Process*, 42 NAT. RESOURCES J. 59, 74-82 (2002).

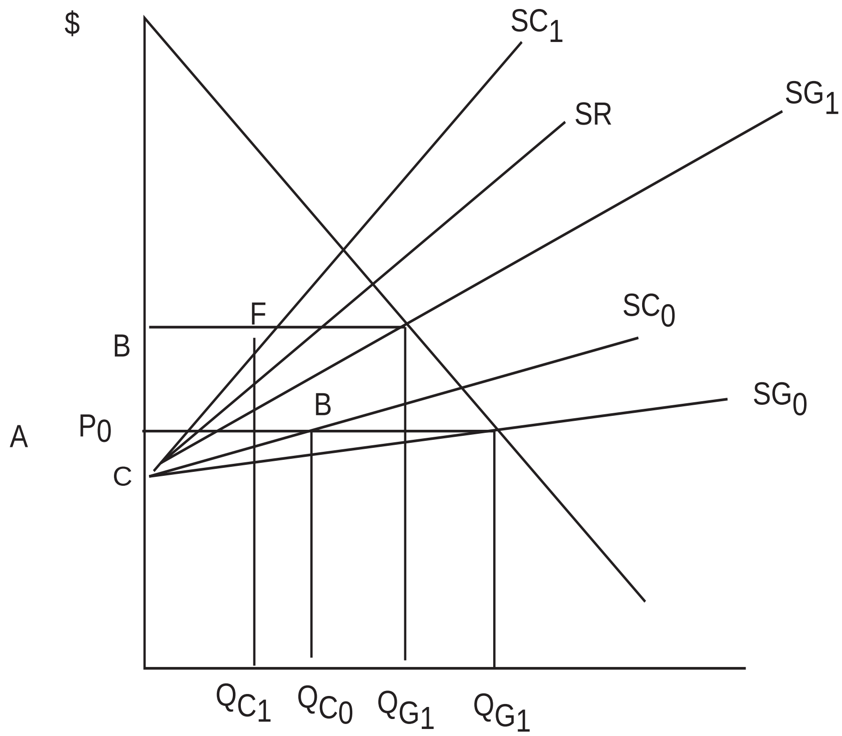

Figure 2

Heterogeneity of Impacts Within the State

Water quality regulations will not affect all firms and regions in California equally. These differentiated impacts should be recognized in the derivation of producer surplus.

California's firms that have to modify their water management practices in response to the regulations have increased costs, lower sales, and are likely to lose from the regulations (unless demand is very inelastic and price effect is drastic). On the other hand, the firms not affected by water quality regulations gain profit as they produce more (taking away market share from the affected firms) and as market price increases.

Several models introduce methodologies to analyze these distributional impacts of natural resource regulations on producer surpluses across regions.[44] Water quality standards frequently target a subset of regions or firms in a particular market. Higher water quality standards that have strong negative affects on, say, tomato growers in the San Joaquin Valley may benefit growers in the Sacramento Valley because of the output price effect. Sunding shows that while the relative impact of a regulation on the aggregate producer surplus across the state may be moderate, its relative impacts on the producer surplus of firms in some regions may be highly significant.[45] Identification of the most affected regions should be an important priority for impact assessment.

Impacts Along the Chain of Production

The standard analysis of policy impacts distinguishes between two major groups of economic actors — consumers and producers. However, the providers of goods and services are multilayered. Producers of consumer goods rely on manufactured input. In some situations, it is valuable to distinguish between *firm* and *consumer* surplus levels. For example, this distinction is relevant in the analysis of regulations affecting the use of pesticides and other chemical pollutants affecting water quality. These regulations may have different effects on chemical manufacturers, as opposed to farmers or industrial users of the chemicals. To a large extent, the impacts on each group will depend on the availability and efficacy of substitutes.[46] The existence of viable substitutes makes manufacturers of the regulated product more vulnerable to regulation at the same time it makes users less affected by regulation.

The distribution of impacts within the production chain also depends on the structure and organization of the industry and assignment of liabilities within various firms among other things. Sunding and Zilberman developed a framework to analyze situations where environmental quality is affected by residue of chemicals used in production, and distinguished between the impacts of regulation on the producer surplus of chemical manufacturers and users.[47] The analysis suggests that both the overall impact of water quality regulations and their distribution among the various parties vary depending on allocation of liabilities and market structure. Outcomes of regulation differ when the chemical is produced by a monopoly or when a competitive firm produces it.

44. David Sunding, *Measuring the Marginal Cost of Nonuniform Environmental Regulations*, 78 AM. J. AGRIC. ECON. 1098, 1100-07 (1996).

45. *Id.* at 1106-07.

46. *Id.* at 1106.

47. David Sunding & David Zilberman, *Allocating Product Liability in a Multimarket Setting*, 18 INT'L REV. L. & ECON. 1, 2-11 (1998).

Competitiveness

Compliance with water quality regulations may be costly and, as we have seen, this cost has many dimensions. Nonetheless, one concept that can summarize much of these costs is competitiveness. While environmental amenities and water quality may make a region more attractive, excessive regulation can also hinder the performance of firms in the region relative to firms residing elsewhere.

Some of the equilibrium effects of regulation are captured by traditional market analysis through, as we have seen, loss of consumer surplus and producer surplus. But in many cases, market information about supply and demand at the present cannot provide the information needed to assess the impact of regulation because there may exist *potential* competition that has not yet become actual. If, for example, the cost of manufacturing electronic components in California increases as a result of regulation, Texas may develop productive capacity in these areas, even though it has not produced these products in the past.

Baumol introduced the notion of contestable markets, arguing that potential entrants play an important role in setting prices that are close to the competitive level. That is, even a monopolist is restrained by the threat of new competition. Here, we suggest that the notion of competitiveness and potential competition restricts the capacity of the industry to raise prices in response to regulation, as the profit opportunities caused by reduction of supply by incumbents will attract new entrants. That suggests that it is important to recognize conditions where water quality regulations will drastically affect cost of production of the local industries that have significant market power, and in these cases it is valuable to assess not only impact of existing competitors but also the threat from potential new entrants.

The impact of water quality regulations on competitiveness has other dimensions. If the implementation of water quality regulations is time consuming and significantly restricts the capacity of industries to respond in a timely manner to new knowledge and new commercial opportunities, it may eventually lead to significant cost. Firms may elect to relocate from California or to reduce their investment in the state if their flexibility and speed of response to opportunities is reduced by regulation. Therefore, it is important to have a good handle on the delay and delay cost of water quality regulation. It is important, for example, to know how much extra time it will take a computer manufacturer to build a new facility because of regulation.

Having financial resources is crucial for firms' capacity to invest in new technologies and new enterprises. Modern industries invest in capital goods that have a short economic life, and while firms may have a significant amount of short-term profits, part of those go to pay debts and part go for use as a capital base for new investment. High-cost water quality regulations may be evaluated in terms of their impact on ability to pay debt and accumulate capital. When this capacity is significantly eroded, it affects firms' ability to survive and grow, and ultimately, the state's competitiveness.

