7-2004 34 ELR 10605

ELR
NEWS & ANALYSIS

Two-Sided Emissions Allowance Markets and the Self-Correction Criterion

by Stefani C. Smith

I. Introduction

The fundamental questions in environmental law and policy are: what role should the government play in environmental control; what is the target level of environmental quality and how is it determined; and, if the government is to act as regulator, what policy instrument should be used.[1] Answers to these questions are extremely varied.

At one end of the ideological spectrum, many free-market environmentalists would restrict government involvement to, at most, that of property rights protector within a framework of property rules and liability laws.[2] Activists and scholars at the other end of the spectrum advocate full government control in which policymakers and regulators would explicitly determine environmental targets and production decisions (such as technology and output) through command-and-control tools.[3]

Most policies lay somewhere between these extremes, specifying market-based tools in some arenas and full command-and-control regulation in others. In this middle-ground, a debate rages over the effects and the desired characteristics of environmental policy tools.[4] Without taking a stand on the larger debate about the role of markets in environmental control, this Article addresses policy instrument choice at that margin.

Broadly specified, available policy instruments include property rules, liability laws, tradeable allowance markets, emissions taxes, abatement subsidies, information programs, emissions standards (quotas), and technology standards.[5] These instruments have been evaluated according to their performances under a wide variety of criteria including: minimization of the costs of achieving a given target (cost-effectiveness)[6]; incentives to innovate (dynamic efficiency)[7]; feasibility and efficacy concerns such as administrative burden, monitoring costs, transactions costs, information requirements, legal feasibility, and public acceptance[8]; and equity[9] and ideological considerations such as environmental justice[10] and the "polluter-pays principle."[11]

The theoretical performance of environmental policy instruments under these criteria has been well-catalogued.[12] And, as a result, support is growing in favor of the more market-based tools over command-and-control.[13] For ex-

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1. Formulations of the environmental policy process are included in Richard B. Stewart, *A New Generation of Environmental Regulation*, 29 Cap. U. L. Rev. 21, 152 (2001).
2. Terry L. Anderson & Donald R. Leal, Free Market Environmentalism (2001); Terry L. Anderson & Donald R. Leal, Enviro-Capitalists (1997); Bruce Yandle, The Political Limits of Environmental Regulation (1989); Jonathan H. Adler, *Free & Green: A New Approach to Environmental Protection*, 24 Harv. J.L. & Pub. Pol'y 653 (2001).
3. Howard Latin, *Ideal Versus Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reform*, 37 Stan. L. Rev. 1267 (1985); Thomas O. McGarity, *Radical Technology-Forcing in Environmental Regulation*, 27 Loy. L.A. L. Rev. 943 (1994); Sidney A. Shapiro & Thomas O. McGarity, *Not So Paradoxical: The Rationale for Technology-Based Regulation*, 1991 Duke L.J. 729 (1991).
4. Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era From an Old Idea?*, 18 Ecology L.Q. 1 (1991); Peter Bohn & Clifford S. Russell, *Comparative Analysis of Alternative Policy Instruments*, *in* 1 Handbook of Natural Resource and Energy Economics 395 (Allen V. Kneese & James L. Sweeney eds., 1985); Giandomenico Majone, *Choice Among Policy Instruments for Pollution Control*, 2 Pol'y Analysis 589 (1976); Kenneth R. Richards, *Framing Environmental Policy Instrument Choice*, 10 Duke Envtl. L & Pol'y F. 221 (2000).
5. Stewart, *supra* note 1.
6. Barry C. Field & Martha K. Field, Environmental Economics: An Introduction 184 (2002).
7. *Id*. at 187.
8. *Id*. at 189, 191.
9. *Id*. at 185.
10. Robert D. Bullard, *Environmental Justice for All*, *in* Unequal Protection: Environmental Justice & Communities of Color 3, 10-11 (Robert D. Bullard ed., 1994); Lily N. Chinn, *Can the Market Be Fair and Efficient? An Environmental Justice Critique of Emissions Trading*, 26 Ecology L.Q. 80 (1999); Luke Cole, *Empowerment as the Key to Environmental Protection: The Need for Environmental Poverty Law*, 19 Ecology L.Q. 619 (1992).
11. Richards, *supra* note 4.
12. For summary evaluations of price- and quantity-based instruments, see Part III, *infra*. For other instruments, see Daniel H. Cole & Peter Z. Grossman, *When Is Command-and-Control Efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection*, 1999 Wis. L. Rev. 887 (1999); Gloria Helfand, *Standards Versus Standards: The Effects of Different Pollution Restrictions*, 81 Am. Econ. Rev. 622 (1991).
13. *See* Robert N. Stavins et al., Project 88—Round II: Incentives for Action: Designing Market-Based Environmental Strategies 92 (1991). For evidence of growing support and use of permit-markets, see Nathaniel O. Keohane et al., *The Choice of Regulatory Instruments in Environmental Policy*, 22 Harv. Envtl. L. Rev. 313, 317-18, 365 (1998). However, it should be noted that the growing consensus in favor of market-based tools is mostly theoretical. Actual policy has been quite varied and may be explained more by the political process than by explicit policy evaluation. *See* Robert W. Hahn, A Primer on Environmental Policy Design 59 (1989); Robert W. Hahn & Albert M. McGartland, *The Political Economy of Instrument Choice: An Examination of the U.S. Role in Implementing the Montreal Protocol*, 83 Nw. U. L. Rev. 592, 609 (1989); Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders*, 3 J. Econ. Persp. 95 (1989); Adler, *supra* note 2.

ample, environmentalist Dave Forman, co-founder of Earth First!, has stated that "we should try free market and voluntary solutions first, and federal government solutions only later."[14] The trend toward support of market-based solutions is reinforced by emerging empirical evidence of success in experimental allowance markets implemented as part of the 1990 Clean Air Act (CAA) Amendments[15] and Los Angeles' Regional Clean Air Management (RECLAIM) program.[16] But a core of skepticism persists regarding the wisdom of widespread and deepening use of market-based tools in environmental policy.[17]