A related impact of water quality regulation on competitiveness is its impact on labor. Labor mobility within the state is an important element of flexibility and enables quick response of industry and the economy to new opportunities. The flexibility of industry is not only restricted by its capacity to build or modify facilities in a timely manner, but by the capacity to provide housing to workers to allow smooth operation of new enterprises. Workers and consumers both demand and deserve high-quality water and related water amenities, but their choice of employment and response to opportunities is also dependent on availability of housing.

Water quality regulations may affect competitiveness for resources available to the public sector. Local governments have to balance expenditures between various objectives, including education, health, roads, and the environment. High cost (water quality regulations) may lead to reduction in expenditures on other items such as education or infrastructure, resulting in reduced capacity to compete and reduced productivity of the private sector.

Insolvency

In the previous section, we argued that frequently water quality regulations might reduce marginal cost of production and reduce supply. However, as long as revenues are greater than costs, it is efficient for the firm to continue operation. Nevertheless, firms have financial obligations and, even though they may have short-term profit, if they cannot pay their debts they will go bankrupt. In theory, if revenues are greater than costs, someone will buy the firm after bankruptcy, and it will continue to operate. In this way, bankruptcy would not seem to affect resource allocation. More recent research suggests otherwise, namely that the costs of insolvency are real. The work of Kahneman and Tversky, for example, established that decision makers have loss aversion, and there is a significant cost to financial losses.[48] Bankruptcy also requires significant costs of readjustment for the affected property owners and employees.

Previous research suggests some avenue for exploring the insolvency implications of water quality regulations. Hochman and Zil-

48. Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263, 274-89 (1979).

berman studied the impact of tighter water quality standards on dairies in the Chino region of Southern California.[49] They suggested that requirements to increase the disposal acreage make the operation of a certain number of growers (less than 10 percent) unprofitable in that the operational cost will be smaller than the revenue. However, they realized that firms have to pay their debts and, even if the revenue after accommodating the regulation exceeds the variable cost, the surplus is not sufficient to meet the financial obligations of the firms. Thus, some firms may be forced to close. The same study found that under reasonable assumptions about the distribution of the debt-equity ratio among producers, the owners of more than thirty percent of the land might not be able to meet their financial obligations resulting from the regulation.

One of the methodological challenges facing economists is to quantify the cost of insolvency. At present, economic theory does not suggest totally satisfactory, formal measurements of the economic costs of insolvency. At a minimum, however, it is useful to develop an estimate of the percentage of business establishments whose solvency may be threatened by water quality regulations.

One regulatory approach to deal with insolvency and ability to pay has been to assess the affordability of water quality regulations under different assumptions about the cost of implementation. In essence, this approach estimates how much firms in the industry can afford to pay for cleanup. An alternative approach that we favor is to estimate of what percentage of the firms will become insolvent after regulation, and what percentage of productive capacity will be affected by insolvency after regulation. This will require information about the debt structure of firms in the industry as well as the distribution of profitability.

Dynamics

Economists realize the importance of technological rigidity. Investments in capital goods often affect the ability to control effluent, but short-term adjustments in the capital stock may be very costly and limited in their effectiveness. This observation implies a need to collect information on the age of the system (i.e., capital stock vintage) and the time and cost required before replacement of existing technology. It may be worthwhile to emphasize changes in waste management brought by a new design, rather than to require heavy investment in structures that will otherwise become obsolete. Some-

49. Eithan Hochman & David Zilberman, *Two-Goal Environmental Policy: An Integration of Micro and Macro Ad Hoc Decision Rules*, 6 J. OF ENVTL. ECON. AND MGMT. 152, 152-174 (June, 1979).

times it may be worthwhile to provide the incentive for the firm to engage in research to find a technological solution, rather than impose high costs within an existing suboptimal system — improve the next vintage rather than the current one. For example, if a plant lasts 10 years and a problem is discovered in the eighth year, unless the problem is severe, it may be desirable to tolerate pollution in the short term and push for improvements in the stock of replacement capital.

The impacts of water quality regulations frequently take years to materialize and thus should be analyzed within a dynamic framework, taking into account the projected changes in the economic situation over time. The state of the economy affects prices of inputs required for activities needed to comply with regulation. For example, the prices of labor and raw materials needed for construction of, say, a drainage disposal facility is likely to increase during periods of high economic growth. The economy affects the impacts of compliance with water quality regulation on output prices and consumer and producer welfare. For example, when an intervention leads to substantial reduction of supply of an affected industry, it may lead to a substantial increase in consumer prices in periods of high economic growth and strong demand, but may have a small effect in periods of low economic growth when demand is sensitive to consumer income.

Finally, the impact of regulation on the economic well-being of affected firms and their capacity to survive extra costs of production and additional constraints on operations depends on macroeconomic conditions. For example, macroeconomic conditions affect the interest rate and the ability of firms to raise capital. Exchange rates affect the earning of California's producers overseas as well as their earning capacity, and thus their ability to invest in compliant technologies.

Compliance with some water quality regulations requires a large investment and a long-term response. In this case, dynamic analysis is paramount. It is important that assumptions about economic growth and macroeconomic conditions are transparent. Because of uncertainty about the future, it is also important to consider several competing scenarios. When possible to assign probabilities to various situations, it may be worthwhile to analyze policy impacts through simulations that will derive the statistical distributions of impacts over time and to develop estimations of their expected values and their variability. Note also that when it is possible to identify several distinct scenarios in terms of the macroeconomy and economic growth, it may be feasible to introduce policy implementation policies that are conditional on the performance of the economy.

Public Sector Expenditures

Water quality regulations frequently affect activities conducted by public or semi-public agencies. Water provision and treatment, flood protection, and construction and maintenance of roads serve the public and are provided by public or semi-public agencies. Many schools and hospitals are to a large extent supported by public monies, and are frequently part of the public sector. Stricter discharge limits and other forms of water quality regulations affect the operation costs of public sector entities. Water quality management by the private sector may affect the cost of public agency management. Discharge regulations that reduce waste generated by firms and consumers may reduce the costs of a sewage district. The change in the expenditure of these nonprofit agencies is an important impact category.

It is important to distinguish between impacts of water quality regulations on public sector expenditures (which are discussed in the previous paragraph) and the impacts of regulations that target public sector activities. Regulations that target activities of public sector entities may affect the private sector to the extent that the output of the public sector changes as a result of the water quality regulation. If the regulation does not affect the output of the agency, but does affect its cost of providing these outputs, then the water quality regulation impacts the level of public sector expenditures. For example, if a Department of Public Works needs to increase expenditures to meet water quality regulations, and a government has a balanced budget constraint, either the government has to increase its revenue to meet the extra expense or the government has to somehow cut its costs.

In most cases raising taxes is difficult, so the increase in cost of complying with water quality regulations leads government agencies to reduce expenditures elsewhere. These reduced expenditures have significant welfare impacts. In particular, they may lead to reductions in producer or consumer surplus. For example, an increase in the cost of compliance with water quality regulations may reduce expenditures on health services, education, or maintenance of roads. If governments are able to raise taxes to meet the extra compliance cost, then that will lead to a reduction of the consumer and producer surpluses of affected taxpayers.

One way to assess the importance of extra water quality regulations is to compare the extra cost of affected public sector agencies to the overall budget of these agencies. Policymakers need to know what percentage of agency budgets must be dedicated to comply with extra water quality regulations.

Price Increases and Consumer Effects

Most environmental regulations affect the per-unit cost of producing output, and thus lead to higher market prices. Consumer surplus is the difference between the maximum amount that consumers would be willing to pay for quantities they consume and the actual price they pay. For example, if a person is willing to pay $100 for a suit, and the actual price is $60, then the consumer surplus would be $40. Technically, consumer surplus is the area between the demand curve and the market price. Regulations that lead to increased variable cost result in loss of consumer surplus as well as producer surplus.

A product may be sold to several groups in the economy. Each has its own demand curve. Consider a typical situation where there is a high-income group of consumers whose demand is not price sensitive, and a low-income group whose demand is very sensitive to price changes. Regulations that increase the market price of the commodity would likely cause a much larger relative reduction in the surplus of the lower-income group.

Delay Costs

An extensive regulatory process can be time consuming and can slow the execution of new projects and the utilization of resources. Frequently, land resources lay idle during the period of regulatory assessment and proposal evaluation. The costs of the economic surpluses lost during periods of delay may be quite substantial. If implementation of new water quality regulation may lead to a two month delay in completion of a road or a housing development, the losses to consumers, producers, and the public sector may be substantial.

The delay cost depends both on the extra time needed to assess the action that needs to be taken in light of new water quality regulations, as well as the time needed to implement these extra regulations. For example, extra protection of habitats or stricter wetland regulation may slow the time it takes to obtain a permit and may increase the amount of time that it takes to implement the project. Thus, the developers have to pay more interest and, more importantly, the consumers and producers who benefit from the new development lose all consumer and producer surplus during the delay period. A quantitative estimate of the impact of a new water quality regulation on the time it takes to obtain a permit and to implement a project is very important as a first step in assessing the delay cost. This information should also be available to the public as a way to assess the performance of the Regional Boards.

When assessing delay cost, it is important to recognize that the operations of some industries depend on the weather and thus may be seasonal in nature. For example, there is much less construction activity during the rainy season. Water quality regulations that lead to minor delays for compliance may nevertheless cause a developer to miss an entire construction season. In this case, the regulation may lead to significant delay costs because of the seasonal nature of the industry.

The delaying effects of regulation can also affect economic well-being through their impact on competitiveness. California is the home of some of the most dynamic industries in the world, and they have a fast rate of innovation and many short-lived products. A firm may lose "first mover advantage" and potential market share if its product introduction is delayed because of extra regulatory requirements. It instructive to compare the time it takes to comply with water quality regulation to the expected length of the economic lives of manufacturing facilities and other infrastructure of various industries.

Costs to Regulatory Agencies

Governments have to expand their staff, conduct studies, and establish mechanisms and organizational capacity to monitor and enforce compliance. In particular, new water quality regulations may affect the costs of processing requests for land-use modifications, other natural resource management, and some industrial and infrastructure projects. The regulatory costs incurred in periods of transition to new water quality regulations may be especially high.

If new water quality regulations are introduced without increasing the budget of the regulatory agency, this may lead to stretching its resources and may affect overall performance. The efficiency of agencies in implementing effective regulation may be reduced as the result of expanded mandates. The cost of the water quality regulation may be borne by individuals directly affected by these regulations and also by those affected by other regulations, but are underserved because of the work overload associated with the new regulation. Implementation of regulation is not costless. The regulatory agency has its own cost, and the regulated public also experiences associated transaction and delay costs.

Risk-Risk Tradeoffs and Unintended Environmental Costs

Risks never exist in isolation, and action to combat one risk may create others. At the federal level, agencies are now permitted to consider substitute risks. In the U.S. Supreme Court case *Whitman v. American Trucking Association*, for example, it was argued that while ground-level ozone creates certain health risks, it also reduces others, mainly because it provides protection against skin cancer and cataracts.[50] The EPA responded that it lacked the authority to consider the risks created by regulation. On its own, the statutory text seemed to support the EPA's view. It provided that ambient standards must be based on "criteria" documents that are supposed to include the "latest scientific knowledge" useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities.[51] The EPA argued that the phrase "identifiable effects" of "such pollutant" was meant to refer to the adverse effects of the "pollutant."

An even more suggestive case is *Competitive Enterprise Institute v. National Highway Transportation Safety Administration* where the plaintiff charged fuel economy standards on the grounds that the agency had failed to consider the adverse effects of such standards on automobile safety.[52] In the face of an ambiguous statute, the court reasoned that a full explanation was required for a decision that would seem to create substitute risks. As a result of this decision, the National Highway Traffic Safety Administration is now required to consider health-health tradeoffs in setting fuel economy standards.

Water quality regulation that aims to improve environmental quality can have unintended consequences that harm the environment and natural resources. The reallocation of water from one location to another, to meet water quality regulation, may reduce the well-being of fish and wildlife dependent on the water in the source region. Reduction of use of chemical pesticides that reduce farm productivity may lead to an increase in utilized land and expansion of the utilized land base to wilderness areas. Diversion of water resources to meet environmental quality objectives may reduce the capacity to utilize this water in provision of environmental amenities. We will discuss the economics of changes in environmental quality later in the paper.

User Cost

Water quality regulations may affect natural resources that are either renewable or nonrenewable. For example, reduction in the concentration of chemicals in a certain body of water may require pumping groundwater from an aquifer. The user costs in this case are the future costs of changes in availability of water from the aqui-

50. *Whitman v. American Trucking Ass'n*, 531 U.S. 457, 495 (2001).

51. *Id.* at 473.

52. *Competitive Enter. Inst. v. Nat'l Highway Traffic Safety Admin.*, 45 F.3d 481, 484 (D.C. Cir. 1995).

fer as a result of this activity. The reduction in the aquifer at present would reduce the availability of water in the future and increase the cost of pumping as the aquifer drops farther below the surface. Similarly, one can compute the user cost of reducing the fish population at present (which includes the cost of having the fish in the future, and the lost value of the population growth).

Employment and Multiplier Effects

Any regulatory cost has a direct economic affect on relevant consumers and producers and other economic agents. Regulatory costs may indirectly affect the economy as they affect the income of various parties, which will allow parties to further spend money and engage in other economic activities. There are methodologies to look at this multiplier effect and assess the direct and indirect impact of regulations. In particular, these methodologies can also assess secondary impacts on employment. In most of our analysis, we would not address this multiplier effect but one must be aware of its existence and how it can be derived.