One prominent manifestation of the debate between market-based and command-and-control instruments is the question of whether quantity-based tools such as emissions standards and traditional allowance markets are more desirable for air quality issues such as sulfur dioxide (SO_2) control than price-based tools such as emissions taxes. Relying heavily on seminal theoretical contributions in environmental economics,[18] legal scholars have made policy recommendations based on the conclusion that, in the presence of uncertainty about marginal abatement costs, no unequivocal argument can be made for either price-based or quantity-based controls.[19]

But recent contributions in environmental economics expand upon the traditional approach to emissions allowance markets to consider how pollutees' purchase of emissions allowances affect market performance.[20] Traditional allowance markets are said to be one-sided in that only polluters participate in the market. In contrast, two-sided emissions allowance markets are markets in which both polluters and pollutees participate. One implication of the exploration of two-sided markets is that the analysis of traditional one-sided allowance markets understates the social welfare benefits of emissions allowance markets. Second, the economic analysis of pollutees' participation in the allowance market provides new support for allowance markets purely on equity grounds. Finally, considering recent pollutee participation in allowance markets,[21] environmental policy recommendations need to incorporate this fuller understanding of allowance market benefits.

In Parts II and III, I review the evaluative criteria that directly pertain to the relative merits of price- and quantity-based control instruments. In Part IV, I present two-sided emissions allowance markets, markets that specifically allow market participation by pollutees, and then evaluate those markets relative to traditional price-based (taxes and fees) and quantity-based (standards and one-sided allowance markets) instruments.

The analysis of two-sided allowance markets also brings to light a new and important criterion for evaluating environmental policy tools. In Part V, I articulate the *self-correction criterion*, the principle of assessing a policy according to its ability to naturally adjust for errors in emissions target selection.[22] Policymakers using this criterion will favor two-sided allowance markets, markets in which pollutees and polluters both directly participate, over traditional quantity-based and price-based controls in the presence of uncertainty about environmental costs and benefits. And favoring two-sided allowance markets will not only promote efficiency but will directly improve the welfare of pollutees.

II. Existing Evaluative Criteria

The list of evaluative criteria for environmental policy instruments includes efficiency, cost-effectiveness, information requirements and costs, monitoring and compliance costs, regulatory costs, adaptability and flexibility, efficacy, political constraints, transparency, various equity considerations, and size of government.[23] In this section, only those

14. Dave Forman, *Am I a Free Market Environmentalist?*, 14 PERC Reps. 1 (Mar. 1996).

15. 42 U.S.C. §403 (2000).

16. *See* Robert N. Stavins, *What Can We Learn From the Grand Policy Experiment? Lessons From SO_2 Allowance Trading*, 12 J. Econ. Persp. 69, 71 (1998); Dallas Burtraw, *The SO_2 Emissions Trading Program: Cost Savings Without Allowance Trades*, 14 Contemp. Econ. Pol'y 79 (1996); J. Clarence Davies & Jan Mazurek, Pollution Control in the United States: Evaluating the System 135-46, 279 (1998); Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 Stan. L. Rev. 1333 (1985); Robert W. Hahn & Gordon L. Hester, *Marketable Permits: Lessons From Theory and Practice*, 16 Ecology L.Q. 361, 363.

17. Robert W. Hahn et al., *Environmental Regulation in the 1990s: A Retrospective Analysis*, 27 Harv. Envtl. L. Rev. 377, 411 (2003), discusses how the efficiency and cost-effectiveness criteria (use of which tend to favor market-based instruments) often clash with the equity criterion. Some skeptics argue that market-based tools do not give strict enough control, cannot guarantee superior performance, and are open to exploitation of loopholes (Stewart, *supra* note 1, at 22-23). *See also* C. Boyden Gray, *Obstacles to Regulatory Reform*, 1997 U. Chi. Legal F. 1, 7 (1997) (unprincipled resistance to policy change exists in rent-seeking behavior by interest groups); *id*. at 10 (perceived media bias toward "big government" is cited as an obstacle to reform). Cole & Grossman, *supra* note 12, and Richards, *supra* note 4, at 226, argue that the efficiency claims of market-based instruments over command-and-control instruments are overstated. Rena I. Steinzor, *Reinventing Environmental Regulation: Back to the Past by Way of the Future*, 28 ELR 10361, 10362 (July 1998), believes that "next-generation" strategies could have a deleterious effects on the environment.

18. Martin Weitzman, *Prices vs. Quantities*, 41 Rev. Econ. Stud. 477-91 (1974).

19. Richards, *supra* note 4.

20. "Pollutee" is used to designate those harmed by emissions. The new contributions in the environmental economics literature are Stefani C. Smith & Andrew J. Yates, *Optimal Pollution Permit Endowments in Markets With Endogenous Emissions*, 46 J. Envtl. Econ. & Mgmt. 425-45 (2003); Stefani C. Smith & Andrew J. Yates, *Should Consumers Be Priced Out of Pollution Permit Markets?*, 34 J. Econ. Educ. 181-89 (2003); John Boyd & John Conley, *Fundamental Nonconvexities in Arrovian Markets and a Coasian Solution to the Problem of Externalities*, 72 J. Econ. Theory 388-407 (1997); and David A. Malueg & Andrew J. Yates, *Citizen Participation in Pollution Permit Markets* (University of Richmond Department of Economics, Working Paper, 2003).

21. In 1995, law students from seven midwestern and northeastern law schools purchased SO_2 permits at the Chicago Board of Trade as part of an effort initiated by Richard Facclo, president of the Environmental Law Coalition at the University of Michigan. *Law Students Buy and Hold Pollution Rights*, N.Y. Times, Mar. 31, 1995, at A28. The cumulative SO_2 allowance retirement for 2003 was 7,829 tons. Press Release, Acid Rain Retirement Fund (ARRF), Legal Right to Emit 14,000 Pounds of Air Pollution Purchased (Mar. 26, 2003) (available from Michael S. Hamilton, Secretary-Treasurer and Founder of the ARRF, and Associate Professor of Political Science at the University of Southern Maine). That is more than the annual allocation for approximately 44% of the largest SO_2 emitters in the United States and is approximately 3% of the number of allowances auctioned by the U.S. Environmental Protection Agency (EPA) each year. *Id*. EPA's website at http://www.epa.gov/airmarkets/trading/buying.html provides links to environmental groups such as the Clean Air Conservancy and the ARRF that participate in permit retirement. Of course, anyone can participate in the EPA auction or can buy permits directly from permit brokers. The website provides information about both methods.