3. General Observation on Cost Analysis

Now that we know the basic cost categories, we can discuss some of the principles of aggregate analysis. In fact, the two methodologies are closely related. In principle, cost effectiveness is nested within cost-benefit analysis. A cost-effectiveness analysis compares interventions in terms of resources expended to achieve some basic objective such as life-years saved or units of habitat restored. Cost effectiveness takes the water quality objective as given, while cost-benefit analysis compares the net economic merits of alternative objectives. A cost-benefit, welfare improvement analysis measures the value of benefits achieved versus the cost of the intervention.[53]

The notion of efficiency is a critical element of economic analysis. Outcomes are said to be efficient if the regulatory objective cannot be met with lower overall costs. Thus, the efficiency criteria merge the overall economic performance of a project or regulation. The efficiency effect of a water quality regulation is a net economic benefit or cost, taking into account all the impacts. For example, a water quality regulation that bans chemicals may affect the well-being of consumers and producers, and yet improve the water quality of a river and result in improved human and environmental health.

53. In economic terminology, these modes of analysis are called “Second Best” and “First Best.”

The difficulty of estimating environmental and resource costs led Baumol and Oates to propose an alternative approach for policy evaluation.[54] They suggest that environmental policy selection will aim to meet environmental policy targets at least cost, and the policymakers are assumed to select these targets. The notion of cost effectiveness is consistent with this approach. It suggests that the market cost of a water quality regulation is a good measure of attaining the environmental policy objective behind them.

Another approach to evaluate the effectiveness of water quality regulation is to consider *internal consistency*. This is especially effective when the main impetus of a regulation is to reduce a certain type of risk (for example, the risk of loss of human lives). By computing the number of expected lives saved, as well as the market cost of compliance to the regulation, one can derive the implicit value of human lives saved. It is desirable that regulations be established so that the value of life saved will be consistent across locations. In cases where the implicit value of life saved is low, the regulation should be stricter. Where it is too high, the regulation should be more lenient.

Scale of Analysis

An impact assessment of water quality regulations can be done from various perspectives, and the assessment of a regulation may vary if it is done from a national versus a regional perspective.[55] For example, water quality regulations that reduce water available to agriculture in California may reduce supply, and thus increase prices and reduce consumer surplus. When most of the buyers of the affected product are out of state, the consumer surplus loss is not taken into account in the impact assessment taken from a California perspective, but is considered in the impact assessment from a national perspective. Similarly, when it comes to goods that are exported abroad, ignoring the impact on consumer surplus of foreign buyers may lead to underestimation of a policy effect. Thus, the national perspective is different than both the regional and the global perspectives.

In most cases, the impact of water quality regulations is local and, therefore, the significance of aggregate analysis is limited. This observation suggests that analyses should be conducted on water basin levels or even lower levels of aggregation. It is important to pinpoint areas that are most affected and have some structure of the distribution of impacts across regions. A certain water quality regula-

54. *See generally* BAUMOL & OATES, *supra* note 12.

55. David Sunding, David Zilberman & Neal MacDougal, *Water Markets and the Cost of Improving Water Quality in the San Francisco Bay/Delta Estuary*, 2 HASTINGS W.-NW. J. ENVTL. L. & POL'Y. 159, 163-64 (1995).

tion may seem to not affect California as whole because it may lead to migration of industries from one region to another. However, as Kahneman and Tversky argue, for a change of a given magnitude, the economic cost of loss outweighs the economic benefits of gain.[56] Therefore, the analysis of distributional effects within the state is very valuable.

The type of information needed in economic analysis may change at different levels of analysis. For example, employment and secondary impacts may be much more important when considering the regional effects of a policy than the national or global impacts. The specific set of distributional impacts needed for different levels of analysis may also be different.

Costs Depend on Implementation

The establishment of water quality standards by themselves is only the beginning of the policymaking and implementation processes that will determine ultimate impacts. First, the regulated public will not modify its behavior merely because regulations are introduced, rather, it has to be convinced that these regulations will be implemented and be aware that there is a system of monitoring and enforcement associated with the regulation. Thus, economic analysis has to develop a system that will predict who will respond to the new regulations and how, given a designed system of implementation.
Second, the capacity of agents to adjust to new regulations depends on the existing rules and constraints faced by the regulated public. Water quality regulation is only one part of a system of rules and regulations that producers may face, and the impact of water quality regulations depends on interaction with other rules and regulations. For example, the impact of a policy that restricts access to certain water supplies will be different whether or not farmers have the capacity to trade or buy water in markets. Sunding et al., showed that the cost of reducing the agricultural water supply due to the Central Valley Project Improvement Act would be 60 percent less if broad-scale water trading were allowed.[57]

Third, the impact of water quality regulations depends on the structure of the markets that are affected by the regulations. In some cases, water quality regulation may affect competitive industries with many small producers, each with a limited capacity to conduct research and development or to construct technologies to adapt to the new regulation. In this instance, public supported research that will

56. Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263, 274-89 (1979).

57. *See* David Sunding et al., *Measuring the Costs of Reallocating Water from Agriculture: A Multi-Model Approach*, 15 NAT. RESOURCE MODELING 201, 220 (2002).

help the industry establish technologies and procedures to deal with the regulation may be very valuable. In other cases, regulated industries may consist of large corporations with a high degree of market power and research capacity, and they may have the internal capacity or know-how to develop effective strategies to respond to regulation.

Costs Depend on Constraints

Entities affected by water quality regulations may be constrained in their ability to raise funds. For example, many water quality regulations affect public sector entities such as counties and cities that operate with limited budgets.[58] The expense needed to meet environmental quality objectives may crowd out the funding needed to pay for education or maintain health services. The extra cost needed to improve water quality to enhance the probability of survival of wildlife may conflict with resources needed to enhance quality of life or health of residents who depend on county services.

These observations imply that a cursory measure of the impact of a new environmental regulation is to assess its share relative to the total budget of the county and the affected agency. Further, it will be useful to compare cleanup expenses with other major budget items of the affected agency.

A more rigorous approach is to assess the incremental value of the public budget. Economists have long recognized that in most instances an extra dollar of cost buys more than an extra dollar of benefits.[59] Minimally, the deadweight loss from taxation should be considered. The bottom line is that the public agency impact must be adjusted, and cases where regulations affect agencies under financial stress must be noted.

In the case of private companies, the principal constraint is solvency. Thus, it is important to consider the effects of regulations on the likelihood of bankruptcy and what it entails in terms of employment, resource use, and income in the region. An important indicator is the extra cost relative to the revenue base or budget of the affected firm. Since 10 percent is a roughly normal rate of profit, an expenditure that is 5 percent of revenue is 50 percent of profit, and may lead to bankruptcy and significantly constrain growth.

58. *See, e.g.*, CAL. WATER CODE § 13247 (West 1992).