22. As is discussed in Part V, the self-correction criteria is distinct from adaptability and reflexivity.

23. See Richards, *supra* note 4, for an exhaustive survey.

criteria that directly bear on the evaluation of price-based and quantity-based policies and in the evaluation of two-sided allowance markets are presented.

A. Efficiency

Efficiency is the maximization of net social benefits, that is total social benefits less total social costs.[24] For example, the efficient level of SO_2 is the emissions level that maximizes polluters' emissions benefits (saved costs of abating industrial emissions or automobile emissions) minus the social damages from emissions (aesthetic losses from smog, health care costs due to respiratory damage, etc.).[25]

Efficiency is achieved when the marginal social benefit[26] from emissions is equal to the marginal social cost[27] of emissions.[28] To see this, refer to Figure 1 and consider starting from the e* level of emissions. From there, a decrease in emissions will benefit society by the amount *b* in the form of less smog, less respiratory damage, etc. But that benefit will be smaller than $a + b$, the additional cost society must bear to achieve the pollution reduction (*abatement*). Similarly, an increase in emissions will reduce abatement costs by *d*, but that reduction will be smaller than the increase in pollution damages to society given by $c + d$. Therefore, any departure from the equimarginal emissions level e* necessarily decreases net social welfare.

The *efficiency criterion* is the principle of preferring policies that yield efficient outcomes to those that do not.[29] In the framework of the debate between price- and quantity-based instruments for pollution control, the efficiency criterion is actually a meta-criterion in that it involves an evaluation of the environmental target itself. In contrast, choosing between price- and quantity-based controls based on criteria such as cost-effectiveness or equity involves the evaluation of the *means* of achieving a particular target while not directly evaluating the target.[30]

It should be noted that the efficient outcome is an abstraction that may not be operationally identifiable.[31] Identifying an efficient outcome in practice requires a full accounting of all social benefits and costs, a difficult and costly undertaking.[32] For example, the social cost of reducing emissions is not simply the current firms' costs using their *existing* technology.[33] Rather, the social cost of abatement is the opportunity cost—what the value of resources used in abatement would be if they were employed in their next best alternative.[34] The costs used to identify an efficient outcome are those of the theoretical least cost method of reduction.[35]

For this reason, applied cost-benefit analysis, an attempt to actually measure social benefits and social costs, should not be taken to be equivalent to efficiency. In practice, cost-benefit analysis is subject to mis-measurement and non-measurement of some benefits and costs.[36] Furthermore, as both sides of the environmental politics debate have occasionally argued, applied cost-benefit analysis is also subject to manipulation by policymakers and regulators.[37]

A critical issue regarding the abstract nature of the efficiency criterion is revealed when considering uncertain benefits and uncertain costs of emissions reduction. True social benefits and true social costs do exist. But those true costs and benefits may be necessarily unidentifiable or uncertain at the time of policymaking.[38] As a result, any policy tool that requires resolution of the uncertainty regarding benefits and costs in order to achieve the efficient outcome will necessarily fare poorly under the efficiency criterion. Conversely, those policy tools that do not depend on prior knowledge of the efficient outcome in order to approach the efficient outcome in practice will fare better under the efficiency criterion.

B. Cost-Effectiveness

A method of emissions reduction is *cost effective* when a given emissions target is achieved in the manner that is least costly to society.[39] It should be clear that because cost-effectiveness does not address what the emissions target is, cost-effectiveness does not imply efficiency. That is, an inefficient target may be reached in a cost-effective manner.[40] Conversely, if a policy is efficient, it also must be cost effective—if the right *level* of emissions has been achieved but not in the least cost manner, then net social benefits could have been higher because the same social gains from pollution reduction could have been achieved using fewer of society's resources. As a result, "for a policy to be efficient it must be cost-effective, but not necessarily vice versa."[41]

24. The concepts of efficiency, cost-benefit analysis, and cost-effectiveness described herein are the standard economics conceptions. *See, e.g.*, Field & Field, *supra* note 6, or Tom Tietenberg, Environmental and Natural Resource Economics (1984).
25. *See* Field & Field, *supra* note 6, at 100-02.
26. Marginal social benefits are the change in benefits resulting from a one unit change in emissions.
27. Marginal social costs are the change in social costs resulting from a one unit change in emissions.
28. This is called the *equimarginal* point. See Field & Field, *supra* note 6, at 60-62, 100-02, for a description of the equimarginal principle and for an application in context of environmental costs and damages.
29. Richards, *supra* note 4, at 228.
30. *Id.* at 239.
31. But not being able to identify an efficient outcome does not mean that it is not achievable in the same way that not knowing a fact does not mean that the fact does not exist.
32. See Field & Field, *supra* note 6, at 118-35, for a discussion of environmental cost-benefit analysis; Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem*, 1997 U. Chi. Legal F. 293, discusses the difficulties of cost-benefit analysis. *See also* U.S. EPA, The Benefits and Costs of the Clean Air Act, 1970 to 1990, at ES-10 (1997); Adler, *supra* note 2.
33. Field & Field, *supra* note 6, at 97-98.
34. *Id.* at 54.
35. *Id.* at 171.
36. In summarizing a leaded gas phaseout project, Field & Field, *supra* note 6, at 122, states: "There were other anticipated benefits, and a few costs, that the phase-out would produce, but these were not included in the study because of difficulties in measuring them." The original study was presented by Albert L. Nichols, *Lead in Gasoline*, *in* Economic Analysis at EPA, Assessing Regulatory Impact (Richard D. Morgenstern ed., Resources for the Future 1997).
37. For a discussion of the history and controversy of cost-benefit analysis, see Stewart, *supra* note 1, at 40. *See also* U.S. EPA, *supra* note 32; Field & Field, *supra* note 6, at 119, 171; Adler, *supra* note 2.
38. A summary of economic risk analysis is given in Field & Field, *supra* note 6, at 131-34.
39. *Id.* at 115-16.
40. *Id.*
41. *Id.* at 184.

Cost-effectiveness is achieved when polluters' marginal abatement costs are all equal.[42] If one polluter's marginal abatement cost is higher than another polluter's, then total abatement costs can be reduced by allowing the high cost abater to abate a little less and allowing the low cost abater to abate a little more.

Cost-effectiveness is a less controversial criterion than efficiency[43] because cost-effectiveness has nothing to say about the environmental target itself.[44] In the 1990s, the efficiency criterion was controversial within the Clinton Administration but embraced by the U.S. Congress.[45] But:

> [C]ost-effectiveness as a criterion for adopting specific policy instruments was embraced by both the Administration and Congress in the 1990s. Most interest groups in the environmental community and the regulated community could support cost-effectiveness because it reduced the burden of compliance on industry and made stringent environmental targets more affordable.[46]

C. Equity

Several equity considerations are gaining momentum in the environmental literature. For example, "environmental justice" involves questions regarding the social desirability of the distribution of benefits and costs of abatement across socioeconomic groups within an economy.[47] And environmental ethics arguments advocating ideologies such as the polluter-pays principle[48] are typically ground in equity claims. In Part V of this Article, equity considerations arise in connection with two-sided allowance markets—markets in which those who are negatively affected by pollution can explicitly engage in market activity that influences environmental outcomes. This possibility of participation is argued to be more equitable than environmental control instruments that remove pollutees from the process of determining environmental outcomes.

III. Performance of Policy Tools

In order to better inform the evaluation of two-sided allowance markets introduced in Part IV, here I provide a brief summary of traditional price- and quantity-based tools and their performance records.

A. Quantity-Based Tools

Quantity-based instruments control emissions by directly controlling the level of emissions. For example, emissions standards (quotas) and one-sided allowances require a policymaker or regulator to identify an overall target level of emissions and then assign caps to individual polluters as a means to achieve the overall target.[49] In some emissions standards programs, leniency provisions such as bubbles, netting, and offsets are introduced to allow firms to more inexpensively achieve the overall target.[50] In tradeable allowance programs, an overall target level of emissions is first determined, emissions allowances are then assigned to individual polluters, and allowances may eventually be traded across polluters.[51]

The efficiency properties of quantity-based tools depend critically on how well the emissions target is chosen[52] because, in effect, these methods mandate the aggregate emissions level. Although standards and allowances are technically only a cap on emissions, they provide no incentive to firms to reduce emissions below their allowed level (after all "trades" have occurred).[53] As a result, the observed level of emissions is expected to be the aggregate target level, subject to costly monitoring and enforcement, regardless of whether the target is efficient.[54]

In order to choose the initial target, policymakers and regulators must resort to applied cost-benefit analysis or some designation of the "right" level of emissions as dictated by some other consideration such as equity or legislative mandate.[55] In either case, it should not be surprising that quantity-based tools do not generally achieve efficiency. I address the efficiency properties of quantity-based tools in the presence of uncertainty about abatement costs or pollution damages in Part V.

If emissions standards and tradeable allowances are fully transferable[56] (they can freely flow across all current and potential polluters), then both tools are cost effective.[57] In practice, however, emissions standards are not perfectly transferable (standards programs typically only allow flexibility within one polluter's decisions, not across polluters)[58] and so they will not be cost effective unless every polluter is assigned an individualized (and perfectly selected) cap properly accounting for differences in marginal abatement costs.[59] Tradeable allowances are transferable by design and so are expected to be closer to cost effective, limited only by flexibility of trades and transactions costs.[60]

But to the extent that emissions standards and allowances are transferable, equity concerns have arisen. Polluters locating or intensifying their pollution in poor areas and areas populated by ethnic minorities implies that the benefits and costs of emissions are being redistributed by government policy.[61] It should be noted that this is not a problem with

42. The equimarginal principle states: "If you have multiple sources to produce a given product or achieve a given goal, and you want to minimize the total cost of producing a given quantity of that output, distribute production in such a way as to equalize the marginal costs between production sources." *Id*. at 61.

43. And, in fact, cost-effectiveness has been embraced more widely than efficiency. *See* Hahn et al., *supra* note 17, at 395; Stavins, *supra* note 32, at 296.

44. Field & Field, *supra* note 6, at 115.

45. Hahn et al., *supra* note 17, at 410-11.

46. *Id*. at 411.

47. *Supra* note 10.

48. *Supra* note 11.

49. Field & Field, *supra* note 6, at 214

50. Hahn et al., *supra* note 17, at 402.

51. One-sided tradeable allowances policies are also called "cap-and-trade" programs.

52. Field & Field, *supra* note 6, at 216.

53. *Id*. at 224.

54. Of course, if the target is chosen to be exactly the efficient level, then these quantity-based tools will be efficient. *See* Weitzman, *supra* note 18, at 477, 480.

55. *See* U.S. EPA, *supra* note 32, at ES-7.

56. Emissions standards are transferable to the extent that offsets and bubbles are permitted.

57. Field & Field, *supra* note 6, at 239.

58. *See* 42 U.S.C. §404 (2000).

59. Field & Field, *supra* note 6, at 221.

60. *Id*. at 249.

61. *Supra* note 10.

quantity-based tools in theory.[62] Rather, the problem arises in practice when the geographic area over which trades are permitted is too large, i.e., trades are permitted across regions with differential damages.[63]

B. Price-Based Instruments

Price-based environmental policy tools are designed to affect polluter behavior by increasing the price of polluting or by decreasing the price of abatement. Emissions taxes specify a fee per unit of emissions that must be paid by the polluter.[64] In order to account for differences in damages related to the location of the emitter, emissions taxes can vary across zones.[65] Abatement subsidies specify a cash award from the government to the polluter for every unit of emissions reduction.[66] Emissions subsidies are generally undesirable under most of the evaluative criterion. Although they will be cost effective, they most certainly will not attain full efficiency due to the perverse incentives—the subsidy will make it profitable for new firms to enter the polluting industry.[67]

Emissions taxes, on the other hand, perform better than abatement subsidies.[68] Emissions taxes work by decreasing a polluter's marginal abatement cost or, equivalently, increasing the cost of emissions. Although a polluter must still pay the technical costs of reducing emissions, the polluter can avoid the tax by reducing its emissions.[69] That is, the marginal cost of abatement is reduced by exactly the amount of the tax and so polluters, responding to those lower costs, will abate more.