59. *See* ANTHONY ATKINSON & JOSEPH STIGLITZ, LECTURES ON PUBLIC ECONOMICS (McGraw-Hill Companies 1980).

4. Economics of Environmental Benefits

Like many other types of environmental regulation, the benefits of water quality regulation (i.e., the economic value of the beneficial uses protected or enhanced) can be divided into several categories. The most useful distinction is between use benefits and nonuse benefits.[60] Use benefits may be consumptive benefits (in the case of fishing) or non-consumptive benefits. One can develop market-related measures to quantify the value of most use benefits.[61] It is more difficult to develop quantitative estimates of nonuse benefits. Demonstrated evidence of willingness to pay for environmental amenities is one indicator of the value of nonuse amenities.[62] Stated willingness to pay provides another type of evidence, but has well-documented problems of reliability and questionable theoretical justification.[63]

Differences Between Market and Non-market Benefits

Much of the beneficial impact of water quality regulations may be on goods that are not necessarily traded in markets. For example, reduction in water supply from a certain location in a river may affect recreational opportunities and the natural ecosystem both of which may provide non-market benefits. As a rule, it is much easier to compute impacts of regulation affecting markets, as opposed to non-market impacts because market prices are usually good indicators of social value.[64] If a policy reduces the availability of certain amounts of traded goods that have a given price, then the product of the price and the quantity is a first-order approximation of the impact. Market prices are not good measures of social values in situations when the market structure is mostly noncompetitive, for example, there is monopolistic pricing. Market prices are also not good indicators of social values in cases of market failures and externalities.

In the case where the water quality regulation generates non-market impacts, the researcher must be creative in developing measures of non-market benefits. Fortunately, several useful approaches have been introduced in the recent years to meet this challenge. Whenever possible, it is useful to infer the value of non-market bene-

60. A. MYRICK FREEMAN III, THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE VALUES: THEORY AND METHODS (2d ed. 2003).

61. *Id.* at 151-52.

62. *Id.* at 153.

63. Report of the NOAA Panel on Contingent Valuation, 58 Fed. Reg. 4601, 4602-09 (Jan. 15, 1993).

64. MAS-COLLEL ET AL., *supra* note 42.

fits from market prices.[65] For example, the value of environmental amenities associated with access to bodies of water may be inferred from the values of properties that are similar in all features, except in their distance from the body of water. The hedonic price approach entails inferring the value of various product characteristics from the prices of market goods that may include these characteristics at various proportions.[66] The travel cost method infers the value of characteristics of a certain body of water by the extra cost associated with traveling that people are willing to pay.[67]

Rather than attempting to compute the value of non-market impacts in monetary terms, it may be beneficial to take an indirect approach and estimate some of the consequences in terms of human and environmental health or other impacts. For example, when considering several alternatives in water quality standards, one may present the market cost and expected lives saved with each policy and stop short of ascribing a monetary value to these changes.

Human Health Impacts

There is a growing body of work on quantifying the health risk posed by environmental contamination to help regulators allocate limited agency resources and set priorities.[68] This work is part of a new form of analysis called risk assessment, a key element of which is the notion of a risk-generating function.[69] Risk is defined as the probability of mortality or other serious damages to the health, and is generated by a sequence of processes including contamination (disposal of chemicals in water), transfer and fate (movement of toxins within water systems), exposure (consumption of contaminated water), and dose/response (vulnerability to exposure).[70] Each of these processes is affected by various factors, including heterogeneity among people, randomness (e.g., weather conditions), and uncertainty about key parameters. Each process may be affected by policy intervention. For example, contamination can be reduced by stricter pollution control, transfer and fate can be affected by barriers to movement, exposure can be changed by introducing alternative sources of water, and dose/response can be affected by availability and quality of medical intervention.

65. *See* FREEMAN, *supra* note 55, at 392-94.

66. James N. Brown & Harvey S. Rosen, *On the Estimation of Structural Hedonic Models*, 50 ECONOMETRICA 765, 765-768 (1982).

67. *See* FREEMAN, *supra* note 55, at 123-24.

68. *See* Erik Lichtenberg & David Zilberman, *Efficient Regulation of Environmental Health Risks*, 103 Q. J. OF ECON. 167, 167-78 (1988).

69. *See Id.*

70. *Id.* at 168-69.

The impact of water quality regulations can be estimated within the existing institutional and policy framework. Given the size of the affected population, the risk can be translated to statistical lives or accidents, and thus the impact of regulation on human health can be quantified. For example, consider the impact of a ban on a chemical that has a probability to cause one in a million cases of disease a year. With an affected population of 7 million people, the ban on the chemical may result in seven fewer cases of the disease on average. If we have a monetary measure of the cost of a case of disease or a statistical value of a life, we can translate the impact into monetary terms. If each case of the diseases costs society $1 million, then the ban on the chemical will result in a gain of $700,000.

Ecosystem Impacts

In the same manner that risk assessment is used to assess damages to human health, it can also be used to assess benefits to wildlife. For example, the expansion of water available to a fishery may reduce mortality and, with quantitative relationships measuring water availability and risk, one can estimate the impact of water quality regulations that enhance water availability on the viability of the fish population. Similarly, one can develop models that assess the impact of various types of regulations on wetland health and various wildlife species. Translating physical measures of environmental health to monetary terms is challenging, but it is easier when there are monetary estimates of values of units of wildlife or members of a species. In some cases, water systems provide recreational benefits that can be estimated, and it is possible to derive the impact of water quality regulations that affect these activities. Diversion of water from one region to another may reduce water availability to recreational activities. The value of the recreation lost is one estimate of the environmental costs.

Neighborhood Effects and Environmental Justice

It is now well known that certain socioeconomic groups often seem to be relatively more concentrated near environmental hazards than in the surrounding community.[71] Since water quality regulations do not have the same effect everywhere, understanding how they address problems of environmental justice is an important aspect of economic impacts that must be addressed.

71. Trudy A. Cameron & Ian T. McConnaha, *Evidence of Environmental Migration*, 82 LAND ECON. 273, 273-290 (2006).

Recent economic research paints a more complex picture of environmental justice considerations than has been available previously. In particular, snapshot cross-sectional statistical analyses cannot reveal how residential mobility for different social groups reacts to changing public perceptions of environmental hazards.[72] Using decennial panel data over four census periods for census tracts surrounding seven different urban Superfund localities, Cameron and Crawford examine how ethnicities, age distribution, and family structure vary over time with distance from these major environmental hazards.[73] If the slope of the distance profile decreases over time, the group in question could be argued to be "coming to the nuisance."

While it appears to be hard to make many generalizations across localities, Cameron and Crawford find a lot of "statistically significant movement, including some evidence of minority move-in and increasing relative exposure of children, especially those in single-parent households."[74] Viewed in this way, environmental justice would appear to be linked with the problem of housing affordability. Some low-income and minority families appear to choose more polluted locations due to the lower housing prices in such neighborhoods. Thus, the analyst must pay careful attention to the impact of water quality regulation on housing affordability, and then use this information to understand the incidence of regulation across various groups in society.