Just as with quantity-based instruments, the performance of taxes under the efficiency criterion depends critically on how well the target is chosen.[70] In the case of taxes, the "target" is the price of pollution. Polluters properly incorporating the tax as a cost of emissions will abate as long as it is profitable to do so, no more and no less. Consequently, similar to quantity-based instruments, the observed level of emissions will be inefficient unless the tax is chosen perfectly.[71]

But, unlike uniform emissions standards (standards that are equal across all polluters and therefore are not "personalized"), uniform emissions taxes will always be cost effective.[72] Without an emissions tax, a polluter will emit as long as emissions are privately costless.[73] With an emissions tax, a polluter faces a choice on every unit of emissions: emit and pay the tax, or abate and pay the abatement costs. Facing that choice, the polluter will emit if the marginal abatement costs exceeds the tax and will abate if the tax exceeds the marginal abatement costs.[74] Following that calculus, the polluter will reduce emissions until its marginal abatement costs are equal to the tax.[75] Since the tax was uniform across all polluters, the process also happens to make all polluters' abatement costs equal. That is, uniform emissions taxes are necessarily cost effective.

Some evidence exists for another efficiency effect with emissions taxes. Taxes generate revenue for the government that may be used to offset the administrative cost of regulation.[76] If the revenues are large enough, emissions taxes might not even have a net regulatory burden. If the revenues more than cover regulatory costs, emissions taxes may generate a "double dividend," the ability to reduce other distortionary government taxes.[77]

IV. Two-Sided Allowance Markets

Two-sided allowance markets broaden traditional quantity-based allowance markets to explicitly allow pollutees an economic voice.[78] In these markets, pollutees can buy allowances and permanently hold them and thereby reduce the economywide allowable level of emissions below the regulatory target.[79] Unused allowances are said to be "retired."[80]

The concept of two-sided allowance markets is not new.[81] In fact, although the SO_2 markets established in relation to the CAA Amendments were conceived to be traded among polluters, permit retirement was not prohibited and a small but increasing number of retirements have occurred.[82] But despite the existence of two-sided allowance markets, the legal scholarship on allowance markets draws all of its conclusions from the economic analysis of one-sided markets.[83] And since the analysis of one-sided markets cannot consider the efficiency gains deriving from the market participation of pollutees, that analysis necessarily mis-measures the gains from allowance markets relative to traditional price- and quantity-based controls.[84] In the remainder of this section, I provide an exposition of recent contributions[85] in en-

62. If social damages are higher in one geographic region than another, then for efficiency reasons alone the trading rules across geographic boundaries should reflect those higher damages. In this sense, this type of equity consideration is not in tension with efficiency, rather, it is a reflection of its inefficiency.

63. Andrew J. Yates, *Decentralization in Pollution Permit Markets*, 4 J. Pub. Econ. Theory 641-60 (2002) (addresses permit trading across regions).

64. Field & Field, *supra* note 6, at 235.

65. *Id*. at 242-44.

66. *Id*. at 252.

67. *Id*.

68. Technically, they both fare identically on cost-effectiveness because they both equalize marginal abatement costs across all polluters.

69. Field & Field, *supra* note 6, at 235-37.

70. *Id*. at 237-39.

71. *Id*. at 245.

72. *Id*. at 239-42.

73. *Id*. at 100.

74. *Id*. at 235-37.

75. *Id*.

76. For an introduction to the economic analysis of the "double dividend" hypothesis, see *id*. at 246.

77. *Id*.

78. The terms "polluter" and "pollutee" are used instead of "firm" and "consumer" in recognition of the fact that consumers generate pollution and some types of firms are damaged by pollution.

79. An introduction to the economics of tradeable allowances is given in Field & Field, *supra* note 6, ch. 13.

80. *Id*. at 263.

81. EPA's tradeable quotas of chlorofluorocarbons as part of the CAA (and with respect to the Montreal Protocol) explicitly allowed for "consumers" to trade. *See* Hahn & McGartland, *supra* note 13.

82. *Supra* note 21.

83. As discussed in Smith & Yates, *supra* note 20, the environmental economics literature did not formally address two-sided allowance markets in the presence of uncertainty about marginal abatement costs and marginal damages.

84. *See id*. (discussing of the welfare gains from two-sided trades).

85. *Id*. (providing the complete economic model).

vironmental economics that analyze the economic effects of two-sided allowance markets.

A. Demand for Allowances

In two-sided allowance markets, two different types of economic agents potentially want to buy allowances. Polluters want to buy allowances in order to legally pollute. Pollutees want to buy and retire allowances and thereby reduce pollution. In the most simple conception, the regulator is the sole supplier of allowances and the regulator either auctions the allowances or endows polluters directly.

To understand how the two different demands for allowances interact, first consider the foundations for each type. Polluter demand for allowances derives from the polluter's benefits from pollution. Pollution reduction is assumed to be costly; a polluter must use resources to reduce emissions. Furthermore, the final unit of abatement (the first unit of emissions) is the most costly. The penultimate unit of abatement (the second unit of emissions) is less costly, etc. That is, the marginal cost of abatement is increasing as the level of abatement increases (decreasing as the level of emissions increases).

Pollutee demand for allowances derives from the pollutee's benefits from reduced pollution. Each unit of pollution is assumed to damage the pollutee and the second unit is more damaging than the first, etc. That is, the marginal damages from emissions increase as the emissions level increases. The damages from pollution may derive from pecuniary costs such as doctor bills for the treatment of respiratory problems or may be a valuation of lost aesthetic value, etc.

The demands for allowances follow directly from the benefits and damages from pollution. Polluters will buy an allowance if the price of the allowance is less than the cost of abating that unit. Pollutees will retire an allowance if its price is less than the damages that would result from the use of that allowance for emissions.