Additional Funding Required to Produce Benefits

Environmental economists have advocated an approach to policy that views the environment as created by a production process, much like more traditional goods. This notion is important in the area of water quality, as regulation is often insufficient to produce the desired beneficial uses. For example, the quality of water in the Los Angeles River may be dramatically improved through more stringent regulation, but there will not be much meaningful improvement in the environment without other accompanying investments in restoration. Pure water flowing through a concrete channel (much of which is fenced and posted with "No Trespassing" signs) will not produce a lot of habitat or be an inviting spot for recreation.

Since both improvement in water quality and accompanying investment are required to produce beneficial uses like swimming and other recreational opportunities, these additional investment needs

72. Trudy A. Cameron & Graham D. Crawford, *Superfund Taint and Neighborhood Change: Ethnicity, Age Distributions, and Household Structure* 2 (Univ. of Or. Econ. Dep't., Working Paper 38, 2003).

73. *Id.*

74. *Id.*

should be called out by the Regional Boards when making decisions. The magnitude of additional investment, together with potential funding sources, would be illuminating in many cases.

5. A Flexible Approach to Economic Analysis Under the Porter-Cologne Act

For statutes like the Porter-Cologne Act in which economic impacts are to be "considered," there is a minimum level of assessment that should be performed. What types of analysis are minimally sufficient to meet the baseline consideration of economics? How should such analysis be accomplished? We now turn to these questions.

Procedure

We believe that the Regional Boards should follow a particular procedure for consideration of economics. The steps in this procedure are the following:

1) A listing of the affected parties, including private industry and government agencies, together with a qualitative description of the impacts;
2) Solicitation of data from the public regarding potential compliance and related costs for the proposed policy;
3) The public's reported cost of compliance in relation to the revenue, cost, and profit margin of affected firms, and relative to the total budget of affected public entities;
4) A statement of what the Regional Board staff thinks the costs are likely to be, which specifically considers the data solicited from the public and the reasons for the Board's estimate;
5) A statement of potential factors that could affect the estimate, such as technological uncertainties, monitoring limitations, etc.;
6) A description of competitive conditions in the affected sectors, and an assessment of whether water quality regulations are likely to place California firms at a significant competitive disadvantage;
7) A statement of the average time needed to obtain permits from the various Regional Boards, and a qualitative assessment of the impacts of delay.
8) A statement of the goals to be achieved by the proposed regulation and an explicit consideration of these goals given the costs (i.e., at least a statement that "the Board believes

that $XX million represents a reasonable expenditure to achieve YY."). This description would include the types and numbers of beneficiaries, and an identification of other investments beyond those resulting from the regulation that are needed to produce the beneficial uses.

Gradual Analysis

It is unlikely that a complete economic analysis will be required in every case. Economic analysis can be expensive, and it is important to be cost-effective when implementing regulation. Rather, we propose a phased approach that distinguishes between minimum analysis and more complex investigations. In particular, we distinguish between:

- I*nitial assessment* to identify possible situations with potential for major impacts. Initial probing will consist of completing a standardized form, providing mostly descriptive information and qualitative assessment.
- D*eeper investigation* of isolated situations. Analysis will be tailored to situations. Rarely will a complete monetization of costs and benefits be required. Instead, we argue for a reliance on quantitative tools used to assess isolated situations where quantitative information is important to policy making.

We are proposing an interactive process for policy assessment. Policy makers will solicit information from the public regarding the magnitude of costs and determine when and how to proceed with analysis (what issues to probe further) based on initial analysis. If the public feels compelled to conduct a deeper and more detailed analysis of impacts, then the Regional Boards should consider these. In cases where aggregate impacts are likely to be significant, or there may be very harmful effects on subsets of firms in an industry, then the Regional Boards should discuss the findings of studies provided by the public or, preferably, present the results of their own analysis.

Elements of a Form for Initial Impact Assessment

In every case, we recommend that the Regional Boards gather a minimum amount of information to ensure that the they live up to the minimum requirements imposed by the Porter-Cologne Act. One approach is to complete a standardized form that will be made public. This form would indicate that the Regional Board staff at least understands economic impacts, and, as discussed earlier, may be used as a trigger for more complete analysis.

Following is an outline of the types of questions that could be included on such a form. Note that we distinguish between impacts on private entities and publicly-owned enterprises.

For Impacts on the Private Sector

1. Identify the affected industry/region combination (e.g., Dairy/Riverside, Electronic Equipment Manufacturing/Sacramento, etc.)
2. Questions for each Industry/Region
    a. Percentage of productive capacity (i.e., output, plants) that is
        i. Affected significantly (more than 5% increase in production cost to accommodate regulation)
        ii. Affected moderately (below 5% increased production costs)
        iii. Not affected
    b. Among those *affected significantly*, what is the relative increase in production cost because of compliance (allow a distribution)
        i. 10% increase for 50% of capacity
        ii. 15% increase for 50% of capacity
        iii. Etc.
    c. Impact of regulation on output price
        i. Negligible
        ii. Low (below 2%)
        iii. High (2% or above)
    d. Cost of initial adjustment to regulation
        i. Negligible
        ii. Modest
        iii. High (explain)
    e. Percentage of firms that may face insolvency problems
        i. None
        ii. Less than 5%
        iii. Between 5-10%
        iv. Higher (give a rough estimate)

For Impacts on Publicly-Owned Activities

1. Identify the affected agency/region combinations (e.g., S.F. Unified School District, Fresno Sewage District, etc.)
2. Questions for each Agency/ Region
    a. Percentage of activities (i.e., output, plants) that are

    i. Affected significantly (more than 5% increase in cost)
    ii. Affected moderately (below 5% increase in cost)
    iii. Not affected
b. Among those *affected significantly*, indicate the relative increase in cost because of compliance (allow a distribution)
    i. 10% increase for 50% of capacity
    ii. 15% increase for 50% of capacity
    iii. Etc.
c. Availability of new fees or other income to pay for regulation
    i. Unavailable
    ii. Increased budget allocation will pay for ________% of extra cost
    iii. Higher fees will pay for ________% of extra cost
d. Impact of regulation on services provides (both on volume and quality)
    i. Negligible
    ii. Low
    iii. High (explain)
e. Percentage of clients that may not be served
    i. None
    ii. Less than 5%
    iii. Between 5-10%
    iv. Higher (give a rough estimate)
f. Cost of initial adjustments to regulation
    i. Negligible
    ii. Modest
    iii. High (explain)

Other Impacts – Completed for All Regulations

1. Employment effects
    a. Positive
    b. Negligible
    c. Small (between 1 and 5%)
    d. High (above 5%)
2. Effects on resources and the environment
    a. None
    b. Minor
    c. Major (specify)
3. Impacts on expansion or future investment

   a. None
   b. Minor
   c. Major (specify)
4. Delay of expansion (when appropriate) because of compliance requirements. For each major activity,
   a. Specify it
   b. Length of delay (in units of days and month)
   c. Relative magnitude of delay
      i. Negligible
      ii. Minor
      iii. Major (explain)

6. Conclusions

The California Porter-Cologne Act regulates the discharge of waste into ambient waters and authorizes Regional Boards to impose requirements on waste dischargers. Before a Regional Board can impose these requirements, however, it "shall take into consideration" the following factors: "the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the provisions of Section 13241."[75] Section 13241 in turn lists six "factors to be considered," including "economic considerations" and "water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area."[76]

While the requirement to consider economics under Porter-Cologne is absolute, the legislature and the courts have done little to particularize this requirement. A main objective of our paper is to describe the ways in which water quality regulations can affect the economy. Some of these impacts are fairly obvious and easy to quantify. Others are subtler, or depend on complex interactions among firms or even sectors of the economy. Economic impacts can sometimes be limited to a small number of well-defined groups. Often, however, many groups will be implicated, especially if impacts are propagated through market interactions.

Despite the frequent complexity of real-world economic impacts, one of our main goals in this paper is to articulate and defend a baseline set of tasks that need to be performed to achieve the minimally adequate "consideration" of economic impacts under Porter-Cologne. We propose a several-step procedure for compiling information on economic impacts. This procedure entails an interactive approach to decision-making that would allow the public a

75. CAL. WATER CODE § 13241.
76. *Id.*

chance to air its concerns and present relevant data, and would oblige agencies to give a rationale for their decisions without imposing any requirements about how the results of economic analysis figure into final decisions.

While adoption of these procedural steps would be an advance, they do not answer the question of *how* economic impacts are to be measured. We propose a series of economic impact tests that are relatively easy to interpret and are at least rough measure of the economic impacts caused by water quality regulations.

Of course, in some situations, large impacts will be apparent, and more detailed analysis will be required. In these cases, our general discussion of the economic effects of water quality regulation will provide guidance to analysts at the Regional Boards and to the regulated community. It is worth reinforcing that traditional economic analysis may not always be adequate to capture the effects of regulation. In particular, water quality regulation may alter the conditions of competition in an industry, result in firms relocating to other areas, may cause delay and result in lost flexibility, cause insolvency, result in unintended risks, have dynamic consequences (especially when regulations result in capital replacement), and affect the operation of public sector facilities. These effects are all somewhat outside the bounds of traditional economic analysis of regulation, but are examples of factors that should be considered in the case of Porter-Cologne.

Appendix

Effective modeling of the impacts of water quality regulations raises a number of technical issues, particularly with regard to calculation of the benefits of improving water quality. Three issues that come to mind immediately are modeling of risk generation, discounting, and sensitivity analysis. Risk generation refers to the physical and biological processes that produce risk to water users and the environment. Understanding the economics of risk generation is essential for adequate modeling of the impacts of policy interventions that can improve water quality. This is an under-researched area in environmental economics, but one with a great deal of potential.

Discounting and sensitivity analysis are better understood, although few water quality regulations have been analyzed with state of the art treatments of these issues. Discounting is especially important since the choice of alternative discount rates can have a large effect on the calculated net benefits of a regulation. Issues that should be considered by the analyst include the choice of an appropriate public sector discount rate, and the wisdom of using a time-invariant discount rate as opposed to a discount rate that falls over the time horizon of the analysis.

Effective Modeling of the Risk Generation Process

Water quality regulations frequently aim to reduce risk to the health of humans and wildlife. Much of the literature on risk analyzes financial risk, and modeling environmental health risks requires its own framework that is interdisciplinary in nature and takes into account the scientific knowledge on the processes that threaten the health and survival of living system. Such a framework would introduce the study of public health and is used in the process of risk assessment by environmental agencies.[77] Lichtenberg and Zilberman have developed an economic decision-making framework that utilizes the risk-generation model of the risk assessment literature.[78]

In our context, risk is defined as probability that a member of a population will die or get ill during a certain period of time. For example, it may be the probability of deaths from drinking water during a season. The key element in the risk assessment literature is the risk-generation function which presents this risk as a final product of several processes, including contamination (which is a disposal of

77. *See* KENNETH T. BOGEN, UNCERTAINTY IN ENVIRONMENTAL HEALTH RISK ASSESSMENT (Taylor & Francis 1990).

78. *See* Erik Lichtenberg & David Zilberman, *Efficient Regulation of Environmental Health Risks*, 103 Q. J. OF ECON. 167, 167-78 (1988).

waste product or toxic material to a body of water at certain locations and given points in time), transfer and fate (which is the process of movement of contaminants over a space in time), exposure (the intake of toxic materials by vulnerable species, and dose-response (the measure of vulnerability to the toxic material that can be affected by treatment). Each of these processes can be affected by policies:

C*ontamination* is affected by pollution control incentives and regulation. For example, the amount of animal waste that can reach a body of water can be reduced by barriers imposed by law or by incentives that may reduce population size or lead to a better containment of waste material.

T*ransfer and fate* may be affected by barriers (including dams, walls, nets, and filters) that may be built in a response to incentives that may vary over time.

E*xposure* is determined by the behavior of the vulnerable species and can be affected by infrastructure (filtering facilities to protect water quality) and extra caution (by consuming alternative sources of water, including bottled water, that may be induced by policy and by wearing protective clothing to reduce dermal exposure).

D*ose response* is the vulnerability to dosage, which varies among individuals according to weight, health, and can be affected by medical treatment.

Each element of the risk-generation process is subject to variability. The sources of variability may be random. For example, the contamination and transfer and fate processes are highly influenced by weather conditions. The variability may be the result of heterogeneity. For example, the dose-response process depends on the characteristic of individuals involved. Furthermore, the policy analyst doesn't have full information about the parameters governing these four processes. The uncertainty about various parameters contributes to the variability of the risk estimates. Formally, if R is risk the risk generation function is

$$R = f_1(X_1, \varepsilon_1) * f_2(X_2, \varepsilon_2) * f_3(X_3, \varepsilon_3) * f_4(X_4, \varepsilon_4)$$

where $f_1(X_1, \varepsilon_1)$ is the contamination component, and it is a function of pollution control policies denoted by and the random element ε_1. Similarly, $f_2(\cdot,\cdot), f_3(\cdot,\cdot), \text{and} f_4(\cdot,\cdot)$ denote the transfer and fate, exposure, and dose response elements of the risk generation function, respectively.