A complication arises from the fact that, from the perspective of pollutees, every unit of abatement is a *public* good, a good offering a nonrival and nonexcludable benefit to other economic actors.[86] If a particular pollutee buys and retires one allowance, a free benefit accrues to each of the other pollutees. This fact encourages free-riding—pollutees may not truthfully represent (in the form of allowance demand) their benefits from abatement because they can costlessly benefit from others' choices. Since this pressure is present for all pollutees, the demand for allowances is not expected to fully reflect the true social benefits from abatement. For this reason, demand for allowance by pollutees will be assumed to derive from revealed damages, those damages expressed by pollutees in the marketplace, rather than true damages. The fact that true damages are not fully expressed in market transactions introduces a source of uncertainty in predicting market outcomes.

Similarly, the presence of high transactions costs, resources used to identify and interact with potential traders, may also indicate that the expressed allowance demand may not fully capture the benefits from abatement. It is convenient here to include both free-riding and transactions costs as incorporated in the concept of allowance demand. And then when the efficiency properties of market outcomes is evaluated, attention will again be focused on actual damages from pollution rather than expressed damages.

B. The Two-Sided Market Outcome

For purpose of this exposition, consider the case when the damages from the first unit of emissions is less than the abatement cost for that unit. (The case when the efficient level of emissions is positive.) Polluters will outbid pollutees for the first allowances auctioned by the regulator because marginal abatement costs initially exceed marginal damages. But since marginal abatement costs are decreasing and marginal damages are increasing, at some point marginal damages will overtake marginal abatement costs and then pollutees will outbid polluters for allowances. The point at which marginal damages equals marginal abatement costs is called the *equimarginal point*.

It follows that the market outcome, how many allowances are purchased by polluters, depends on the supply of allowances determined by the regulator. If the supply of allowances is less than the equimarginal level of allowances, then polluters buy all the allowances and pollutees are completely priced out of the allowance market. In Figure 2a, e' represents the allowance endowment. For each allowance from 0 up to e', marginal abatement costs exceed marginal damages and so polluters outbid pollutees. The observed emissions is e' and, thus, the two-sided allowance market effectively reverts to a one-sided market in that only polluters are observed to participate.

If the supply of allowances is greater than the equimarginal level as in Figure 2b, then polluters buy all the allowances up to the equimarginal level e* and pollutees buy the remaining allowances, from e* up to e'. In this case, the availability of allowances provides a cap on emissions similar to the emissions cap imposed by emissions standards. But unlike emissions standards, the regulator target does not predetermine the minimum level of emissions. In fact, the actual level of emissions is reduced by the amount of allowance retirement. If pollutees were prevented from participating in this market, firms would buy up all the allowances—without competing demanders for allowances, the price of allowances will continue to fall until all the allowances are purchased by polluters.

When pollutees participate in the market, every retired allowance reduces pollution and thereby reduces damages from pollution. Furthermore, every retired allowance represents a unit of emissions for which the marginal damages exceed the marginal abatement costs. Therefore, every retired allowance necessarily represents a step toward the efficient outcome as well.

It is now important to recall that the demand for allowances represents revealed marginal damages, not true marginal damages, due to free-riding and transactions costs. Does this incomplete expression of marginal damages mitigate the benefits of the two-sided allowance market? Yes and no. If the demand for allowances only partially incorporates true marginal damages and if the regulator errs by setting the allowance endowment inefficiently high, then

86. A *nonrival* benefit is one for which one person's enjoyment of the benefit in no way precludes the enjoyment of the same benefit by another. For example, consuming an apple is a rival benefit but the enjoyment of sunshine is not. *Nonexcludability* means that a person cannot, technologically, be prevented from enjoying a particular benefit. For example, broadcast radio is nonexcludable whereas satellite radio is excludable.

pollutees will not retire enough allowances to reach the efficient outcome.

In Figure 3, e* represents to efficient outcome and e' represents to allowance endowment. Pollutees buy allowances and reduce to e'' where revealed marginal damages equal marginal abatement costs, but not all the way to e*. However, the two-sided market will decrease damages more (and come closer to the efficient emissions level) than either emissions standards and one-sided markets would, given that the regulator acts on the same information in setting those targets. That is, if standards were set at e', pollution damages would be higher and social welfare would be lower than if two-sided allowance markets were used.

This emissions reduction and efficiency gain of the two-sided allowance market occurs when the regulator errs in selecting an inefficiently high emissions target. Of course, if the regulator has full information about pollution benefits and damages, the emissions target will presumably not be inefficiently large. It is in the presence of uncertainty about abatement costs and emissions damages that the emissions target can be expected to be inefficient.

C. Uncertainty and Efficiency

1. Price-Based Versus Quantity-Based Instruments

In the presence of uncertainty about marginal damages, quantity-based instruments and price-based instruments fare similarly to the efficiency criterion because in both cases the known marginal abatement costs perfectly indicate the post-regulatory emissions level.[87] But in the case of uncertainty about marginal abatement costs, the efficiency performance of price-based instruments (emissions taxes) as compared to quantity-based instruments (emissions standards or one-sided allowance markets) depends critically on nature of abatement costs and damages.[88]

Suppose that marginal damages are fully known but only the steepness of marginal abatement costs are known—the steepness of marginal abatement costs tells how much a one unit change in emissions changes abatement costs. Since marginal abatement costs are unknown, the regulator can only estimate the efficient level of emissions. If the regulator uses a quantity-based instrument, the resulting level of emissions will be precisely the emissions target. And if the regulator uses a price-based instrument, the resulting level of emissions will be higher or lower than the target, depending on the actual marginal abatement costs. Which type of instrument gets closer to efficiency depends on the relative steepnesses of marginal damages and marginal abatement costs.

If marginal damages are steeper than marginal abatement costs, then the efficient level of emissions will be close to the efficient emissions level. Therefore, price-based instruments that create deviations from the target emissions level are associated with large social welfare losses. But instruments that target quantity, while they may be inefficient, have no change in emissions from the target, which is close to the efficient emissions level. Therefore, when marginal damages are steeper than unknown marginal abatement costs, instruments that constrain quantity are generally preferable under the efficiency criterion.

If marginal abatement costs are steeper than marginal damages, then the efficient level of emissions will be quite different than the target level of emissions. Therefore, quantity-based instruments will result in a large departure from the efficient emissions level and will be associated with large social welfare losses. But price-based instruments that allow polluters to adjust their emissions levels in response to their own marginal abatements costs will actually get close to the efficient outcome and are therefore associated with smaller social welfare losses. In this case, price-based instruments are generally preferable.

Of course these stated preferences for quantity-based and price-based tools in the presence of uncertainty are primarily theoretical distinctions because they require knowledge about which is steeper, marginal abatement costs or marginal damages. It seems unlikely that a regulator would be certain about the relative steepness of marginal abatement costs but have no knowledge about marginal abatement costs. As a result, this theoretical rule-of-thumb about when to use price- or quantity-based tools is scarcely operational.

2. Two-Sided Permit Markets and Uncertainty

A two-sided allowance market, however, is neither a purely price-based nor a purely quantity-based instrument and offers an operational advantage over both tools in the presence of uncertainty.

In contrast to quantity-based targets such as emissions standards or one-sided allowance markets, the environmental target in two-sided allowance markets (as represented by the number of allowances issued) does not dictate the end level of pollution—the market level of pollution will be less than the allowance endowment whenever pollutees participate. In this sense, two-sided markets are not purely quantity-based tools as are one-sided allowance markets. Similarly, since the price of allowances is determined by the allowance market itself, two-sided markets are not purely price-based tools. In fact, the price of allowances will be driven higher by pollutee participation in the market, thereby making emissions more costly to polluters.

As mentioned above, if marginal abatement costs are uncertain and marginal damages are steeper than marginal abatement costs, then quantity-based instruments such as emissions standards or one-sided allowance markets are generally preferable to price-based instruments. But two-sided allowance markets offer an advantage over purely quantity-based instruments. If the emissions target was inefficiently low, two-sided allowance markets would revert to a one-sided market because pollutees are priced out of the market. But if the target was inefficiently high and pollutees participate in the allowance market, then every retired permit represents an emissions reduction and an increase in social welfare. In this case, allowances are preferred to quantity-based tools which are preferred to price-based tools.

If marginal abatement costs are uncertain and marginal abatement costs are steeper than marginal damages, then

87. This statement slightly overstates the case for quantity-based instruments. As stated above, uniform emissions taxes and tradeable permits are always cost effective. But uniform emissions standards generally require personalized standards to achieve cost-effectiveness.

88. For the complete analysis of the relative performances of the traditional price- and quantity-based tools in the presence of uncertainty, see Weitzman, *supra* note 18. The comparative analysis of two-sided allowance markets derives from results in Smith & Yates, *supra* note 20. *See also* FIELD & FIELD, *supra* note 6, at 245-55.

price-based instruments such as emissions fees are generally preferable to quantity-based instruments. As above, if the target was inefficiently low, the two-sided allowance market reverts to a one-sided market and so offers no advantage over quantity-based tools. But if the target was inefficiently high, the two-sided allowance markets allow emissions to adjust (downward) in response to the mistake and hence the market outcome is superior to the quantity-based tools. It is unknown whether the two-sided allowances fare better than price-based tools in this case. It is possible that a price-based tool gives better control and smaller welfare losses. However, it is also possible that a two-sided allowance market reduces emissions to the point that social welfare losses are smaller than with price-based tools. In total, two-sided allowance markets are a compromise, a hedge, between the price-based instruments and the quantity-based instruments. Given this uncertainty scenario, two-sided allowance markets do not perform as well as emissions fees but they perform better than emissions standards.

Taken together, over all the possible cases of uncertainty in marginal abatement costs, a distinct advantage of two-sided allowances can be articulated. Correctly choosing between price-based and quantity-based instruments requires prior knowledge about the relative steepness of marginal abatement costs and marginal damages. In comparing those tools to two-sided allowances, several conclusions can be made: (1) two-sided allowances never perform worse than the weakest of price- and quantity-based tools; (2) in some cases, two-sided allowances offer larger emissions reductions and larger social welfare gains than both price-and quantity-based tools; and (3) at their worst, two-sided allowance markets offer a hedge between price- and quantity-based tools when it is uncertain which tool is preferred under the efficiency criterion.

3. Efficiency and Uncertainty in Marginal Damages

If marginal abatement costs are known but marginal damages are uncertain, the regulator does not generally have a preference (based on efficiency) between the quantity-based tools and price-based tools because the regulatory outcome is certain in both cases. Under price- or quantity-based tools, marginal damages do not influence the observed emissions levels.

But with two-sided allowance markets, pollutee participation in the market makes the outcome indeterminate when marginal damages are uncertain. Although indeterminacy of emissions is typically a problem for the regulator, in the case of two-sided allowances, the indeterminacy is asymmetric—emissions will necessarily be smaller than the emissions target and those smaller emissions will also translate to welfare gains.

Suppose the regulator sets the allowance endowment equal to the emissions standard target, where marginal abatement costs are equal to estimated marginal damages. If the marginal damages are actually smaller than originally believed, then pollutees are priced out of the market and the two-sided allowance market reverts to a one-sided market and offers no advantage over pure quantity-based or price-based instruments.

However, if revealed marginal damages are actually larger than originally believed, then two-sided allowances are strictly preferable to either purely quantity-based or price-based instruments. If revealed marginal damages are larger than originally believed, the regulatory target level of emissions was too loose. Emissions standards, one-sided allowance markets, and emissions fees offer no recourse to pollutees. But two-sided allowance markets permit pollutees to retire permits in order to reduce the allowable emissions below the target. Two-sided allowance markets thus reduce emissions more and provide larger welfare gains than the other instruments.

In conclusion, two-sided allowance markets at their best offer greater emissions reductions and efficiency advantages over purely price-based or purely quantity-based instruments. At their worst, two-sided allowance markets offer a hedge solution between quantity-based controls and price-based controls when uncertainty in marginal abatement costs otherwise precludes making a definitive instrument choice.