Quantitative risk assessment generates estimates of risk with certain degrees of variability. These estimates may be the expected value of the risk or a certain point of the risk distribution. For example, one estimate of risk is the probability of deaths of members of the population that would occur with a probability smaller than 5 percent. The cost of the regulation is a function of the policy measures denoted by $C(X_1, X_2, X_3, X_4)$. In this formulation, $\bar{R}$ denote the level of risk attained with a probability α, and $\bar{C}$ is the upper limit of regulatory cost. The optimization problem is

$$\min_{\bar{R}, X_1, X_2, X_3, X_4} \Pr\left[(R < \bar{R})\right] \leq \alpha$$

$$subject\ \ to\ C(X_1, X_2, X_3, X_4) \leq \bar{C}$$

With this formulation, there is a tradeoff between the degree of reliability of the containment of the risk and the upper bound imposed on risk with this reliability factor. Namely, there is a tradeoff between $\bar{R}$ and α. An increase in the cost constraint $\bar{C}$ is likely to reduce the upper bound of risk $\bar{R}$ for any degree of reliability.

The Importance of Consistency in Risk Regulation

Economic analysis requires a significant amount of judgment and creativity in designing and implementing assessment procedures, but one must avoid arbitrary choices in doing so. The same set of problems should be analyzed using the same procedures and decision criteria. For example, the same techniques should be used to assess non-market benefits and non-market costs. If hedonic prices are used to assess the cost of loss of a certain category of environmental amenities, they should also be used to assess benefits of gaining the same category of environmental amenities. Similarly, when risk estimates are derived, they will be obtained with the same degree of statistical significance.

Since much of the water quality regulations are aimed to control a random and risky outcome, it is important that the modeling of the risk-generating process in various applications will be consistent. The estimators of the parameters of the risk generation process (i.e., the parameters of contamination, transfer and fate, exposure, dose/response, etc.) are shrouded with a high degree of uncertainty. Frequently, policy analysts may not use the expected value of the unknown parameter as an estimate, but rather a value at the tail of the distribution that has a very low likelihood to be exceeded.

For example, the value of the 95th percentile of the distributions of the exposure and dose/response parameters may be used to compute a risk estimator. This will lead to high estimators of risk. When the policymakers are not aware of the estimation approach, these high values will lead to strict regulation. Thus conservative estimation techniques are leading to "creeping safety."[79] It is useful to require the technical risk estimates to be used in policy analysis will be consistent in the sense that they will present the same point at the final risk distribution. For example, if policymakers are more comfortable to use the 95th percentile of the overall risk distribution as an estimator of risk, so be it as long as all studies are using the same point of the risk distribution.

The treatment of risk estimates is related to another important policy choice regarding the design of water quality regulations addressing risky outcome. Policymakers sometimes may apply the so-called "precautionary principle," and establish regulation to eliminate all risk or reduce the likelihood of risk to a negligible level. Since one cannot avoid risk, an attempt to eliminate risk may result in high economic cost and may generate new risks.

Discounting

The impact of water quality regulations may last over a long period of time, thus it is especially important to have weighted indicators that account for temporal differences. Discounting is used for this purpose and the net present value (NPV) of any benefit or cost category is a sum of the benefit and cost discounted. For example, the measure of producer surplus in our analysis is the NPV of producers' surplus over a period of time. Let PS_t define the temporal producer surplus at period *t*, PS, which is the net value of producer surplus, is:

$$PS = PS_0 + \frac{PS_1}{1+r} + \frac{PS_2}{(1+r)^2} + \frac{PS_3}{(1+r)^3} + \ldots \frac{PS_n}{(1+r)^n}$$

where *r* is the interest rate. The choice of this discount rate matters. Higher discount rates reduce weight given to future stream or benefits or cost. Thus, if the costs of building a dam are immediate and the benefits are far into the future, the transition from a discount rate of 6 percent to 10 percent may lead to a transition from a positive NPV that support undertaking the project to a negative NPV that suggests that the project is not economically efficient and, from an economy perspective, it is better that money will be spent on other projects.

The interest rate reflects human impatience and preference to consumers sooner rather than later, and the productivity of assets that results from investment choices. The interest rate is an equilibrium outcome reflecting a balance between the demand of borrowers

79. *See* KENNETH T. BOGEN, UNCERTAINTY IN ENVIRONMENTAL HEALTH RISK ASSESSMENT (Taylor & Francis 1990).

and the supply of lenders. In reality, there are many interest rates reflecting different conditions and contingency associated with various loans and investments. In assessing water quality regulations we have to distinguish between the interest rate used to assess the NPV of a firm that has to invest in pollution control equipment and the social benefit from improved environmental conditions over time. When considering the interest costs of a specific firm, one has to use the interest rate that the firm is paying. A risk-free interest rate paid or received by consumers is appropriate for discounting consumer benefits over time. If the benefits are projected in nominal terms and one expects inflation, the interest rate should be the real interest rate (a risk-free interest rate paid to consumers for savings accounts or government bonds) plus the rate of inflation. For example, an appropriate interest rate for the period 2000-2004 is between 5 percent and 6 percent. The real interest rate for consumer was about 4 percent with a 2 percent inflation rate.

Recent studies have shown that consumers' behavior frequently is not consistent with assuming a uniform interest rate that applies to choices of different duration. People behave in a manner consistent with hyperbolic discounting.[80] Namely, the interest rate declines over time. People are more willing to delay consumption from tomorrow to the next day than from today to tomorrow. We do not have sufficient empirical information to operationalize this concept. However, it suggests that the benefits in the far future should be evaluated with a lower interest rate than benefits in the short term.

Sensitivity Analysis

Impact assessment is not a precise science, especially given the high degree of variability resulting from the macroeconomic cycles, political uncertainty, randomness of weather, and the uncertainty about human behavior and the value of key parameters that drive the system. Therefore, it is important to investigate the robustness of results of economic analysis to changes in value of key parameters. That suggests that economic analysis will result in computerized routines that can be modified and easily adjusted to conduct sensitivity analysis. Several aspects of the systems should be emphasized in the sensitivity analysis.

1. *Sensitivity of results to specification of cost and demand parameters* Policies with a strong effect on the private sector are likely to impact the economy through their impacts on the welfare of both consumers and producers, and both depend on the specifications of demand and supply functions of

80 M. Weitzman, *Gamma Discounting*, 91 AM. ECON. REVIEW 260 (March 2001).

various goods. In these situations, the robustness of the water quality regulation is likely to depend to a large extent on the sensitivity of results to demand and cost parameters.

2. *Sensitivity of results to assumptions of value to statistical life and risk parameters*
   The main purpose of water quality regulations is to reduce human and environmental health risks and their costs. Policymakers need to have some estimate on the likelihood that proposed regulation will reach their objectives and, if not, what can be done about it.
3. *Discounting and treatment of capital expenditure*
   The impact of regulation overall and specifically on the affected industries depends to a large extent on the treatment of discount factors' use and how capital expenditures are treated. That is especially the case in projects with long economic life and where large investment are taken early in life of the project.
4. *Underlying economic conditions*
   The macroeconomy has been recognized as the main driver of some of the more export-oriented sectors of the California economy. The demands of all sectors of water depend on the macroeconomic conditions and precipitation. Comparative analysis that will present estimates of sensitivity of outcomes to macroeconomic conditions will allow us to identify situations where the performance will be problematic and suggests what to do about it.