D. Evaluating Two-Sided Markets Under Other Criteria

1. Cost-Effectiveness of Two-Sided Markets

Two-sided markets are necessarily cost effective for the same reason that traditional one-sided markets are. A polluter will buy allowances up to the point where its marginal abatement cost equals the allowance price. Since polluters all face the same allowance price, all polluters' marginal abatement costs will be naturally equalized. Pollutee participation in the market only increases that common market price.

2. Equity and Two-Sided Markets

From an equity perspective, two-sided allowance markets provide a unique advantage over each of the traditional control instruments—*after* the policymaking process and *after* the regulatory target-setting, two-sided allowance markets offer pollutees and environmental activists an economic voice in the determination of the aggregate level of emissions. Furthermore, this equity gain is not achieved at the expense of efficiency considerations. In fact, as noted above, voluntary pollutee participation always results in an increase in social welfare.

V. The Self-Correction Criterion

In contrast to pure price-based or quantity-based instruments, two-sided allowance markets possess the distinctive feature of a natural post-regulatory correction that is always an efficiency improvement.[89] Purely quantity-based controls such as one-sided allowance markets or emissions standards effectively dictate the post-regulatory emissions level. If the regulatory target was inefficiently loose, no incentives exist for polluters to further reduce their emissions. And purely price-based controls such as emissions taxes provide only loose control over emissions. In response to emissions taxes, emissions levels may be inefficiently high or low and pollutees have no mechanism to change the emissions level other than restarting the policymaking process.

89. Self-correction should not be mistaken with reflexivity, the idea that the regulatory approach should be responsive to the changing legal, regulatory, or physical environment. (See Stewart, *supra* note 1, at 130, for a discussion of reflexive law).

However, post-regulatory self-correction is a natural feature of two-sided allowance markets. If the emissions target is inefficiently loose, pollutees have some post-regulatory power to lower the emissions level. Furthermore, the fact that pollutees participate in the allowance market provides valuable information about the actual sizes of marginal abatement costs and marginal damages.[90]

In evaluating purely price-based and quantity-based instruments, efficiency is at most a meta-criterion, a consideration in selecting an emissions target but not helpful in choosing between instruments.[91] As a result, the efficiency criterion is typically operational only through cost-benefit analysis applied to the target selection.[92] To the extent that cost-benefit analysis is both difficult and manipulable by selective disregard of various difficult-to-measure benefits or costs, efficiency has been a weak criterion.

But two-sided allowance markets actually serve as an automatic efficiency correction to the original emissions target. In this way, the efficiency criterion enters more broadly and in a less manipulable manner than just through target choice. Furthermore, through two-sided allowance markets, the efficiency criterion can be operationalized in a much less controversial way than that offered by cost-benefit analysis.

From an equity perspective, two-sided allowance markets also offer a distinctive feature to pollutees: none of the purely price- or quantity-based instruments offer pollutees a post-regulatory voice. That is, two-sided allowance markets provide pollutees a check on the political and regulatory process that selects the emissions target level.

VI. Conclusion

Recent contributions in the environmental economics literature analyze pollution allowance markets when pollutees participate in the market by buying and retiring allowances. These new contributions indicate that previous legal scholarship that compares allowance markets, emissions standards, and emission taxes greatly underestimate the advantages of using markets. When pollutees participate in allowance markets, overall emissions are necessarily lower (than would be with equivalent standards), social welfare is necessarily higher, and pollutees are able to express their preferences for environmental quality through the marketplace. In conclusion, policymakers should reassess the use of standards or emissions when allowance markets are feasible.

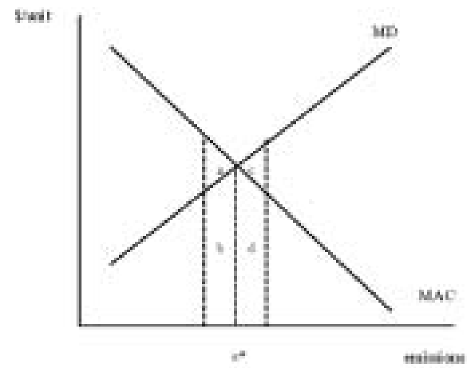
90. Smith & Yates, *supra* note 20, discuss the possibility of learning from the two-sided allowance markets.

91. *See supra* notes 24-38 and accompanying text (section discussing efficiency).

92. *See supra* notes 49-63 and accompanying text (section discussing quantity-based tools).

Appendix

Figure 1



MD – marginal damages

MAC – marginal abatement costs

e* -- equimarginal level of emissions

Figure 3

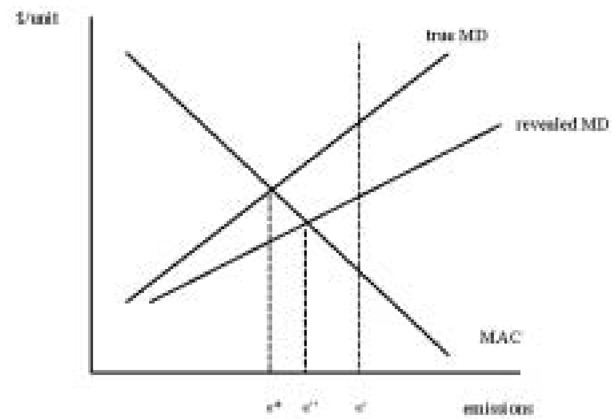


Figure 2a

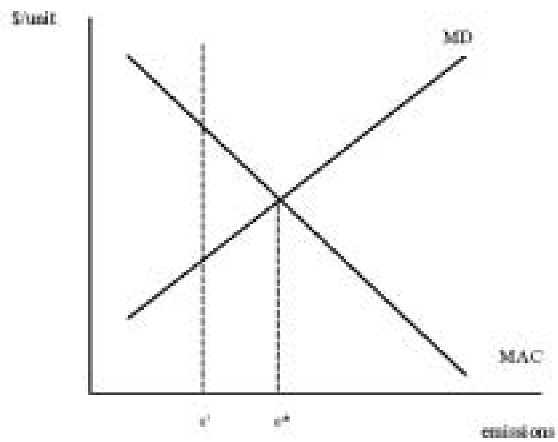


Figure 2b